

1685 77-B
10/975-23)
1

UNIVERSIDAD DE CHILE
FACULTAD DE CIENCIAS FISICAS Y MATEMATICAS

DEPARTAMENTO DE ASTRONOMIA

Publicaciones
Volumen III

PRIMERA REUNION ASTRONOMICA
REGIONAL LATINOAMERICANA
PRIMEIRA REUNIÃO ASTRONÔMICA
REGIONAL LATINO-AMERICANA
FIRST LATIN-AMERICAN REGIONAL
ASTRONOMY MEETING

16-21 de enero de 1978

Adelina Gutiérrez-Moreno, Hugo Moreno

EDITORES

OBSERVATORIO ASTRONOMICO NACIONAL, CERRO CALAN
SANTIAGO DE CHILE

BIBLIOTECA NACIONAL



0480149

DEPARTAMENTO DE ASTRONOMIA

Publicaciones
Volumen III

PRIMERA REUNION ASTRONOMICA
REGIONAL LATINOAMERICANA

PRIMEIRA REUNIÃO ASTRONÔMICA
REGIONAL LATINO-AMERICANA

FIRST LATIN-AMERICAN REGIONAL
ASTRONOMY MEETING

16-21 de enero de 1978

Adelina Gutiérrez-Moreno, Hugo Moreno

EDITORES

25667

DEPARTMENT
OF
AGRICULTURE

Division of
Entomology

REPORT ON THE
RESULTS OF THE

ENTOMOLOGICAL SURVEY
OF THE

STATE OF TEXAS
FOR THE YEAR

1907

BY
J. M. ALLEN

WASHINGTON
GOVERNMENT PRINTING OFFICE

La publicación de los trabajos presentados en la Primera Reunión Astronómica Regional Latinoamericana ha sido posible gracias a la ayuda económica de la Vicerrectoría de Extensión y Comunicaciones y de la Facultad de Ciencias Físicas y Matemáticas, de la Universidad de Chile.

Agosto de 1979

PREFACIO

La Primera Reunión Astronómica Regional Latinoamericana, auspiciada por la Unión Astronómica Internacional, se realizó en Santiago de Chile, en la Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile, entre el 16 y el 21 de Enero de 1978.

La conferencia fue organizada por el Departamento de Astronomía de la Universidad de Chile, con la cooperación del Observatorio Interamericano de Cerro Tololo y del Observatorio Europeo Austral.

Los miembros del Comité Científico Organizador fueron:

Claudio Anguita, Presidente	Universidad de Chile
Víctor M. Blanco	CTIO, Chile
Jacques Breysacher	ESO, Chile
Hugo Moreno	OAN, Cerro Calán, Chile
José L. Sérsic	OA, Córdoba, Argentina
Jurgen Stock	CIDA, Mérida, Venezuela
Patrick A. Wayman	IAU, ex officio

Los miembros del Comité Organizador Local fueron:

Hugo Moreno, Presidente	OAN, Cerro Calán, Chile
Guillermo Carrasco	OAN, Cerro Calán, Chile
Adelina Gutiérrez	OAN, Cerro Calán, Chile
Patricio Loyola	OAN, Cerro Calán, Chile
Gordon Newman	CTIO, Chile

La conferencia se realizó en doce sesiones, dos de las cuales (VIII y VIIIa) fueron simultáneas. Estas sesiones fueron presididas por:

Sesión I E.E. Mendoza
II N. Vogt
III V.M. Blanco
IV N. Walborn
V W.E. Kunkel
VI J. Stock

Sesión VII A. Feinstein
VIII E. Bajaja
VIIIa C. Anguita
IX J.L. Sérsic
X J.A. de F. Pacheco
XI C.U. Cesco

Muchas personas han contribuido al éxito de la reunión. Deseamos agradecer a todas ellas. Especial mención merece el Prof. Atilano Lamana, Director del Instituto de Investigaciones y Ensayos de Materiales de la Facultad de Ciencias Físicas y Matemáticas (en cuyo Auditorio se realizó la conferencia), quien proporcionó todas las facilidades necesarias. No podemos dejar de mencionar al personal del Departamento de Astronomía, y a nuestro pequeño grupo de estudiantes, quienes cooperaron eficientemente durante todas las sesiones.

También queremos agradecer a todas las personas que han colaborado en la publicación de este volumen: a los autores por sus contribuciones; a la señorita Mariela Fajardo por su excelente trabajo al mecanografiar todas las comunicaciones; a la señora Guadalupe Cortés, por su cooperación en leer todas las pruebas, y a la señorita Gloria Silva por su actuación como secretaria de los editores.

Adelina Gutiérrez-Moreno
Hugo Moreno
Editores

Cerro Calán, Mayo 1979.

PREFÁCIO

A Primeira Reunião Astronômica Regional Latino-Americana, auspiciada pela União Astronômica Internacional, realizou-se em Santiago do Chile, na Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile, entre 16 e 21 de Janeiro de 1978.

A conferência foi organizada pelo Departamento de Astronomía de la Universidad de Chile, com a cooperação do Observatório Interamericana do Cerro Tololo e do Observatório Europeu Austral.

Os membros do Comitê Científico Organizador e do Comitê Organizador Local dão-se na página 7.

A conferência realizou-se em doze sessões, duas das quais (VIII e VIIIA) foram simultâneas. Os presidentes das diferentes sessões se indicam na página 8.

Muitas pessoas contribuíram ao êxito da reunião. Desejamos agradecer a todas elas. Especial menção merece o Prof. Atilano Lamana, Director do Instituto de Investigaciones y Ensayes de Materiales de la Facultad de Ciencias Físicas y Matemáticas (em cujo Auditório realizou-se a conferência), quem proporcionou todas as facilidades necessárias. Não podemos deixar de mencionar ao pessoal do Departamento de Astronomía, e a nosso pequeno grupo de estudantes, que colaboraram eficientemente durante todas as sessões.

Também queremos agradecer a todas as pessoas que colaboraram na publicação deste volume: aos autores por suas contribuições, a Senhorita Mariela Fajardo por seu excelente trabalho ao datilografar todas as comunicações; a Senhora Guadalupe Cortés, por sua cooperação em ler todas as provas, e a Senhorita Gloria Silva por sua atuação como Secretária dos editores.

Adelina Gutiérrez-Moreno

Hugo Moreno

Editores

Cerro Calán, Maio de 1979.

PREFACE

The First Latin American Regional Astronomy Meeting, sponsored by the International Astronomical Union, was held at the Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile at Santiago, on January 16-21, 1978.

The conference was organized by the Departamento de Astronomía de la Universidad de Chile, with the cooperation of Cerro Tololo Interamerican Observatory and the European Southern Observatory.

The members of the Scientific Organizing Committee and of the Local Organizing Committee are listed in page 7 .

The conference was divided in twelve sessions, two of which (VIII and VIIla) were held simultaneously. The Chairmen for the individual sessions are listed in page 8 .

Many people have contributed to the success of the meeting. We wish to thank them all. Special mention deserves Prof. Atilano Lamana, Director of the Instituto de Investigaciones y Ensayes de Materiales de la Facultad de Ciencias Físicas y Matemáticas (where the conference was held), who provided all the facilities. We also have to mention the staff of the Departamento de Astronomía and our small group of students, who worked hard during all the sessions.

We also wish to thank all those who have contributed to the publication of this volume: the authors for their contributions; Miss Mariela Fajardo for her excellent work in typewriting all the manuscripts; Mrs. Guadalupe Cortés for her help in proof-reading all the book, and Miss Gloria Silva for acting as the editors' secretary.

Adelina Gutiérrez-Moreno
Hugo Moreno
Editors

Cerro Calán, May 1979.

LISTA DE PARTICIPANTES
LIST OF PARTICIPANTS

Abraham, Zulema	IF, Porto Alegre, Brasil
Agüero, Estella L.	OA, Córdoba, Argentina
Alcaíno, Gonzalo	IIN, Santiago, Chile
Aldrovandi, Sueli M.V.	IAG, São Paulo, Brasil
Altavista, Carlos	OA, La Plata, Argentina
Andrei, Alexandre H.	ON, Rio de Janeiro, Brasil
Anguita, Claudio	OAN, Cerro Calán, Santiago, Chile
Aparici, Juan	ORA, Maipú, Chile
Arnal, Edmundo M.	IAR, Villa Elisa, Argentina
Arnedo, Mónica M.V. de	OA, Córdoba, Argentina
Bajaja, Esteban	IAR, Villa Elisa, Argentina
Bitrán, Mauricio	Depto. de Astronomía, Santiago, Chile
Blaauw, Adrian	SL, Leiden, Holanda
Blanco, Betty	CTIO, La Serena, Chile
Blanco, Víctor M.	CTIO, La Serena, Chile
Bórquez, Juan	Depto. de Astronomía, Santiago, Chile
Breysacher, Jacques	ESO, Santiago, Chile
Calderón, Jesús H.	OA, Córdoba, Argentina
Campusano, Luis E.	OAN, Cerro Calán, Santiago, Chile
Cardona, María A.	UTE, Santiago, Chile
Carestia, Reinaldo A.	OA, San Juan, Argentina
Carranza, Gustavo	OA, Córdoba, Argentina
Carrasco, Guillermo	OAN, Cerro Calán, Santiago, Chile
Cesco, Carlos U.	OA, San Juan, Argentina
Clariá, Juan J.	IF, Porto Alegre, Brasil
Costa, Edgardo	OAN, Cerro Calán, Santiago, Chile
Chaves, Otávio L.	ON, Rio de Janeiro, Brasil
Danks, Anthony C.	ESO, Santiago, Chile
de la Reza, Ramiro	ON, Rio de Janeiro, Brasil
dos Santos, Paulo M.	CRAAM, São Paulo, Brasil
Dubner, Gloria M.	IAR, Villa Elisa, Argentina
Ducati, Jorge R.	IF, Porto Alegre, Brasil
Feinstein, Alejandro	OA, La Plata, Argentina
Fernández, Silvia	OA, Córdoba, Argentina

Freire, Rubens
 Graham, John A.
 Gutiérrez-Moreno, Adelina
 Kunkel, William E.
 Lapasset, Emilio
 Lasker, Barry M.
 Lépine, Jacques R.D.
 Levato, Hugo
 Loyola, Patricio
 Lyngå, Gösta
 MacConnell, Jack
 Magalhães, Antonio M.
 Malaroda, Stella
 Manrique, Walter
 May, Jorge
 Méndez, Roberto H.
 Mendoza, Eugenio E.
 Milone, Luis A.
 Moreno, Hugo
 Morras, Ricardo
 Mourão, Rolando R. de Freitas
 Muzzio, Juan C.
 Newman, Gordon
 Niemela, Virpi
 Noël, Fernando
 Ojeda, David
 Pacheco, João A. de Freitas
 Penna, Jucira L.
 Pöppel, Wolfgang G.L.
 Queiroz, Margaret de
 Quintana, Hernán
 Rovira, Marta
 Rubio, Mónica
 Sérsic, José L.
 Shen, Chun-Shan
 Steiner, João E.
 Stock, Jurgen
 Strauss, Federico M.
 Torres, Carlos
 Vieira, Edemundo R.
 Vogt, Nikolaus
 Walborn, Nolan R.
 Wamsteker, Willem
 Wielebinski, Richard
 Wroblewski, Herbert

ON, Rio de Janeiro, Brasil
 CTIO, La Serena, Chile
 OAN, Cerro Calán, Santiago, Chile
 ON, Rio de Janeiro, Brasil
 OA, Córdoba, Argentina
 CTIO, La Serena, Chile
 CRAAM, São Paulo, Brasil
 OA, La Plata, Argentina
 OAN, Cerro Calán, Santiago, Chile
 LU, Lund, Suecia
 CIDA, Mérida, Venezuela
 IAG, São Paulo, Brasil
 OA, La Plata, Argentina
 OA, San Juan, Argentina
 ORA, Maipú, Chile
 IAFE, Buenos Aires, Argentina
 IA, UNAM, Ciudad de México, México
 OA, Córdoba, Argentina
 OAN, Cerro Calán, Santiago, Chile
 IAR, Villa Elisa, Argentina
 ON, Rio de Janeiro, Brasil
 OA, La Plata, Argentina
 CTIO, La Serena, Chile
 Villa Elisa, Buenos Aires, Argentina
 OAN, Cerro Calán, Santiago, Chile
 Depto. de Astronomía, Santiago, Chile
 IAG, São Paulo, Brasil
 ON, Rio de Janeiro, Brasil
 IAR, Villa Elisa, Argentina
 ON, Rio de Janeiro, Brasil
 NRAO, Charlottesville, EE.UU.
 IAFE, Buenos Aires, Argentina
 Depto. de Astronomía, Santiago, Chile
 OA, Córdoba, Argentina
 CS, Taiwan
 IAG, São Paulo, Brasil
 CIDA, Mérida, Venezuela
 IF, Porto Alegre, Brasil
 OAN, Cerro Calán, Santiago, Chile
 IF, Porto Alegre, Brasil
 ESO, Santiago, Chile
 CTIO, La Serena, Chile
 ESO, Santiago, Chile
 MPIR, Bonn, Rep. Federal Alemana
 OAN, Cerro Calán, Santiago, Chile

Las abreviaturas usadas en la lista precedente corresponden a las instituciones y direcciones siguientes:

Argentina

IAFE, Buenos Aires:

Instituto de Astronomía y Física del Espacio

Casilla de Correo 67 Sucursal 28

Buenos Aires

IAR, Villa Elisa:

Instituto Argentino de Radioastronomía

Casilla de Correo N°5 - 1894 Villa Elisa

Provincia de Buenos Aires

OA, Córdoba:

Observatorio Astronómico

Universidad Nacional de Córdoba

Laprida 854

5000 Córdoba

OA, La Plata:

Observatorio Astronómico

Universidad Nacional de La Plata

1900 La Plata

OA, San Juan:

Observatorio Astronómico "Félix Aguilar"

Avda. Benavides 8175 Oeste

5407 Marquésado

San Juan

Brasil

CRAAM, São Paulo:

Centro de Rádio-Astronomia e Astrofísica

Universidade Mackenzie

Rua Maria Antônia, 403

São Paulo

CEP 01222

IAG São Paulo:

Instituto Astronômico e Geofísico

Caixa Postal N°30.627

São Paulo

IF, Porto Alegre:
Instituto de Física
Universidade Federal do Rio Grande do Sul
Av. Professor Luiz Englert s/n
90.000-Porto Alegre - RS

ON, Rio de Janeiro:
Observatório Nacional
Rua General Bruce 586 - ZC-08
20.000 Rio de Janeiro - RJ

Chile

CTIO, La Serena:
Cerro Tololo Interamerican Observatory
Casilla 63-D
La Serena

ESO, Santiago:
European Southern Observatory
Casilla 16317
Santiago 9

IIN, Santiago:
Instituto Isaac Newton
Casilla 8-9
Correo 9
Santiago

OAN, Cerro Calán, Santiago:
Observatorio Astronómico Nacional Cerro Calán
Departamento de Astronomía
Universidad de Chile
Casilla 36-D
Santiago

ORA, Maipú:
Observatorio Radioastronómico de Maipú
Departamento de Astronomía
Universidad de Chile
Casilla 36-D
Santiago

UTE, Santiago:
Departamento de Geodesia y Obras Civiles
Universidad Técnica del Estado
Ecuador 2467
Santiago

Estados Unidos de Norteamérica

NRAO, Charlottesville:

National Radio Astronomy Observatory

Edgemont Road

Charlottesville, Virginia 22901

Holanda

SL, Leiden

Sterrewacht Leiden

Huygens Laboratorium

Wassenaarseweg 78

Leiden 2405

México

IA, UNAM, Ciudad de México:

Instituto de Astronomía

Universidad Nacional Autónoma de México

Apartado Postal 70-264

México 20, D.F.

República Federal Alemana

MPIR, Bonn:

Max-Planck-Institut für Radioastronomie

Auf dem Hügel 69

D-5300 Bonn 1

Suecia

LU, Lund:

Lunds Universitet

Institutionen för Astronomi

S-222, 24 Lund

Taiwan

CS, Taiwan:

National Tsing Hua University

College of Sciences

Hsinchu, Taiwan 300

Venezuela

CIDA, Mérida

Centro de Investigación

de Astronomía "Francisco J. Duarte"

Apartado 264, Mérida

As abreviaturas usadas nas páginas 13 e 14 correspondem às instituições e direções que se detalham na lista precedente.

The abbreviations used in pages 13 and 14 correspond to the institutions and addresses given in the preceeding list.

INDICE - CONTENTS

Prefacio	7
Prefácio	9
Preface	11
Lista de Participantes - List of Participants	13
Indice - Contents	19

SESIONES CIENTIFICAS

Palabras de Bienvenida por el Prof. C. Anguita, Decano de la Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile, Presidente del Comité Científico Organizador	25
Opening Words by Prof. A. Blaauw, President of the International Astronomical Union	27

PRIMERA PARTE ASTRONOMICA EXTRAGALACTICA

Sérsic, J.L.- La Escala de Distancias Extragalácticas en el Hemisferio Sur (Discurso Invitado)	31
Lasker, B.M.- A Photographic Study of Supernova Remnants in the Magellanic Clouds	48
Kunkel, W.E.- The Magellanic Stream and its Associated Stellar Component	49
Strauss, F.M. e Braz, M.A.- Fotometria Fotoelétrica da Nebulosa 30 Doradus em $H\alpha$ e $H\beta$	51
Blanco, V.M., Blanco, B. and McCarthy, M.- Red Giants in the Galactic Bulge and the Magellanic Clouds	52
Carranza, G.- El Medio Ionizado en algunas Galaxias Australes	53
Sérsic, J.L. y Calderón, J.H.- Las Regiones HII en NGC 1566	55
Agüero, E.L.- Condiciones Físicas del Gas Ionizado y Distribución de la Relación Masa-Luminosidad en NGC 7793	61
Graham, J.A.- The Fourcade-Figueroa Galaxy	63
Bajaja, E.- Observation of HI in Southern Galaxies	64
	19

Sérsic, J.L. y Cerruti, M.A.- Rotación, Distancia y Masa de IC 5152	70
Carranza, G. y Agüero, E.L.- Sobre la Cinemática de NGC 5236	73
Quintana, H.- Clusters of Galaxies (Invited Lecture)	75
Sérsic, J.L., Arias, J.C. y Araujo, A.- Velocidades Radiales de Galaxias Australes	105
Wielebinski, R.- Radio Continuum Observations of Nearby Galaxies	110
Campusano, L.E. y Pedreros, M.- Espectroscopía de Candidatos a Cuasares en la Zona $\delta < -75^\circ$	115
Aldrovandi, S.M.V. y Natale, A.A.- The Effect of Hydrogen Ly α on the HeII Emission Lines	120
Quintana, H.- Astrophysical Consequences of the Existence of Heavy Neutral Leptons in the Universe	126

SEGUNDA PARTE

ASTRONOMIA GALACTICA

Blaauw, A.- Galactic Structure (Invited Lecture)	133
Arnal, E.M. and Franco, M.L.- A Search for HI in the Chamaeleon T-Association	136
Arnal, E.M.- HI in Nine Open Clusters	142
Feinstein, A., Clariá, J.J. y Cabrera, A.L.- Fotometría Multicolor del Cúmulo Abierto NGC 2287	146
Clariá, J.J.- Parámetros de Composición Química del Cúmulo Abierto de Edad Intermedia NGC 7789	150
Clariá, J.J.- Estudio del Cúmulo Abierto Collinder 140	151
Alcaíno, G.- Basic Parameters of Galactic Globular Clusters: Histograms, Correlations, Selection Effects	153
Muzzio, J.C.- Current Research on Galactic Structure at La Plata Observatory	154
MacConnell, D.J.- Results of an H α Survey in the Southern Milky Way	158
Stock, J.- Radial Velocities from Objective Prism Plates	160
Méndez, R.H.- Las Estrellas Centrales de NGC 2346, He 2-36 y NGC 3132	167
Méndez, R.H. y Niemela, V.S.- Búsqueda de Binarias Espectroscópicas entre Estrellas Centrales de Nebulosas Planetarias	169
Aldrovandi, S.M.V.- The Elemental Abundances in Halo Planetary Nebulae	171
Colomb, F.R. and Dubner, G.M.- HI Associated with the Supernova Remnant G. 261.9,+5.5	175
Lépine, J.R.D., Le Squeren, A.M. and Scalise Jr., E.- Detection of New Stellar SiO Maser Sources	180
Bajaja, E., Colomb, F.R. and Morras, R.- Galactic HI Survey at Low and Intermediate Latitudes between $\ell=220$ and $\ell=325^\circ$	183
Pöppel, W.G.L., Vieira, E.R., Olano, C.A. and Franco, M.L.- A Low-Latitude Southern Atlas of Galactic Hydrogen	188
Colomb, F.R., Pöppel, W.G.L. and Heiles, C.- Low Velocity Galactic HI at $ b \geq 10^\circ$	195
May, J., Reyes, F. and Aparici, J.- A 45 MHz Radiotelescope for Galactic and Extragalactic Research	193

TERCERA PARTE
ASTROFISICA ESTELAR

Pacheco, J.A. de F.- Observational Aspects of Blacks Holes (Invited Lecture)	203
Niemela, V.S. and Zorec, J.- Model of Equipotential Surfaces for Luminous Binary Systems	211
Quintana, H.- Relativistic Elasticity Theory and the Structure Equations of Solid Neutron Stars	212
Mourão, R.R. de F. e Chaves, O.L.- Órbita de dois Sistemas Binários em que uma das Componentes é uma Estrela Variável	217
Vogt, N.- Sobre la Investigación de Variables Cataclísmicas en el Hemisferio Sur de la Reza, R. and Querci, F.- Lithium Line Formation in Carbon Stars	221 225
Freire, R.- Perfíles de Líneas de CaII, CII, SiII observadas con gran Resolución en Estrellas A y el Problema de la Existencia de Cromosferas en dichas Estrellas	228
Danks, A.C. and Houziaux, L.- Spectroscopic Observations of 27 CMa from 0.14 to 4.7 Microns	232
Malaroda, S. and Levato, H.- The Mn-Hg Star HD 161698	241
Milone, L.A.- Distribución de Velocidades de los Electrones en un Plasma que no está en Equilibrio Termodinámico	242
Lapasset, E.- Estudio en Fotometría UBV de TY Mensae	244
Laporte, R., Gneiding, C., Magalhães, A.M., Codina Landaberry, S.J. e Pacheco, J.A. de F.- A Photoelectric Photopolarimeter using a Star-Sky Chopper	247
Mendoza V., E.E.- Observaciones Estelares en Hidrógeno y Oxígeno Neutros (Discurso Invitado)	250
Wamsteker, W.- The Continuum Distribution of V 1500 Cygni	256
Gutiérrez-Moreno, A. and Moreno, H.- Effects of Interstellar Reddening on Spectrophotometric Gradients	257
Mendoza V., E.E.- Fotometría UBVRI de Estrellas Am	263
Niemela, V.S. and Sahade, J.- The Spectroscopic Binary γ -2 Velorum	266
Steiner, J.E.- Discovery of Optical Pulsations in HD 77581 $\equiv$ Vela X-1	268
Arnedo, M.M.V. de.- Análisis de la Estrella RY Sgr	269
Levato, H. and Malaroda, S.- On the Properties of the Helium Variable HD 184927	271
Strauss, F.M. e Ducati, J.R.- Estrelas Padrão para Fotometria H α	272

CUARTA PARTE
ASTROMETRIA

Carestia, R.A., Zaragoza, A. y Gallego, M.- Procedimiento para Reducción en Declinación de Series Küstner. Resultados obtenidos con el Círculo Meridiano de San Juan (Argentina)	275
Carrasco, G.- Resultados de las Observaciones en Declinación de Estrellas de los Programas FK4, SRS y BS, en la Zona -20° a -40°	279
Andrei, A.H., Penna, J.L., Queiroz, M. de, e D'Avila, V.M.- Cuidados com a Refração de Sala na Instalação do Astrolábio Danjon no Observatório Nacional	287

Carrasco, G. y Loyola, P.- Resultados Finales en Ascensión Recta de 6876 Estrellas observadas en el Círculo Meridiano Repsold de Cerro Calán	289
Stock, J.- Position Determinations from Objective Prism Plates	296
Manrique, W., Actis, E. y Serafino, A.- Correcciones Preliminares $\Delta\alpha$ y $\Delta\delta$ de 120 Estrellas del FK4 y FK4 Sup.	299
Cesco, C.U.- El Leoncito: Programas Actuales y Planes para el Próximo Futuro	304

QUINTA PARTE

SISTEMA SOLAR

Abraham, Z. y Strauss, F.M.- Modelo de una Ocultación de Europa por Io	307
Altavista, C.A.- Sobre el Desarrollo de la Función Perturbadora en Términos de Funciones de Bessel con Argumentos Imaginarios Puros	309
May, J., Carr, T.D. and Desch, M.D.- Determination of Jupiter's Magnetospheric Rotation Period through the Analysis of Decametric Observations	310
Fernández M., S.- Evolución Orbital del Cometa Kohoutek 1973f	311
Noël, F.- Resultados Preliminares de Observaciones de Urano con el Astrolabio Danjon de Santiago	316
May, J., Desch, M.D. and Flagg, R.S.- High Speed Spectrograms of Short Bursts from Jupiter at 32 MHz	318
May, J., Thieman, J.R. and Smith, A.G.- Studies of the Spectral Morphology of Jupiter's Decametric Radio Sources	319
Altavista, C.A.- El problema de las Series Semiconvergentes en Mecánica Celeste y las Soluciones Periódicas de Poincaré	321
Altavista, C.A.- Sobre la Posibilidad de construir Orbitas Intermediarias en el Problema de los Tres Cuerpos	327
Palabras de clausura por el Dr. E.E. Mendoza V., Instituto de Astronomía, Universidad Nacional Autónoma de México	332
Indice de Autores - Index to Authors	333

SESIONES CIENTIFICAS

Palabras de Bienvenida
por el
Prof. C. Anguita
Decano de la Facultad de Ciencias Físicas y Matemáticas
de la Universidad de Chile
Presidente del Comité Científico Organizador

Señor Presidente de la International Astronomical Union, Profesor Adrian Blaauw; estimados colegas de Latinoamérica, Estados Unidos y Europa, señoras y señores:

Es un gran honor para la Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile dar la bienvenida a tan selecto grupo de astrónomos y amigos, que hoy inician la Primera Reunión Astronómica Regional Latinoamericana. Esta reunión científica ha sido organizada por el Departamento de Astronomía de nuestra Facultad bajo los auspicios de la IAU - a la cual agradecemos especialmente en la persona de su Presidente, Prof. Blaauw - y en estrecha colaboración con el Observatorio Inter-Americano de Cerro Tololo y el Observatorio Europeo Austral de Cerro La Silla.

Hay que destacar que esta reunión es una muestra de reconocimiento al progreso experimentado por la Astronomía en el Cono Sur; son muchos los ejemplos que podemos citar y, si nos limitamos al territorio chileno, podemos señalar que en el curso de los últimos años hemos visto crecer, en las cercanías de La Serena, tres grandes observatorios astronómicos: el Observatorio Inter-Americano de Cerro Tololo, el Observatorio Europeo Austral de Cerro La Silla y el Observatorio Carnegie del Sur de Cerro Las Campanas. En este grupo de grandes observatorios astronómicos existe un conjunto de alrededor de veinte instrumentos, algunos de gran tamaño, que forman la mayor concentración de telescopios ópticos existentes en el mundo.

Cuando preparábamos esta Reunión Latinoamericana hemos podido apreciar el grado de madurez alcanzado por las actividades astronómicas en esta parte del mundo y, por este motivo, y aunque la ciencia no tiene fronteras, creemos que será necesario hablar de la astronomía latinoamericana, y no de una astronomía de cada país en particular, cuando se consideren en el futuro los avances de nuestra Ciencia.

Estimados colegas, espero que disfruten de una provechosas reuniones científicas y de una agradable estadía en tierras chilenas.

Opening words

by

Prof. A. Blaauw

President of the International Astronomical Union

Ladies and gentlemen, dear Professors Anguita and Moreno,

It is a great pleasure indeed for me to be able to attend this meeting and to renew the acquaintance with the Chilean astronomical community with whom I have had so many contacts during the past ten years.

I wish to use this opportunity to express to you the deep interest which the IAU takes in this event. The idea of having regional IAU meetings arose some 6 years ago, when it became more and more apparent that the existing system of meetings, the IAU Symposia and Colloquia, does not sufficiently meet one of the main purposes of the IAU, namely to bring together astronomers from different countries in order that their work may benefit from more personal contacts. It was felt that especially the many younger astronomers who do not yet have access to such meetings, should become more involved. It was therefore proposed to encourage - and to support financially within the IAU's limited financial means - meetings on a regional basis. It should be stressed, however, that the initiative for such meetings must come first of all from the local astronomical community, rather than from the IAU.

The IAU has, so far, promoted several regional meetings, the first three of which were held in Europe (Athens, Triest and Tbilisi). The present meeting in Santiago will be the fourth in the series and it will be the first one outside the European continent. The IAU is very grateful for this Chilean initiative and wishes you all a pleasant conference and profitable discussions.

PRIMERA PARTE
ASTRONOMIA EXTRAGALACTICA

LA ESCALA DE DISTANCIAS EXTRAGALACTICAS EN EL HEMISFERIO SUR

Discurso Invitado

J.L. Sérsic

Observatorio Astronómico, Córdoba
CONICET*, Buenos Aires

I. INTRODUCCION

Aunque resulta a todas luces evidente que el problema de la escala de distancias extragaláctica es uno solo, independiente de la posición geográfica del observador, no es menos cierto que el desarrollo económico y social de la humanidad ha privilegiado hasta el presente la astronomía del hemisferio boreal. Esta asimetría se marca particularmente en el campo extragaláctico, pues requiere telescopios de grandes dimensiones, existentes sólo en latitudes superiores a los 30° hasta hace sólo muy pocos años.

El advenimiento de grandes instrumentos - adecuados para estudiar el universo en profundidad - en Chile y Australia, tardará aún unos años en cerrar la brecha en nuestro conocimiento de las galaxias australes hasta equiparlo al que ya se tiene en el hemisferio norte. Ello se debe por una parte, a que la mera información básica surge de placas de gran resolución que, para ser recabadas en número y calidad adecuados para las 281 galaxias del catálogo Shapley-Ames situadas al sur de -30° de declinación, tomará aún algunos años, aunque el ESO/SRC Southern Sky Survey constituye un progreso muy significativo en esa dirección. Por otra parte, no todo el tiempo disponible en los grandes telescopios puede usarse para estos fines.

A manera de compensación, la presencia de las Nubes de Magallanes en declinaciones inadecuadas para su observación desde el hemisferio norte y su condición de galaxias un orden de magnitud más próximas que M31, signó las investigaciones extragalácticas en el sur; tanto en el Africa y la América Meridionales como en Australia, los observatorios locales y las estaciones dependientes de observatorios boreales desarrollaron programas de estudio del contenido estelar e interestelar de estos sistemas en considerable detalle. A este efecto - como consecuencia de su proximidad - sólo necesitaron telescopios pequeños o medianos, en relación con los patrones contemporáneos.

Pero la gran mayoría de las galaxias australes permanecía ignorada y de ellas sólo se contaba con las descripciones de los Herschel condensadas en el New General Catalogue y la información

* Bajo contrato N°169.

Lo demás es historia reciente: ella se ha desarrollado con diversos grados de continuidad e intensidad en Australia, la República Sudafricana y Argentina, llenando así los dos decenios que transcurrieron hasta la puesta en operación del primero de los grandes telescopios del sur.

Existen, empero, también razones naturales de asimetría entre ambos hemisferios celestes. Dado que el centro del sistema supergaláctico local (de Vacouleurs, 1956) se halla en el Cúmulo de Virgo y éste a su vez se encuentra en las vecindades del polo galáctico norte, el hemisferio sur se halla orientado principalmente hacia el "anti-centro" del sistema super-galáctico. Este hecho, conocido de antaño, se traduce en una escasez de grupos de galaxias brillantes con distancias no superiores a la decena de megaparsec, como se puede observar en la figura 1. Hasta distancias de este orden es posible usar confiadamente indicadores secundarios (estrellas más brillantes, regiones HII) con telescopios de más de dos metros de apertura, hasta hace muy poco inexistentes en estas latitudes.

TABLA I
 Grupos de galaxias más cercanos que 10 Mpc

32

$\Delta \leq 10 \text{ Mpc}$

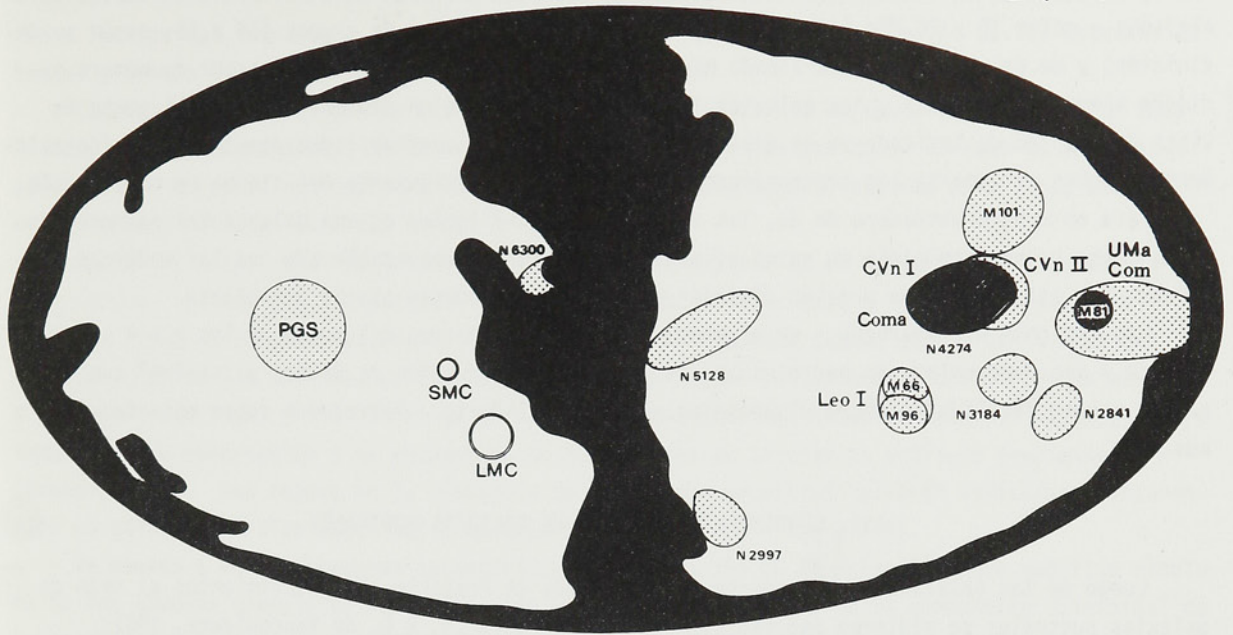


Fig. 1. Grupos de galaxias más cercanos que 10 Mpc. A la izquierda el Hemisferio Galáctico Sur y a la derecha el Hemisferio Galáctico Norte (adaptado de de Vaucouleurs, 1975).

$10 \text{ Mpc} < \Delta \leq 17 \text{ Mpc}$

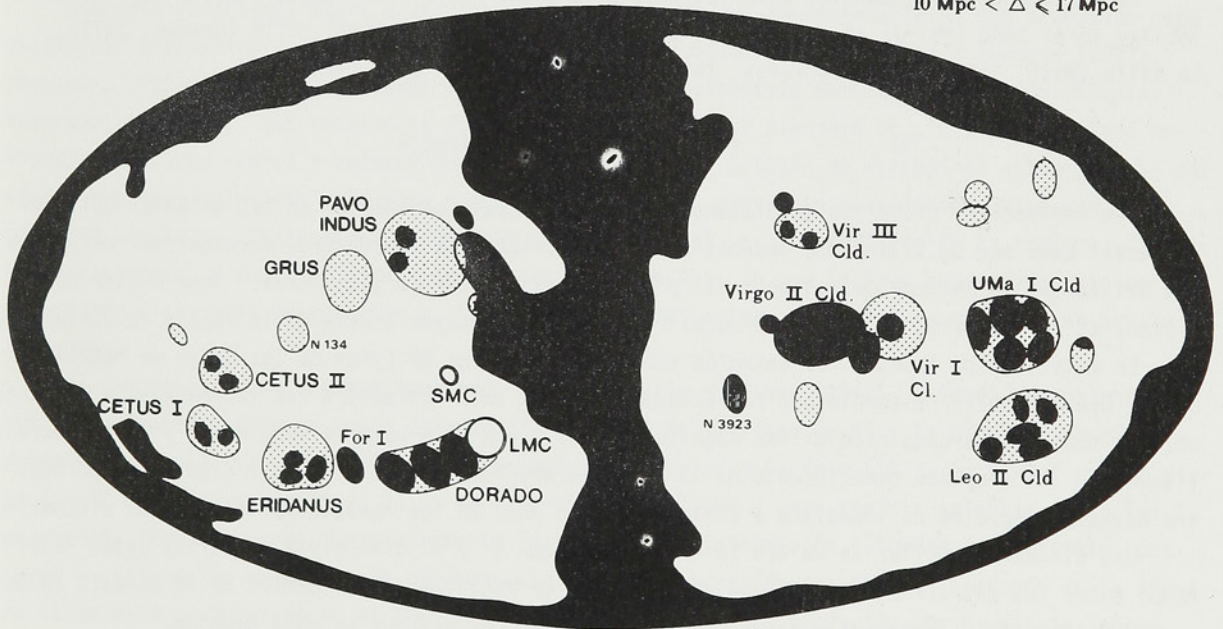


Fig. 2. Grupos de galaxias con distancias comprendidas entre 10 y 17 Mpc.

Esta situación un tanto desalentadora cambia drásticamente cuando consideramos los grupos más alejados - entre 10 y 20 MPc (figura 2). Si bien el mayor número de grupos (12 a 15, según su definición) y de galaxias continúa siendo mayor en declinaciones boreales, en el sur su número asciende ahora a una decena y las galaxias involucradas a más de un centenar. Desde el punto de vista del empleo de indicadores de distancia secundarios, su confiabilidad desciende considerablemente y deben extremarse las precauciones, con un aumento consiguiente del tiempo de observación.

Para un módulo verdadero de 31, las estrellas más brillantes en una galaxia ScI aparecen en $B=22$: y una buena fotometría en estos niveles es una empresa respetable aún con las modernas técnicas. Por otra parte, es preciso disponer previamente de buenas placas del objeto.

Las regiones HII aparecen - en el mismo caso - con diámetros del orden de los 3 a 4 segundos de arco y son razonablemente medibles con la excelente combinación de óptica y "seeing" que se da en las nuevas facilidades ahora disponibles en este hemisferio. Volveremos sobre este tema más adelante.

III. CORRIMIENTOS AL ROJO DE GALAXIAS AUSTRALES

Luego de las observaciones pioneras de D.S. Evans en Pretoria, los corrimientos al rojo de galaxias australes se midieron esporádicamente en Australia (A. y G. de Vaucouleurs, 1961; Shobbrook, 1966), Sudáfrica (Evans, 1963) y Córdoba (T.L. Page, 1967, Carranza, 1966; A. y G. de Vaucouleurs, 1973; Sérsic y Agüero, 1972), sea para fines específicos o para programas de exploración.

Se debe, sin embargo, a A.R. Sandage la culminación del programa iniciado en 1935 por Humason y Mayall, consistente en medir los corrimientos al rojo de las 1200 galaxias contenidas en el catálogo de Shapley y Ames. Durante tres temporadas observacionales (1969, 1971 y 1975) Sandage observó en Mt. Stromlo de esas galaxias aquellas situadas al sur de la declinación -30° y actualmente prepara, juntamente con G. Tammann, un catálogo de la lista de Shapley-Ames (Sandage, 1975; Babcock, 1976).

Paralelamente continúan las observaciones orientadas hacia fines específicos y objetos más débiles en el SAAO (Martin et al., 1976), Córdoba (Sérsic et al., 1978), CTIO (Graham, 1977), La Silla (West, 1976), Calán (Pedreros, 1977) y el AAO (Dawe et al., 1977).

IV. INDICADORES DE DISTANCIA

Los indicadores primarios de distancia juegan un papel fundamental en las galaxias del Grupo Local, pues por su intermedio podemos calibrar entonces los indicadores secundarios: estrellas más brillantes, diámetros de regiones HII y magnitudes de cúmulos globulares. Toda mejora de las distancias de las galaxias del Grupo Local redundará en un mayor ajuste de la escala de distancias.

En este sentido apuntan los estudios sobre las estrellas RR Lyrae de las Nubes de Magallanes que J. Graham (1977) ha completado recientemente. Este autor encuentra que la frecuencia de estos objetos tiene un marcado pico en las magnitudes $B=20.0$ y $B=19.6$ para la Nube Menor y Mayor respectivamente. Un adecuado conocimiento de la magnitud absoluta de estrellas del mismo tipo en nuestra Galaxia conducirá de inmediato a estimas de gran peso de los respectivos módulos de distancia.

Una situación similar se da con la comparación que V. y B. Blanco y M. McCarthy están realizando entre las estrellas M de Carbono en las Nubes de Magallanes y el centro de la Galaxia (Blanco y McCarthy, 1976) como nos enteraremos dentro de algunos minutos en esta Reunión.

Un mejor conocimiento de las distancias de las galaxias enanas del Grupo Local permitirá estimar mejor sus magnitudes absolutas y la de los cúmulos globulares que ellas contienen, lo que

a su vez perfecciona la relación entre esos dos parámetros para una muestra de galaxias de diferente luminosidad intrínseca (de Vaucouleurs, 1977a). De aquí la importancia de los estudios de Kunkel y Demers (1976) sobre el sistema enano de Fornax.

También debemos a J. Graham (1977) la búsqueda y seguimiento de novas en las Nubes de Magallanes. Dicho programa reditúa en media un par de esos eventos por año. Al cabo de un período adecuado, el material reunido será de gran importancia para mejorar estimas anteriores basadas en muy escaso material (van den Bergh, 1977).

Fuera del Grupo Local de galaxias, el sistema más próximo es el Grupo del Polo Galáctico Sur o de Fornax. Su distancia - estimada hasta el presente sólo en base a indicadores secundarios (Sérsic, 1960; de Vaucouleurs, 1975) será mejorada sensiblemente cuando puedan ser discutidas las observaciones de las cefeidas en NGC 55 y NGC 300 realizadas conjuntamente por J. Graham en CTIO, B. Madore (Cambridge) y M.G. Smith en el AAO. Estos autores han obtenido material durante cuatro temporadas de observación y se encuentran en condiciones de iniciar un análisis preliminar (Graham, 1977). Una mejora en la distancia de este grupo permitirá calibrar indicadores secundarios en galaxias tardías (Sc, Scd) y de baja luminosidad ($L_c = 3.5$ a 4.5).

En cuanto a los indicadores secundarios, la calibración de la relación entre magnitud absoluta de los cúmulos globulares más brillantes y la magnitud absoluta de la componente esferoidal de la galaxia respectiva, ha permitido a de Vaucouleurs (1977a) estimar las distancias de algunos cúmulos de galaxias australes: Fornax e Hydra. Por otra parte, el material que se acumule sobre NGC 55 y NGC 300 para el estudio de las cefeidas, permitirá también calibrar las estrellas más brillantes azules y rojas, una vez que se disponga de una secuencia fotoeléctrica adecuada (M.G. Smith, 1977).

Entre los indicadores terciarios, los diámetros y magnitudes totales reducidos a condiciones standard, éstos distan mucho de ser satisfactorios en el hemisferio sur. La reciente publicación de de Vaucouleurs y Corwin (1977) es elocuente al respecto. El grupo liderado por J. Pacheco en Sao Paulo ha iniciado un encomiable y laborioso proyecto de fotometría superficial UBV de grandes galaxias australes, desde su estación en Valinhos con el telescopio de 0.6m.

Restaría referirnos ahora a dos importantes técnicas que recientemente se han propuesto para determinar distancias de galaxias. Me refiero a los trabajos de Visvanathan y Sandage (1977), (Babcock, 1976) en Australia, donde han completado una fotometría multicolor para 405 galaxias tempranas (E a Sa). Los resultados finales son: una magnitud standard V_{26} , tipo morfológico revisado, velocidad radial y colores medios u-V, b-V y V-r. Después de corregirse estos colores por efecto K y enrojecimiento galáctico, se ha encontrado una excelente correlación entre u-V y la magnitud absoluta. Dicha correlación parece ser universal, e independiente de la riqueza, del tipo Bautz-Morgan, y de la distancia de los grupos y cúmulos, lo que la hace muy conveniente para determinar distancias de galaxias E, SO directamente del color ultravioleta medido y el brillo aparente.

La segunda técnica que mencionáramos es la de Tully y Fisher (1977), quienes encuentran una buena correlación entre el ancho del perfil integrado de la línea de HI y la magnitud absoluta y diámetros de galaxias. Recientes observaciones de Whiteoak y Gardner (1977) en Parkes con el disco de 64m nos dan los datos de 21 cm necesarios para aplicar a unas treinta galaxias australes la mencionada técnica, pero, lamentablemente la carencia de información fotométrica confiable, posterga su aplicación precisa. Un programa similar de observación del perfil integrado de la línea de 21 cm está en progreso en el IAR, cerca de Buenos Aires y es conducido por E. Bajaja, quien reportará sus resultados en esta conferencia. Dado que los discos del IAR son de 30m, el haz de antena (30') resulta más conveniente para varios objetos de grandes dimensiones angulares que escapan al disco de Parkes.

V. LOS DIÁMETROS DE LAS REGIONES HII

Las regiones HII y el problema de la medición de sus diámetros ha sido considerablemente debatido en años recientes, particularmente después de la aparición del primer trabajo de Sandage y Tammann (1974-I) de la serie titulada "Steps toward the Hubble Constant".

Las siguientes son las dificultades apuntadas por diversos astrónomos, como inherentes a la medición de diámetros de regiones HII en galaxias y su empleo como indicadores de distancia:

- a- Ambigüedad en la definición de una región HII: La multiplicidad jerárquica de estos objetos presenta dificultades para definir lo que entendemos por una región HII (Hodge, 1976). Algunas galaxias presentan este fenómeno en mayor grado que otras. Típico es el caso de NGC 5236 (M83) mencionado tanto por G. Carranza (1968) cuanto por M.G. Smith (1977) en este sentido.
- b- El extremo superior de la función de frecuencia de diámetros está pobremente definido. No debería usarse el promedio de los tres mayores sino sólo el tercer diámetro (Abell, 1977).
- c- En las placas en H-alfa las regiones HII muestran contornos débiles, mal definidos. Para evitar esta dificultad y, a la vez, conservar en parte el mayor poder de detección de esas placas, Sandage y Tammann optaron por introducir los conceptos de diámetros de "core" y "halo" promediándolos. Esto originó críticas de G. de Vaucouleurs (1977b) en razón del comportamiento fotométrico no lineal de los dos niveles de densidad, y por otra parte, restó alcance en distancia a un esfuerzo que aspiraba llegar más lejos que con placas azules ordinarias.
- d- Errores accidentales de medición. M. Smith (1977) encuentra dificultades para reproducir los diámetros medidos en NGC 604 por Sandage en placas ad-hoc, tomadas con el telescopio de 4m de CTIO. Sobre una muestra de 27 galaxias P. Hodge (1976) también halla errores accidentales, pero arriba a la conclusión de que en promedio está midiendo la misma cosa. Dado que este autor no menciona corrección alguna por dispersión atmosférica e instrumental, es difícil asignar una justa medida a sus resultados.
- e- Errores sistemáticos, dependientes de la distancia. P. Hodge (1976) menciona la posibilidad de un error sistemático, dependiente de la distancia, en el sentido de que sus mediciones son comparativamente mayores que las de Sandage, para objetos más lejanos. Este es, precisamente, el efecto que deberíamos esperar si los diámetros no han sido corregidos por dispersión atmosférica e instrumental. Otro efecto sistemático (Sérsic, 1978) dependiente de la escala, será presentado más adelante.

En el año 1959, este autor tuvo la oportunidad de inspeccionar la Hubble Plate Collection en los Observatorios Hale. Como resultado de ello - y continuando una investigación preliminar hecha en Córdoba (Sérsic, 1959) - logró medir diámetros de los tres mayores complejos de emisión en un total de 130 galaxias. Posteriores mediciones en placas de Córdoba y nuevas placas en la ya mencionada colección, en 1966, han llevado el material a un total de ciento cincuenta galaxias. Del material original de 1959, se usaron sesenta galaxias (y el Grupo Local) para definir un sistema de módulos de distancia para 10 grupos y estimar la constante de Hubble (Sérsic, 1960). Se propuso también en esa ocasión, la existencia de una correlación entre los diámetros absolutos logarítmicos Q y los tipos morfológicos T de las galaxias.

En el lapso transcurrido entre 1959 y el presente se han definido nuevos grupos de galaxias en ambos hemisferios (de Vaucouleurs, 1975; Sandage y Tammann, 1975-V), se incrementó considera-

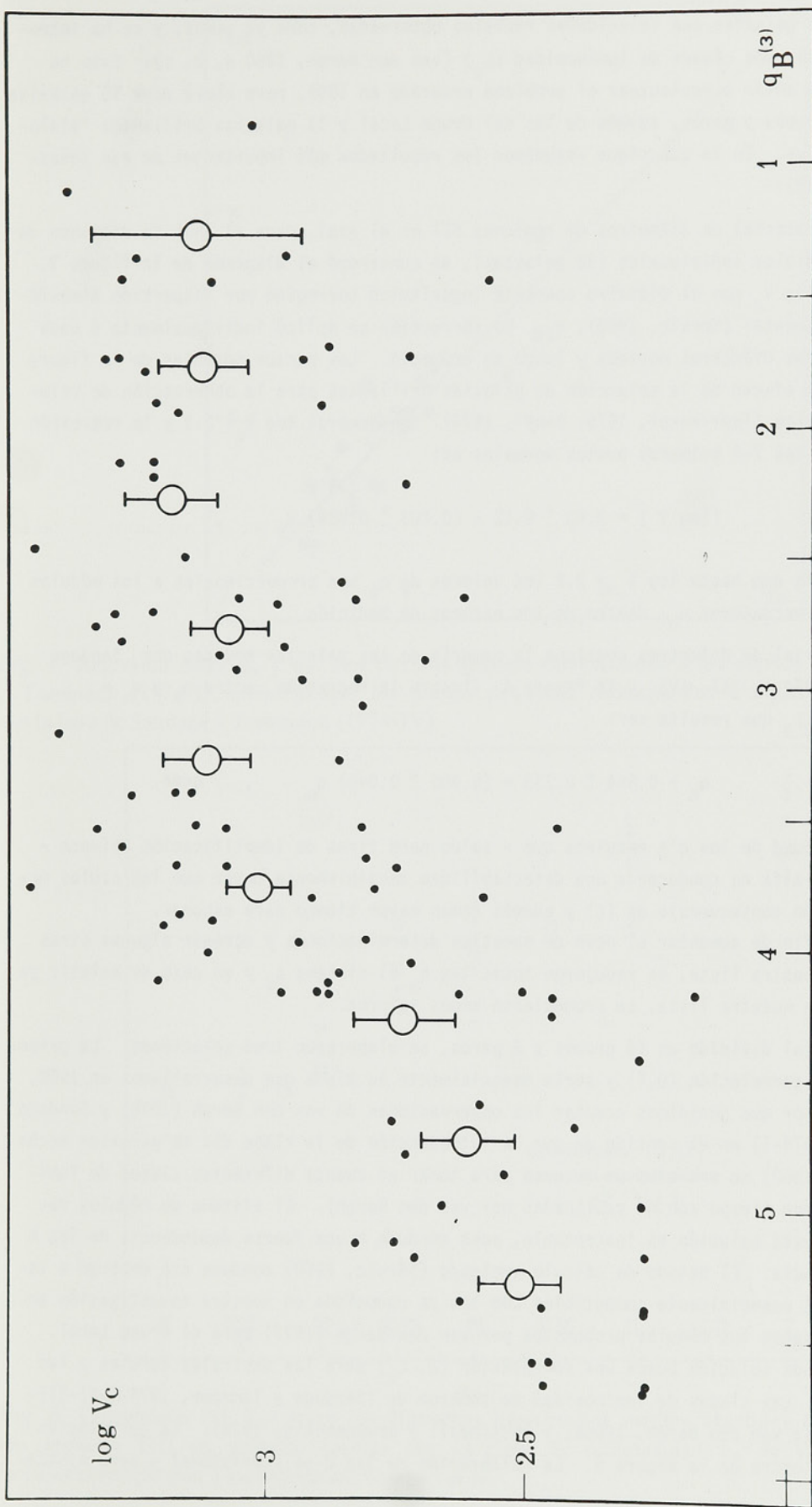


Fig. 3. Diagrama $\log V_c$ - $q_B^{(3)}$, construido para galaxias individuales. Los círculos y las barras corresponden a puntos normales y las dispersiones respectivamente.

blemente el número de galaxias con velocidades radiales observadas, como ya vimos, y se ha introducido la clasificación por clases de luminosidad (L_c) (van den Bergh, 1960 a, b, c). Esto ha conducido al presente autor a replantear el problema encarado en 1959, pero ahora para 98 galaxias distribuidas en 21 grupos y pares, además de las del Grupo Local y 11 galaxias brillantes "aisladas" del hemisferio sur. En lo que sigue resumimos los resultados más importantes de esa investigación (Sérsic, 1978):

- i- con todo el material de diámetros de regiones HII en el azul, para el cual se disponen velocidades radiales individuales (92 galaxias), se construyó el diagrama de la figura 3, que vincula $\log V_c$ con el diámetro aparente logarítmico corregido por dispersión atmosférica e instrumental (Sérsic, 1960), q_B . La corrección se aplicó individualmente a cada uno de los tres diámetros medidos y luego se promedió. Los puntos normales de la figura 3 muestran el efecto de la selección de galaxias brillantes para la observación de velocidades radiales (Teerikorpi, 1975; Bahýl, 1974). En general $\log V_c < 3.3$ y la regresión definida por los 7-8 primeros puntos normales es:

$$(\log V) = 3.63 \pm 0.12 - (0.203 \pm 0.028) q_B,$$

lo que sugiere que hasta $\log V_c \approx 3.2$ los valores de q_B son proporcionales a los módulos de distancia verdaderos μ_0 , dentro de los errores de medición.

- ii- Nuestro material de diámetros contiene la mayoría de las galaxias medidas por Sandage y Tammann (1974-I, III, IV) y la figura 4 ilustra la regresión entre q_B y $q_\alpha = 5 \log (\theta_H, \theta_C)_3$ que resulta ser:

$$q_B = 0.564 \pm 0.233 + (0.906 \pm 0.045) q_\alpha, \quad N=44.$$

La casi igualdad de los q 's requiere que - salvo para fines de identificación unívoca - las placas H-alfa no conducen a una detectabilidad sensiblemente mayor que las azules ordinarias, como consecuencia de (c) y además toman mayor tiempo para exponer.

Con el fin de aumentar el peso de nuestras determinaciones y agregar algunas otras galaxias a nuestra lista, se redujeron todas las q_α al sistema q_B y en caso de existir ya mediciones de nuestra lista, se promediaron ambos valores.

- iii- Con el material dividido en 19 grupos y 2 pares, se elaboraron tres soluciones. La primera buscó una correlación (Q, T) y sería esencialmente la misma que desarrollamos en 1960, si no fuera por que decidimos aceptar las observaciones de van den Bergh (1975) y Sandage y Tammann (1974-I) en el sentido de que la introducción de la clase dSc de galaxias hecha en (Sérsic, 1960) no era sino un recurso para tomar en cuenta diferentes clases de luminosidad (en ese tiempo aún no publicadas por van den Bergh). El sistema de módulos resultante de esta solución es inaceptable, pues conduce a una fuerte dependencia de $\log H$ con la distancia. El método de cálculo empleado (Sérsic, 1960) conduce sin embargo a valores de $Q(T)$ esencialmente compatibles con los ya conocidos en nuestra investigación anterior, si usamos los módulos propuestos por van den Bergh (1977) para el Grupo Local.
- La segunda solución busca una correlación (Q, L_c) para las espirales tardías y las irregulares. Las clases de luminosidad se tomaron de (Sandage y Tammann, 1974-I-II-III-IV; 1975-V-VI; van den Bergh, 1960a; y Bottinelli y Gouguenheim, 1976). La correlación hallada se ilustra en la figura 5. La calibración de las Q es provisional y será ajusta-

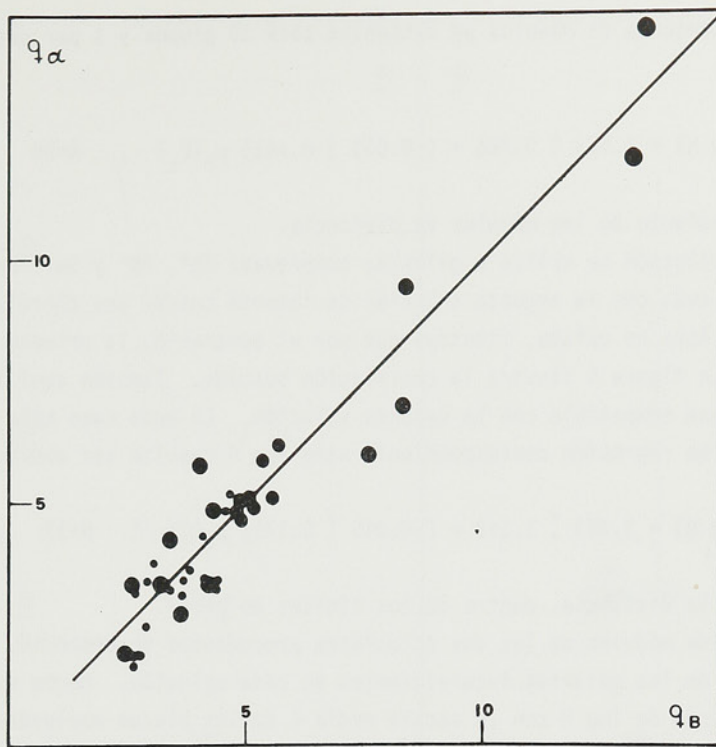


Fig. 4. Regresión entre q_α y q_B . Los círculos gruesos corresponden a los objetos listados en Sandage y Tammann (1974-I), mientras que los puntos pequeños corresponden a aquellos objetos comunes con la lista de Sandage y Tammann (1974-IV).

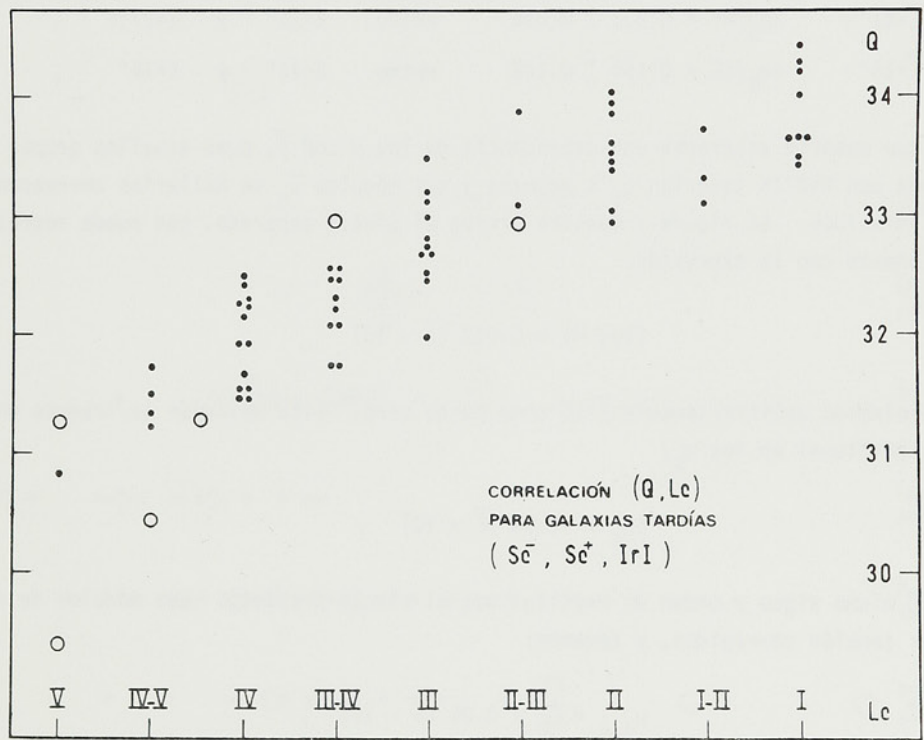


Fig. 5. Correlación (Q, L_c) entre los diámetros logarítmicos medios absolutos Q de las tres mayores regiones HII en galaxias tardías con la clase de luminosidad L_c de van den Bergh. Los círculos corresponden a los objetos del Grupo Local.

da en (iv). El conjunto de módulos de distancia para 19 grupos y 1 par satisface la regresión:

$$(\log H) = 2.323 \pm 0.796 + (-0.011 \pm 0.141) \mu_0(L_c) , \quad N=20 ,$$

es decir, independiente de los módulos de distancia.

La tercera solución se aplica a galaxias tempranas: Sb⁺, Sb⁻ y Sa. La razón de este procedimiento es que, con la segunda solución se intentó buscar una correlación (Q, L_c) para dichos objetos y ésta no existe, mientras que por el contrario, la primera solución sí la muestra con T. La figura 6 ilustra la correlación buscada. También aquí la calibración es provisional, aunque compatible con la segunda solución. En este caso sólo se dispuso de 17 grupos y pares. La regresión correspondiente para log H resulta ser ahora:

$$(\log H) = 3.323 \pm 1.143 + (-0.045 \pm 0.176) \mu_0(T) , \quad N=17 ,$$

independiente de la distancia, dentro de los límites de error.

El material de módulos de las dos soluciones precedentes se promedió, pesando cada módulo con el número de las galaxias intervinientes en cada solución. Hecho esto, se buscó una eventual dependencia de log H con la escala media E de las placas empleadas en cada grupo. La razón de ello surge de la observación de nuestro material de diámetros. Existen varios objetos medidos simultáneamente en placas de diferentes escalas (PH=11"05; H=16"0; S=Sc=27"5). Del material disponible se dedujo:

$$\begin{aligned} \bar{E}=21'' : \quad \delta q_B / \delta E &= 0.071 \pm 0.016 & \text{entre } E=16'' \text{ y } E=27''5 , \\ \bar{E}=14'' : \quad \delta q_B / \delta E &= 0.150 \pm 0.148 & \text{entre } E=11'' \text{ y } E=16'' , \end{aligned}$$

de modo que debería esperarse una dependencia de log H con $\bar{E}$, pues aquellos grupos medidos en Córdoba con E=27"5 tendrían q_B's mayores y sus módulos $\bar{\mu}_0$ se hallarían correspondientemente disminuidos. La figura 7 muestra arriba el efecto esperado, que puede representarse razonablemente con la expresión:

$$(\log H) = 0.012 (\bar{E} - 10) ,$$

habiendo elegido arbitrariamente $\bar{E}=10$ como punto cero. Esta relación se traduce en una corrección adicional en los q_B,

$$\delta q_B = -0.06 (\bar{E} - 10) ,$$

que es del mismo signo y orden de magnitud que el efecto previsto. Los módulos de distancia deben ser también corregidos, y tenemos:

$$\mu_{0,c} = \bar{\mu}_0 + 0.06 (\bar{E} - 10) ,$$

con lo que arribamos a la Tabla II que resume la solución final pero con la calibración provisional. La primera columna identifica el grupo de galaxias, la segunda nos da el módulo verdadero, la tercera la correspondiente distancia en Mpc, luego la velocidad media del gru-

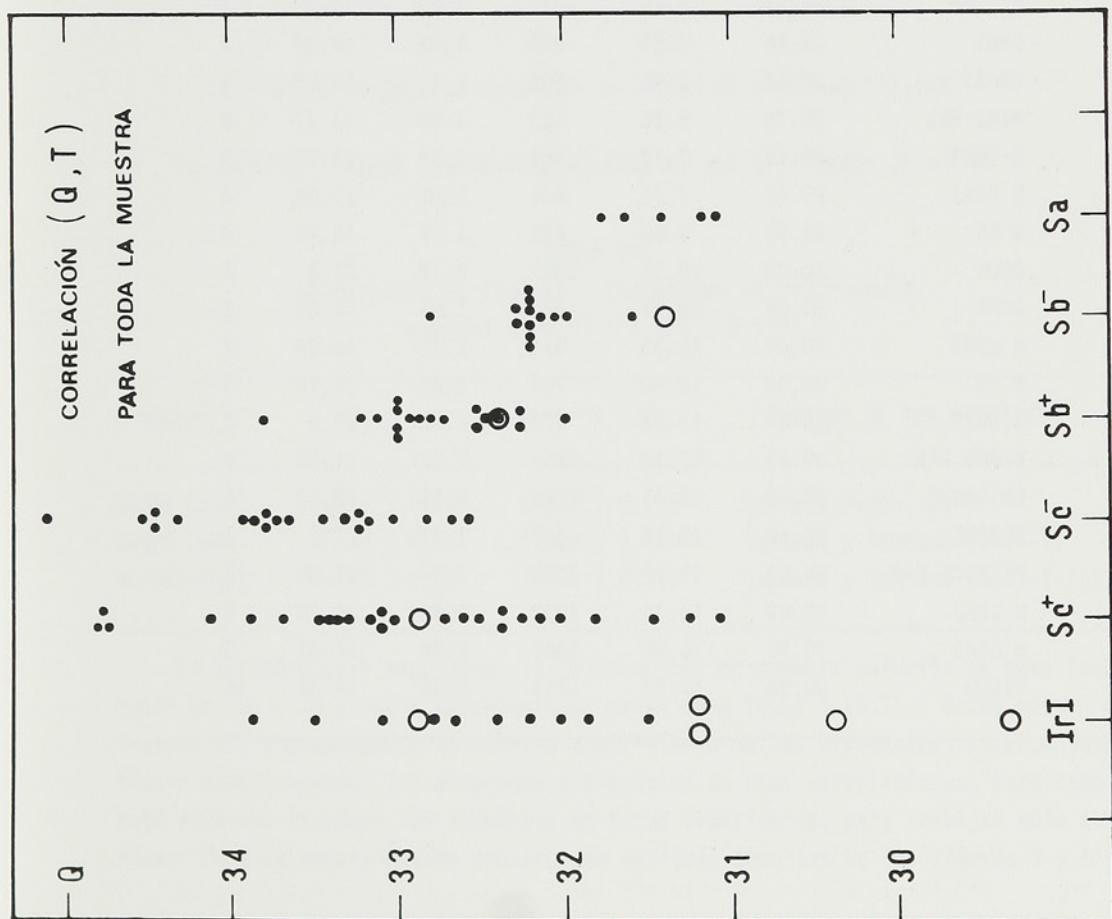


Fig. 6. Correlación (Q, T) basada en la tercera solución, para galaxias tempranas, pero extendida a toda la muestra. Obsérvese la gran dispersión de Q para las galaxias tardías.

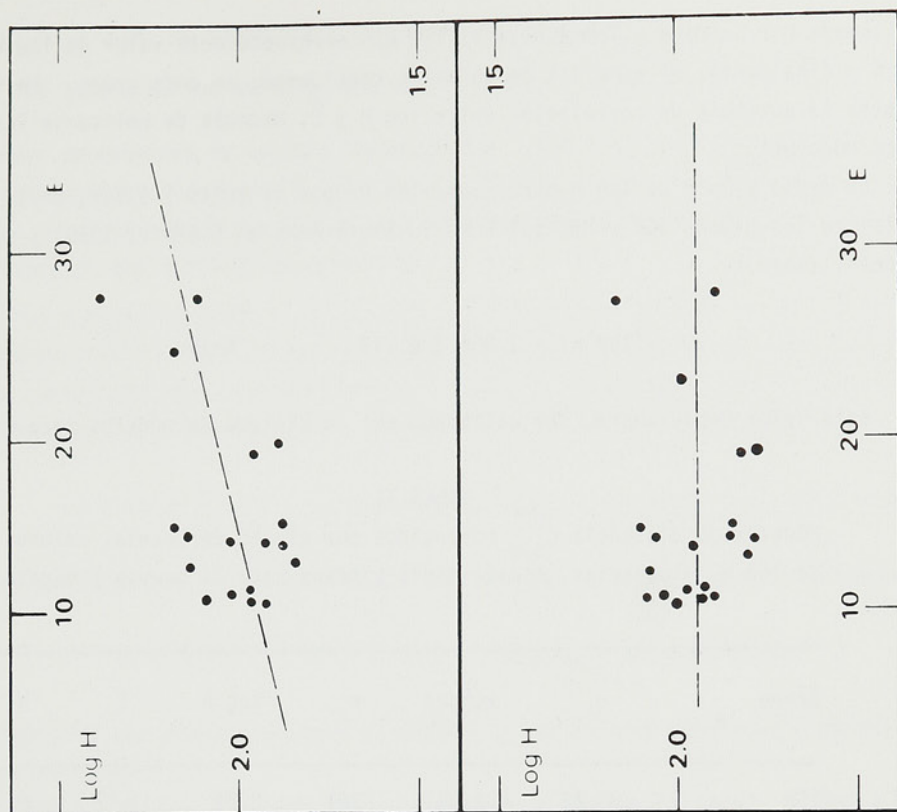


Fig. 7. Correlación entre $\log H$ y la escala media E para cada grupo, antes y después de aplicarse la corrección discutida en el texto.

po (tomada por Sandage y Tammann-V; VIII), el correspondiente valor de $\log H$, la escala media E y finalmente, el número N de galaxias considerado en cada grupo. La figura 7, abajo, muestra la ausencia de correlación entre $\log H$ y $\bar{E}$, después de aplicarse las correcciones a los módulos $\bar{\mu}_0$.

La media simple de $\log H$ para todos los grupos es 1.949 ± 0.118 , $N=21$; si en cambio excluimos los grupos SGP y M81 tal como lo hiciéramos en (Sérsic, 1960) y por las mismas razones, tenemos:

$$(\log H) = 1.935 \pm 0.119 \quad , \quad N=19 \quad .$$

Este valor debe, ahora, ser calibrado con un sistema de módulos para el Grupo Local.

TABLA II

Módulos de distancia $\mu_{0,c}$ corregidos por efecto de escala, valores de $\log H$, distancias, escala media y pesos para 21 grupos y pares.

Grupo	$\mu_{0,c}$	$r(\text{Mpc})$	v_c	$\log H$	E	N
PGS	26.86	2.36	281	2.08	11.06	5
M81	27.06	2.58	286	2.04	11.06	7
N 5128	28.34	4.66	317	1.83	19.25	3
CVnI	28.36	4.69	339	1.86	14.02	7
CVnII	28.68	5.45	698	2.11	15.00	5
M101-M51	28.70	5.50	463	1.93	11.77	9
N 1023	29.27	7.14	669	1.97	11.77	9
N 2841	29.44	7.73	601	1.89	11.06	4
M 66	29.93	9.68	592	1.79	13.44	4
GRUS	30.03	10.14	1581	2.19	27.5	4
COMA I	30.06	10.26	922	1.95	14.02	5
N 2997	30.07	10.33	611	1.77	19.28	2
M 96	30.09	10.40	741	1.85	15.12	4
N 3938	30.40	12.02	873	1.83	27.5	1
VIRGO PAR	30.42	12.13	1262	2.02	11.06	2
ERIDANUS	30.48	12.47	1520	2.09	12.30	3
DORADO	30.60	13.18	897	1.83	27.5	3
PEGASUS PAR	30.61	13.24	1160	1.94	11.06	2
N 1068	30.69	13.74	1332	1.99	24.40	2
N 6643	30.95	15.46	1842	2.08	14.35	3
VIRGO	30.98	15.70	1111	1.85	14.02	15

VI. EL VALOR LOCAL DE LA CONSTANTE DE HUBBLE

(o "El jardín de los senderos que se bifurcan", cuento de J.L. Borges).

A los resultados precedentes de nuestra investigación sobre la escala de distancias basada en los diámetros de las regiones HII, medidos sobre placas azules ordinarias, debemos agregar ahora una discusión sobre el punto cero de la escala, que habremos de fijar en base a un sistema determinado de módulos obtenidos con indicadores primarios.

iv- Mediante los módulos verdaderos μ_{LG}^0 de M31, M33, LMC, SMC, NGC 6822 e IC 1613 dados por van den Bergh (1977) y los valores de q_B corregidos por el efecto de escala, podemos computar los correspondientes valores absolutos $Q_B(GL)$ y compararlos con aquellos deducidos de las soluciones segunda y tercera: obtenemos así la siguiente corrección:

$$\delta Q = -0.27 \pm 0.74, \text{ que equivale a tener : } \delta(\log H) = +0.054 \pm 0.148.$$

Realizando lo mismo con los módulos dados por Sandage y Tammann (1974-I) tenemos:

$$\delta Q = +0.04 \pm 0.598, \text{ ó sea : } \delta(\log H) = -0.008 \pm 0.118,$$

lo que significa que nuestro sistema de módulos y los valores absolutos Q coinciden esencialmente con aquel.

Finalmente, fijemos el punto cero recurriendo a los Grupos Local, de M81 y de M101, tal como lo hacen Sandage y Tammann (1974-I-III). En este caso, con los módulos verdaderos de 27.56 y 29.3 para estos dos últimos grupos, se obtiene:

$$\delta Q = 0.55 \pm 0.59, \text{ de modo que : } \delta(\log H) = -0.110 \pm 0.118.$$

La tabla III resume los valores de $(\log H)$ así calibrados (Fig. 8).

TABLA III
Calibración de $(\log H)$ · (Adoptando el valor medio
nominal $(\log H) = 1.935 \pm 0.119$)

Método	δQ	σ	$(\log H)$	σ	Fuentes de los módulos
GRUPO LOCAL	-0.27 ± 0.74		1.989 ± 0.135		van den Bergh, 1977
GRUPO LOCAL	$+0.04 \pm 0.59$		1.927 ± 0.118		Sandage y Tammann (1974-I)
GL+M81+M101	$+0.55 \pm 0.59$		1.825 ± 0.118		Sandage y Tammann (1974-I-III)

El procedimiento seguido en la construcción de nuestra solución se basa fundamentalmente en que - de existir correlaciones tales como (Q,L) ó (Q,T) - éstas pueden construirse con independencia de nuestro conocimiento de las distancias, superponiendo (gráfica o numéricamente) los diagramas elementales de esas correlaciones, para cada grupo. Esto requiere expresar los diámetros en forma logarítmica, para trabajar sólo con diferencias. De esta manera pueden construirse gráficas como las de las figuras 5 y 6 sin extra-

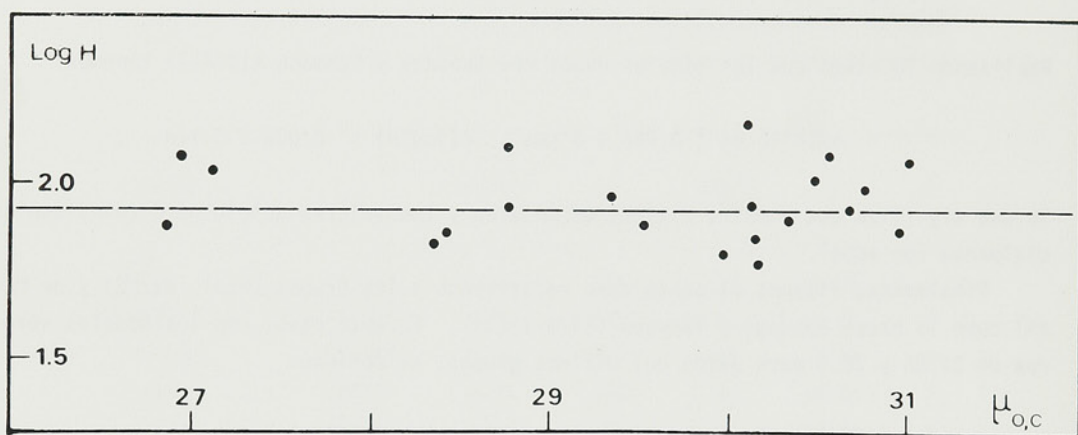


Fig. 8. Valores de $\log H$ en función de los módulos de distancia corregidos para los grupos y pares considerados.

polaciones innecesarias y peligrosas. Nuestra solución - basada en las regiones HII - reitera la ubicación más próxima de los grupos de M81 y M101 y señala a los módulos de estos grupos propuestos por Sandage y Tammann (1974-I-II-III) como los responsables de una sobre-calibración de los diámetros de las regiones HII para las galaxias ScI. Resultados en este sentido (basados en clases de luminosidad) han sido encontrados por Bottinelli y Gouguenheim (1976). Una rediscusión del módulo de NGC 2403 (miembro del grupo de M81) basado en las cefeidas y hecha por B. Madore (1976) también apunta hacia un valor de la distancia del grupo de M81 comparable con el nuestro que, por otra parte, no difiere sensiblemente del tradicionalmente aceptado.

La conclusión que aquí se impone es descartar el último valor de H en la Tabla III y convenir en que el valor local de la constante de Hubble, se halla más cerca de 100 km/s.Mpc que de 50 ó 60 km/s.Mpc. La Tabla IV resume los valores de $Q(L_c)$ y $Q(T)$ para galaxias tardías y tempranas respectivamente, calibradas con los módulos del Grupo Local dados por Sandage y Tammann (1974-I).

TABLA IV
Valores de Q calibrados con los módulos del
Grupo Local de Sandage y Tammann (1974-I)

L_c	$Q(L_c)$	$\pm\sigma$	N	T	$Q(T)$	$\pm\sigma$	N
1.0	34.95	0.36	9	Sb ⁺	32.90	0.79	12
1.5	33.73	0.19	3	Sb ⁻	32.21	0.64	10
2.0	33.53	0.36	10	Sa	31.71	0.23	2
2.5	33.57	0.57	2				
3.0	33.79	0.40	11				
3.5	32.20	0.29	9				
4.0	32.09	0.38	13				
4.5	31.53	0.32	4				
5.0	30.9	-	1				

REFERENCIAS

- Abell, G., 1977, *IAU Colloquium* N°37, 13, Ed. CNRS, París.
- Babcock, H., 1976, *Annual Report 1975-76*, Carnegie Institution Washington, 299.
- Bahýl, V., 1974, *Bull. Astr. Czech.* 25, 115.
- Blanco, V.M., 1976, *Bol. Acad. Nac. Cienc. Cba.* Tomo 52, entr. 1-2.
- Blanco, V.M., McCarthy, M., 1976, *Bol. Acad. Nac. Cienc. Cba.* Tomo 52, entr. 1-2.
- Bottinelli, L., Gouguenheim, L., 1976, *Astron. Astrophys.* 51, 275.
- Carranza, G.J., 1966, *The Observatory*, 87, 38.
- _____ 1968, Tesis. Univ. Nac. Cba.
- Dawe, J., Dickins, R., Peterson, B., 1977, *M.N.R.A.S.* 178, 675.
- de Vaucouleurs, G., 1956, *Mem. Comm. Obs.* N°13.
- _____ 1956, *Vistas in Astronomy* 2, 1584.
- _____ 1975, *Stars and Stellar Systems* 9, Ch. 14.

- _____ 1977a, *Nature* 266, 126.
- _____ 1977b, *IAU Colloquium* N°37, 69. Ed. CNRS, París.
- _____ 1977c, *Ocas. Rep. Edinburgh Obs.* N°2, 50.
- de Vaucouleurs, G., Bollinger, G., 1977, *Ap. J. Suppl.* 33, 247.
- de Vaucouleurs, G., Corwin, H.G., 1977, *Ap. J. Suppl.* 33, 219.
- de Vaucouleurs, G., de Vaucouleurs, A., 1961, *Mem. R.A.S.* 68, 91.
- _____ 1973, *A. J.* 78, 377.
- Evans, D.S., 1963, *M.N.A.S.S.A.* 22, 140.
- Graham, J., 1977, *Comunicación Privada*.
- Hodge, P., 1976, *R.G.O. Bull.* N°182, 170.
- Kunkel, W., Demers, S., 1976, *Bol. Acad. Nac. Cienc. Cba.* Tomo 52, entr. 1 y 2.
- Madore, B., 1976, *M.N.R.A.S.* 177, 215.
- Martin, W., 1976, *M.N.R.A.S.* 175, 633.
- Page, T.L., 1967, *A. J. Abstr.* 72, 821.
- Pedrerros, M., 1978, *P.A.S.P.* en prensa.
- Sandage, A.R., 1975, *Ap. J.* 202, 563.
- Sandage, A.R., Tammann, G., 1974-I, *Ap. J.* 190, 525.
- _____ 1974-II, *Ap. J.* 191, 603.
- _____ 1974-III, *Ap. J.* 194, 223.
- _____ 1974-IV, *Ap. J.* 194, 559.
- _____ 1975-V, *Ap. J.* 196, 313.
- _____ 1975-VI, *Ap. J.* 197, 265.
- _____ 1976-VIII, *Ap. J.* 202, 563.
- Sérsic, J.L., 1959, *The Observatory* 79, 54.
- _____ 1960, *Zeits. für Astrophys.* 50, 168.
- _____ 1978, en preparación.
- Sérsic, J.L., Agüero, E.L., 1972, *Astrophys. and Sp. Science* 19, 387.
- Shobbrook, R.R., 1966, *M.N.R.A.S.* 131, 293.
- Smith, M.G., 1977, *IAU Colloquium* N°37, 75. Ed. CNRS, París.
- Teerikorpi, P., 1975, *The Observatory* 95, 105.
- Tully, R.B., Fisher, J.R., 1977, *Astron. Astrophys.* 54, 661.
- van den Bergh, S., 1960a, *Publ. D.D. Obs.* II, N°6.
- _____ 1960b, *Ap. J.* 131, 215.
- _____ 1960c, *Ap. J.* 131, 558.
- _____ 1975, *Stars and Stellar Systems* IX, Ch. 12.
- _____ 1977, *IAU Colloquium* N°37, 13. Ed. CNRS, París.
- Visvanathan, N., Griersmith, D., 1977, *Astron. Astrophys.* 59, 317.
- Visvanathan, N., Sandage, A.R., 1977, *Ap. J.* 216, 214.
- West, R.M., 1976, *Astron. Astrophys.* 53, 435.
- Whiteoak, J.B., Gardner, F.F., 1977, *Austr. J. Phys.* 30, 187.

DISCUSSION

LASKER.- What do you think of "ring-like" HII regions, e.g., as indicated by Gum and de Vaucouleurs, as a narrower class of nebulae that could be used as distance indicators?

SERSIC.- Los anillos de HII son ideales como indicadores de distancia, pues para ellos no se dan las dificultades de definición y medición que se dan en las regiones HII ordinarias.

Sin embargo, la dificultad es su escasez, y requeriría tiempo hacer una búsqueda de ellos. Es un problema del futuro.

PACHECO.- Pode comentar efeitos de possíveis gradientes de composição química na determinação da escala de distancia de indicadores secundarios, como por exemplo as Cefeidas?

SERSIC.- Creo que los efectos de composición son importantes, pero las dificultades presentes (por ejemplo 50 vs 90) en el valor de H se deben a problemas más gruesos, más conectados con la filosofía con que se lo encara.

CAMPUSANO.- ¿Permite la situación actual de la escala extragaláctica de distancias alguna conclusión sobre la isotropía del parámetro de Hubble?

SERSIC.- No creo que ello sea posible, dada la dispersión de los valores individuales (para cada grupo) (Teerikorpi, 1975, *The Observatory* 95, 105).

A PHOTOGRAPHIC STUDY OF SUPERNOVA REMNANTS
IN THE MAGELLANIC CLOUDS

Barry M. Lasker

Cerro Tololo Inter-American Observatory*

ABSTRACT

An Atlas of supernova remnants in the Magellanic Clouds, was assembled using the prime focus of the 4-m telescope with narrow band interference filters. These photographs, together with various other results, are presented.

Further details of this work may be found in *Bull. Roy. Greenwich Obs.*, N°182, p.185, 1976; and in *Ap. J.* 212, 390, 1977.

DISCUSSION

BLAAUW.- Is it possible to say whether the shapes of the emission features that mark the boundaries of these objects are determined primarily by the inhomogeneities of the surrounding medium or by anisotropies in the ejection process?

LASKER.- Probably both the ambient interstellar matter (ISM) and the blast wave itself share in determining the shape of the supernova remnants (SNRs). A SNR blast will tend to propagate most rapidly into the least dense parts of the ISM, and perhaps the shapes of objects like N86 are so determined. However, in the absence of very strong density fluctuations, a spherical shape is expected.

ALCAINO.- Because of the lack of scale in the plates, which is roughly the size range in parsecs, more than in arc seconds, of the remnants?

LASKER.- Ten to twenty parsecs - plates are from the 4-m prime focus - with a scale of 18 arc second mm^{-1} .

MENDOZA.- ¿Cuáles son las diferencias más notables entre los remanentes de las Nubes y los de la Galaxia?

LASKER.- They are easier to study in the Clouds, of course. That the abundance of the elements like O is lower probably also results in less rapid cooling and thicker cooling zones in the Magellanic Clouds.

* Cerro Tololo Inter-American Observatory, supported by the National Science Foundation under contract N° AST 74-04128.

THE MAGELLANIC STREAM AND ITS ASSOCIATED STELLAR COMPONENT

William E. Kunkel

CNPq-Observatorio Nacional, Rio de Janeiro

Data for the Magellanic Stream are re-examined taking into account the stellar systems lying at galactocentric distances between 25 and 250 kpc. With a confidence of 99 percent the latter are shown to be non-randomly distributed, the deviation being a concentration toward a planar component inclined by some 43 degrees to the equator of the Local Group, and by more than 60 degrees to the Local Supergalaxy. The velocity distribution of members of this planar group show a symmetry typical of debris associated with a disruptive event at the perigalactic passage of a victim moving in elliptical orbit.

These data may be used to constrain the multidimensional character of numerical solutions resulting from computer simulation a la Toomre. Among such constraints are several:

The observed angle between the plane of the Magellanic Stream and the plane formed by the stellar systems (Magellanic Plane Group) of 35.5 degrees is explained by motion perpendicular to the victim's orbit of the bridge and tail material (seen from the Galactic center) as it detaches at perigalacticon. To a first approximation this angle depends on the cosine of the inclination of the victim's spin to the orbit normal, and on the mass ratio of the victim to the perturber (the Galaxy). This ratio is found to be 0.028, consistent with current mass estimates for the LMC (of $6 \times 10^9 M_{\odot}$, McGee and Milton, 1966) and for the Galaxy (of $1.8 \times 10^{11} M_{\odot}$, Thackeray, 1971).

Color-magnitude studies of some of the stellar systems, and the marked difference in composition between the Stream (purely HI) and the Magellanic Clouds (at least 80 percent stars by mass) point to a considerable age for the epoch of the most disruptive perigalactic pass, possibly just less than the age of the globular clusters of the Galactic halo.

The direction of orbital motion is determined in several ways: (1) from the age of the dominant stellar component in an extreme tip portion of the Wing of the Small Magellanic Cloud, (2) from the dominance of HI in the Stream and of stars in the Magellanic Plane Group, and from (3) the uniformity of material (or its lack) in position along the debris orbits.

In contrast to the recent models of Davies and Wright (1977) and of Lin and Lynden-Bell (1977) the model most favored by these arguments places the Magellanic Clouds just past perigalac-

ticon on a third or subsequent orbit. The first encounter producing the most violent disruption (and much of the Magellanic Stream and the Magellanic Plane Group) occurred more than 5×10^9 years ago. This model requires a greater mass for both the LMC and the Galaxy, of about $1.5 \times 10^{10} M_{\odot}$ and $6-7 \times 10^{11} M_{\odot}$, respectively.

REFERENCES

- Davies, R.D., Wright, A.E., 1977, *M.N.R.A.S.* 180, 71.
Lin, D.N.C., Lynden-Bell, D., 1977, *M.N.R.A.S.* 181, 59.
McGee, R.X., Milton, J.A., 1966, *Austr. J. Phys.* 19, 343.
Thackeray, A.D., 1971, in *The Magellanic Clouds*. A.B. Muller, ed. Dordrecht, Reidel, pp 3-8.

DISCUSSION

PACHECO.- Qual a ideia que lhe é desagradavel?

KUNKEL.- Lo encuentro muy desconcertante, pero si se intenta construir un modelo consistente, implica una órbita de las Nubes de Magallanes muy extensa, con un semieje mayor de 125 kpc. Junto con las velocidades de la corriente de Magallanes y las velocidades de las galaxias y cúmulos de Hartwick y Sargent indican una masa de la galaxia bastante elevada, muy en el sentido del trabajo de Einasto y sus colegas.

MORRAS.- El modelo propuesto ¿tiene en cuenta, o explica, los gradientes de velocidades observados en el stream?

KUNKEL.- Hay un acuerdo entre las velocidades y posiciones en el plano orbital. Velocidades elevadas ocurren en los dos brazos de una letra "V", con velocidades bajas en el medio. Las velocidades de la corriente y las de los cúmulos y galaxias esferoidales concuerdan bien, e indican momentos angulares (por unidad de masa) bien parecidos, dentro de un factor de dos - y esto aparece casi independiente del modelo que se propone.

FOTOMETRIA FOTOELÉTRICA DA NEBULOSA 30 DORADUS EM $H\alpha$ E $H\beta$ *

F.M. Strauss e M.A. Braz

Instituto de Física, Universidade Federal do Rio Grande do Sul
Pôrto Alegre

RESUMO

Utilizando o telescópio refletor de 50 cm da UFRGS, equipado com um contador de fótons, foram feitos mapas da região HII 30 Doradus em $H\alpha$ e $H\beta$ com resolução angular de 0.5. A razão entre as intensidades de ambas as linhas em cada ponto é comparada com o valor obtido da teoria de recombinação para calcular os excessos de cor. Assim foi comprovada a existência de um gradiente na absorção visual, a qual cresce de 1 para 2 mag na direção NW-SE. Com os fluxos integrados de $H\alpha$ e $H\beta$ obteve-se $\bar{A}_v = 1.18$ mag, sendo que combinando $H\beta$ com fluxos em microondas resulta $\bar{A}_v = 1.15$ mag.

DISCUSSION

LASKER.- I think the region you have studied may include the non-thermal sources near N157A and N158B; but no optical identifications have been made. This may be attributed to high interstellar absorption; but, according to your results, the reddening here is small; this suggest that the lack of optical identifications for these sources may be due not to absorption but simply to confusion from the adjacent HII regions.

STRAUSS.- El estudio sólo abarca una región de 10' x 10' aproximadamente, y con baja resolución; puede existir absorción alta en algunas partes, que no hemos observado.

* Financiado parcialmente pelas Instituições Brasileiras CNPq e FINEP.

RED GIANTS IN THE GALACTIC BULGE AND THE MAGELLANIC CLOUDS

V.M. Blanco and B. Blanco

Cerro Tololo Inter-American Observatory*

M. McCarthy

Specola Vaticana

ABSTRACT

Near-infrared spectral surveys of selected regions near the galactic center and on both Magellanic Clouds have been carried out at the prime focus of CTIO's 4-meter telescope. The method allows classification of M- and carbon-type giants to near-infrared magnitude 18.5, making it possible to easily survey the space distribution of these stars to apparent distance moduli over 22.5. The survey yields reliable absolute magnitudes for the M giants in the Galactic nucleus and shows the carbon stars are extremely rare in that region. However, in the bars of the two Magellanic Clouds, and especially in that of the SMC, carbon stars are much more numerous than late M-type giants.

DISCUSSION

MENDOZA.- ¿Cuáles son las magnitudes absolutas de las estrellas C?

BLANCO.- En las Nubes la magnitud absoluta de las estrellas C es - 4.6 en el sistema I de Kron, Gascoigne y White.

MENDOZA.- ¿Hay estrellas S en las Nubes?

BLANCO.- Se podrían reconocer las estrellas S con este método, pero no las hemos encontrado hasta la fecha.

WALBORN.- ¿Está bien definido el gradiente de metalicidad en la Nube Mayor desde el centro hacia la periferia?

BLANCO.- Pagel, en el Observatorio de Greenwich, ha estado derivando el gradiente de metalicidad. Sus resultados indican un gradiente similar al de nuestra galaxia. No sé cuán bien fundamentados están estos resultados.

* Cerro Tololo Inter-American Observatory, supported by the National Science Foundation under contract N° AST 74-04128.

EL MEDIO IONIZADO EN ALGUNAS GALAXIAS AUSTRALES

G. Carranza

Observatorio Astronómico, Córdoba
CONICET, Buenos Aires

Desde hace varios años se observa en Córdoba la emisión $H\alpha$ de galaxias australes con instrumentos de alta luminosidad y filtros interferenciales estrechos (8 a 35 Å).

Las características del medio en emisión observado de esta manera en algunas galaxias son las siguientes:

- NGC 55 : Las regiones de emisión son brillantes, grandes y complejas en la mitad precedente, y más débiles y pequeñas en la mitad opuesta. Al mismo tiempo existen sugerencias de que las primeras se hallan algo más al N del cuerpo principal que las mencionadas en último lugar.
- NGC 253 : La imagen $H\alpha$ muestra el comienzo de la estructura espiral, con trazos de absorción nítidos. La forma en que se desarrollan los brazos sugiere un objeto barreado, en coincidencia con la clasificación de de Vaucouleurs (SAB(s)c).
- NGC 300 : Se observa la extensión de los brazos espirales durante casi una vuelta completa, con regiones bastante débiles en las partes más externas. Además, interferogramas de este objeto muestran la existencia de un medio $H\alpha$ general.
- NGC 1313: Las placas $H\alpha$ muestran la asimetría presente en la estructura espiral de esta galaxia, y mediante interferogramas se constata la existencia de un medio $H\alpha$ general y débil.
- NGC 1672: Nuestras observaciones realzan el carácter barreado de su estructura, sugerente de un tipo algo más tardío que el usualmente asignado a este objeto (SA(s)b). Debe notarse un esbozo de brazo que nace en dirección opuesta al menos desarrollado.
- NGC 2997: Debe notarse en esta galaxia el abrupto comienzo de los brazos trazados por las regiones de emisión recién a casi un minuto de su núcleo. Interferométricamente se advierte la existencia de un pronunciado gradiente a lo largo del brazo más austral.
- NGC 4945: Las fotografías $H\alpha$ de esta galaxia recuerdan las de NGC 253 mencionada precedentemente, y sugieren un tipo barreado (SAB) antes que espiral normal (SA) como indicase de Vaucouleurs. Es notable la cadena de regiones HII situada al sp.
- NGC 5236: Brillante galaxia rica en regiones de emisión entre cuyas estructuras se destacan un arco de regiones HII que precede la mitad de la barra, las ramificaciones en ambos brazos y casi normales a la barra, y la nitidez de los arcos más externos de regiones de

emisión ubicados al W de la galaxia. Posee asimismo un campo emisivo general.

NGC 6744: Posee regiones HII pequeñas y numerosas, y las ramificaciones existentes hacen difícil percibir la estructura espiral. La imagen $H\alpha$ es muy parecida a la que se obtiene en banda ancha. Ha sido imposible obtener interferogramas utilizables de esta galaxia.

NGC 7793: Objeto normal de estructura compleja, su imagen $H\alpha$ no permite distinguir las características espirales que se observan en banda ancha, pese a ser rica en regiones de emisión y en un medio emisivo generalizado.

Circinus Galaxy (CG): Las observaciones $H\alpha$ permiten distinguir un núcleo formado por dos regiones de emisión y un brazo no muy largo que se extiende hacia el S, en posición aproximadamente simétrica a la banda oscura que se percibe al N. La imagen conjunta que se obtiene de esos rasgos recuerda a la estructura de NGC 3347 y sugiere para CG un tipo Sb.

Otros objetos observados han sido NGC 2442 (de la cual poco puede decirse por la debilidad de la señal), NGC 5128 (para la cual se determinara el campo de velocidades de las regiones emisoras situadas sobre la banda oscurecedora), NGC 7090 (cuya similitud con NGC 55 se realza en el $H\alpha$) y NGC 7424 (cuyas observaciones son insatisfactorias).

Finalmente debe señalarse la estructura global detectada en las Nubes de Magallanes con instrumentos de campo apropiado a su dimensión angular.

LAS REGIONES HII EN NGC 1566

J.L. Sérsic

Observatorio Astronómico, Córdoba
CONICET*, Buenos Aires

J.H. Calderón

CONICET, Buenos Aires

RESUMEN: En el presente trabajo se sintetizan los resultados de un estudio de la distribución y propiedades de las regiones HII en NGC 1566, basado en un catálogo de próxima publicación.

I. MATERIAL OBSERVACIONAL

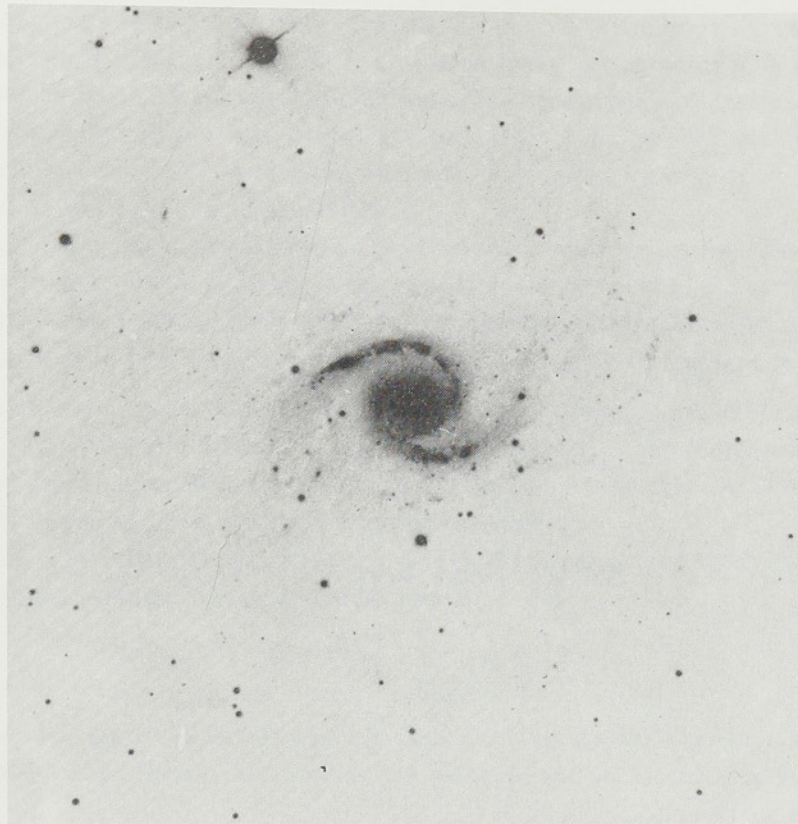
Consiste en un juego de dos placas, una en el continuo y otra sensible a la zona de $H\alpha$, obtenidas por J.L. Sérsic en Febrero de 1976 con la cámara UBK 7 en el foco primario del telescopio de 4 m de CTIO.

Para el continuo se utilizó una placa KODAK IIIa-J con filtro GG 385, con una exposición de 45 minutos. Para las regiones de emisión se combinó una placa KODAK 098-04, horneada en nitrógeno, con un filtro Schott interferencial de banda ancha ($100 \text{ \AA}$) con una exposición de 100 minutos. La escala en placa es $1 \text{ mm} = 18''6$ (Figuras 1a y 1b respectivamente).

II. IDENTIFICACION DE LAS REGIONES HII

La identificación de las regiones HII se realizó por comparación de las placas antes mencionadas en el comparador por parpadeo (Blink) del Observatorio de Córdoba. Por su aspecto se las clasifica en 4 clases, que en el catálogo se indican con los números I a IV respectivamente. Los tipos I a IV representan una escala decreciente de densidades, y por ende contrastes, con respecto al fondo de placa, siendo las de tipo I las de mayor densidad y contraste. Los tipos I y II presentan por lo general bordes bien definidos, no así los tipos III y IV, que presentan un borde más

* Bajo contrato N°169.



b) placa H α .

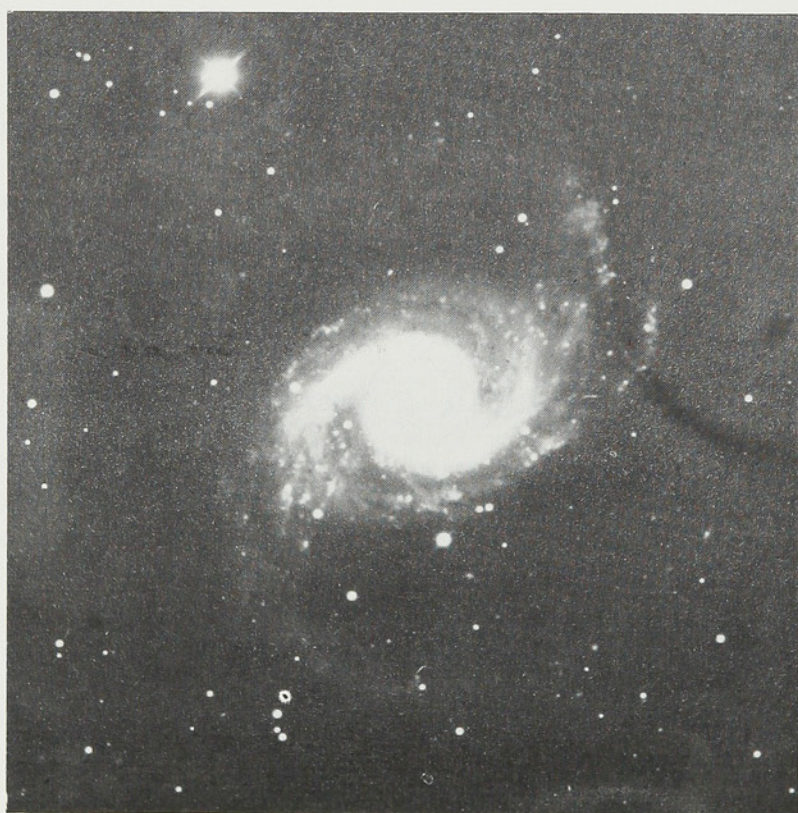


Fig. 1. a) Placa en el continuo;

bien difuso. La tabla que sigue da el número de regiones HII distribuidas por tipos.

Tipo :	I	II	III	IV
N° (HII) :	91	67	35	6

III. DISTRIBUCION ESPACIAL DE LAS REGIONES HII

Mediante la información contenida hemos construido los diagramas de la figura 2. En ellos se ha usado el ángulo de fase θ como abscisa y logaritmo del radio vector R como ordenada. De esta suerte, una espiral logarítmica se representará con una línea recta inclinada en el plano $(\theta, \log R)$.

La distribución de las regiones HII muestra en la figura 2a interesantes regularidades que se asocian íntimamente a las propiedades globales del sistema de regiones HII. En efecto, los rasgos más destacados de la figura 2a lo constituyen las dos secuencias paralelas que hemos denominado Bi y Bii (figura 2b), y la distribución aproximadamente continua que se extiende para todo θ con valores positivos de $\log R$, que hemos denominado zona A.

Otros detalles estructurales más finos lo constituye la secuencia de puntos precedente y paralela a Bi que hemos llamado Ei y la correspondiente secuencia, aunque algo menos marcada, que llamamos Eii. Finalmente existe un conjunto de puntos siguientes a Bii y también paralelo a éste que hemos denominado Eiii.

No solamente se evidencia una segregación puramente espacial en la figura 2a: también se observa una correlación bastante marcada entre las características morfológicas de las regiones HII (tal como se las definió en los tipos I a IV), y su localización en el plano $(\theta, \log R)$. En efecto, las secuencias Bi y Bii se hallan mayoritariamente pobladas por regiones de tipo I, particularmente hacia los valores pequeños de $\log R$. La secuencia Eiii se halla prácticamente en su totalidad poblada por regiones HII pertenecientes al tipo I.

Por el contrario, en la zona A que ocupa los máximos valores de $\log R$, predominan las regiones HII de tipo III y IV.

La interpretación de las secuencias en la figura 2b es inmediata, particularmente si tenemos presente la figura 1. Las secuencias Bi y Bii corresponden a sendas espirales logarítmicas o brazos principales originados en el núcleo del sistema. Por el contrario, las secuencias Ei y Eii corresponden a sendos brazos paralelos a los anteriores y de un brillo superficial inferior. Finalmente la secuencia Eiii de la figura 2b corresponde a una estructura o brazo interior, situado entre Bii y el núcleo, cuyas regiones HII son comparables en brillo superficial y dimensiones a las de los brazos principales.

Finalmente la zona A corresponde a un segundo sistema de brazos que contempla casi totalmente una estructura anular en torno al objeto.

IV. RECuento DE REGIONES HII

En un primer análisis consideramos las regiones HII como elementos individuales indistinguibles, es decir, sin tomar en cuenta características que pudieran diferenciarlas. Se realizaron entonces recuentos en anillos circulares, centrados en el núcleo, del mismo espesor, y con radios crecientes. La figura 3 ilustra el histograma resultante. En éste se insinúa el carácter bimodal de la distribución, ya que se observan dos máximos, en $R \approx 1'$ correspondiente al subsistema

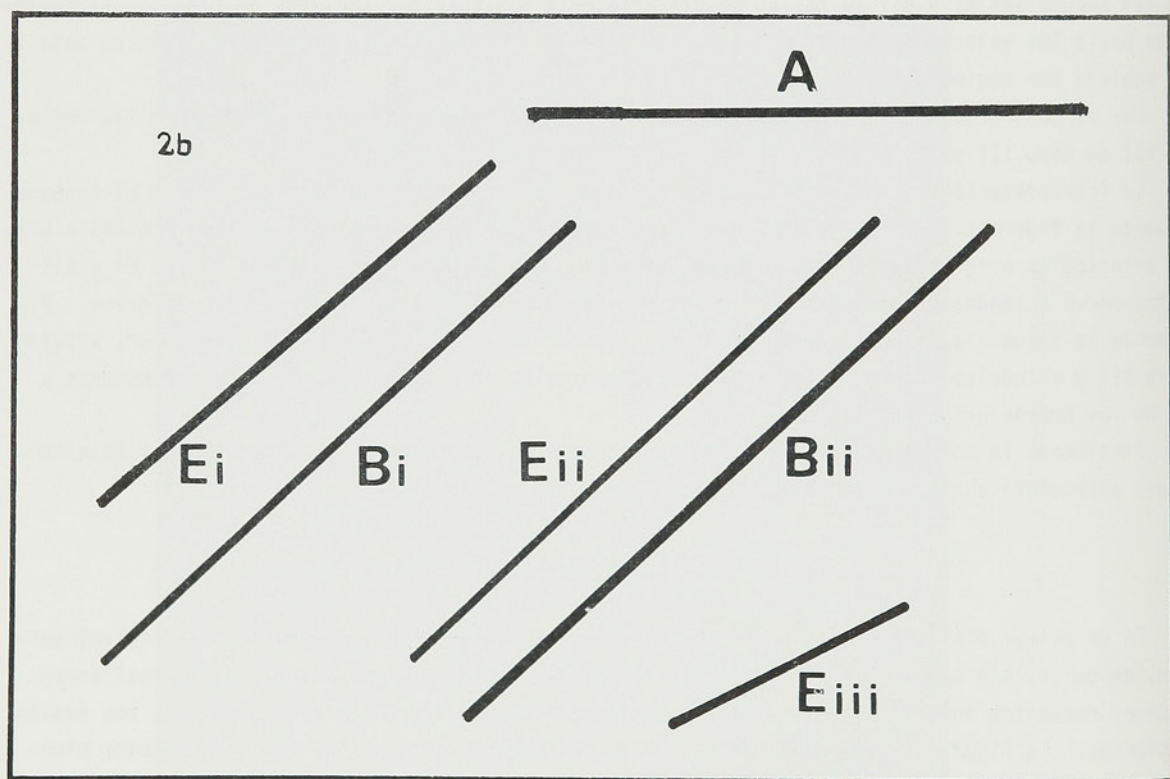
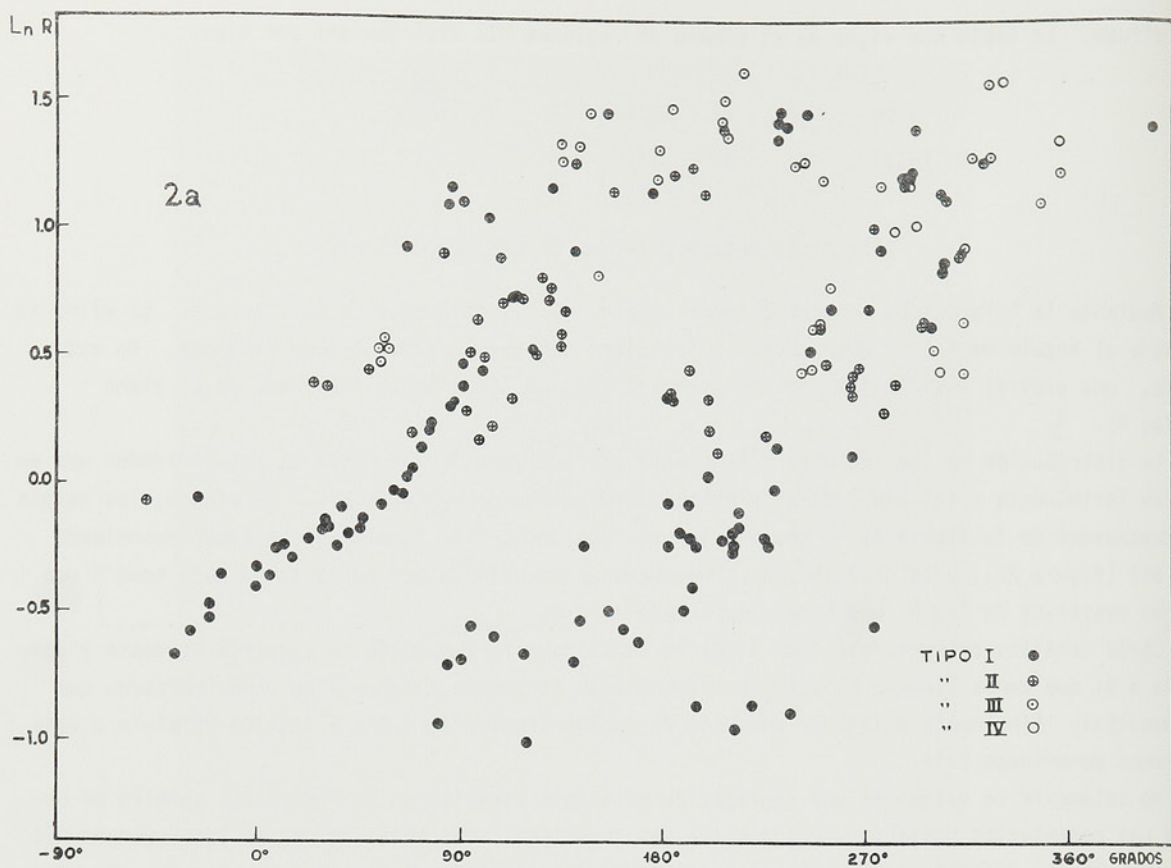


Fig. 2. Distribución espacial de Regiones HII.

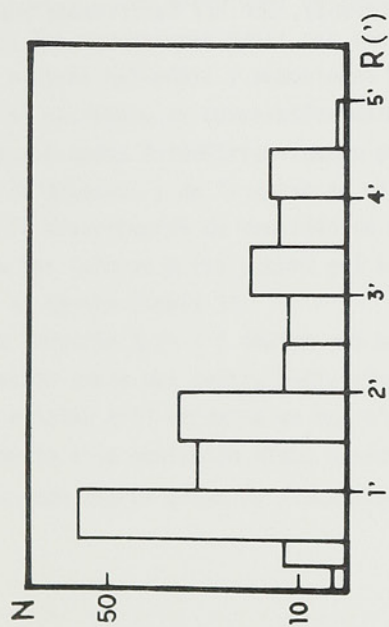


Fig. 3. Recuentos de regiones.

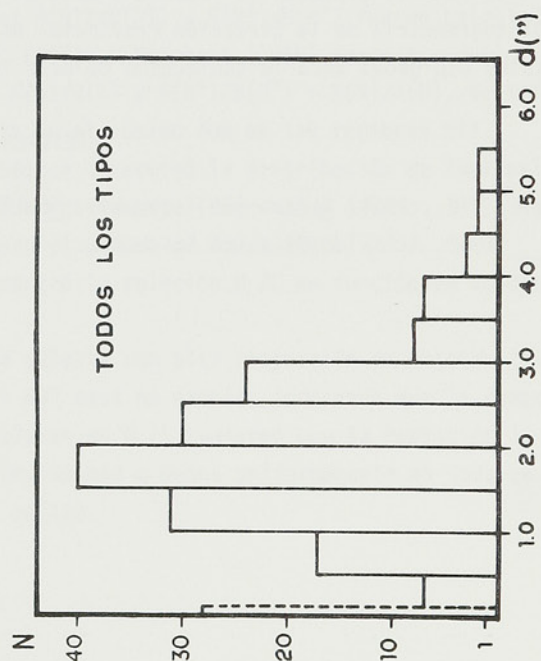


Fig. 4. Histograma de diámetros.

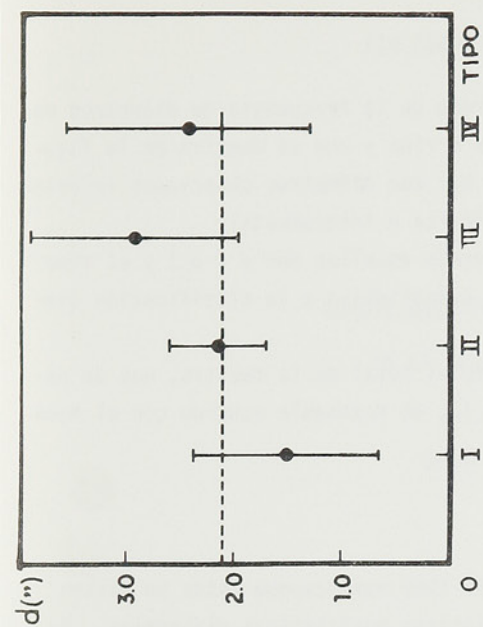


Fig. 5. Diámetros característicos.

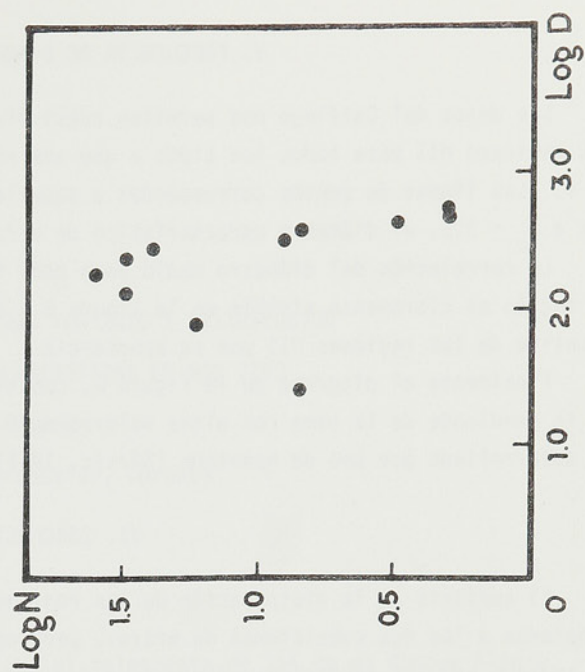


Fig. 6. Función de frecuencia.

interno de brazos y $R = 3.5$ para la estructura anular (Zona A, figura 2b).

V. FRECUENCIA DE DIAMETROS DE REGIONES HII

Los datos del Catálogo nos permiten construir el histograma de la frecuencia de diámetros de las regiones HII para todos los tipos a que nos referimos más arriba y que se muestra en la figura 4. Las líneas de puntos corresponden a aquellas regiones HII con diámetros observados inferiores a $d_0 = 3.5$, el diámetro característico de difusión atmosférica e instrumental.

La correlación del diámetro medio para cada tipo (excluyendo aquellos con $d < d_0$) y el tipo de región es claramente visible en la figura 5 y da una base cuantitativa a la clasificación cualitativa de las regiones HII por su apariencia.

Finalmente el diagrama de la figura 6, construido en base al total de la muestra, nos da para la pendiente de la rama con altos valores de D el valor 3.11, en razonable acuerdo con el modelo desarrollado por uno de nosotros (Sérsic, 1964).

VI. CONCLUSIONES

El análisis de la distribución de las regiones HII en NGC 1566 muestra que éstas se hallan asociadas a los dos subsistemas de brazos, pero con características morfológicas diferentes. Esto sugiere que las condiciones físicas conducentes a la formación de estas regiones son sistemáticamente diferentes en cada subsistema. Un análisis de la distribución superficial de HI, cuando sea posible en este objeto, seguramente aportará interesantes datos a este respecto. Los diámetros de las regiones HII siguen el patrón hallado en otras galaxias en lo que respecta a su función de frecuencia.

AGRADECIMIENTOS: Uno de los autores (J.L.S.) agradece al Dr. V.M. Blanco la oportunidad de haber podido obtener el material de placas para este trabajo con el telescopio de 4 m de CTIO en Febrero de 1976.

Los autores expresan su reconocimiento al Ing. Ansil y sus colaboradores del Departamento de Aerofotogrametría de la Dirección Provincial de Catastro de Córdoba, por las facilidades instrumentales otorgadas para la confección de este trabajo.

REFERENCIAS

- Sérsic, J.L., 1964, *Zeits. für Astrophys.* 58, 259.
_____, 1968, *Atlas de Galaxias Australes*.

CONDICIONES FISICAS DEL GAS IONIZADO Y DISTRIBUCION
DE LA RELACION MASA-LUMINOSIDAD EN NGC 7793

E.L. Agüero

Observatorio Astronómico, Córdoba

NGC 7793 fue estudiada espectroscópicamente con el telescopio de 154 cm de Bosque Alegre, equipado con el Espectrógrafo Nebular y Tubo de Imágenes.

Los espectros muestran, aparte de la emisión característica de las regiones HII, la existencia de un campo general emisivo. Del material obtenido se determinaron las relaciones de intensidades $I(H\alpha)/I(\lambda 6584)$, $I(H\alpha)/I(\lambda 6717 + \lambda 6731)$ e $I(\lambda 6717)/I(\lambda 6731)$ para veinte regiones de emisión distribuidas en el cuerpo de la galaxia y además en varias zonas entre aquellas.

Las características espectrales observadas indican que NGC 7793 es un objeto de moderada excitación, con $T_e \sim 10000$ °K.

La densidad electrónica obtenida a partir de la relación $I(\lambda 6717)/I(\lambda 6731)$ con el método de Saraph y Seaton (1970) es relativamente baja ($N_e \sim 1400$ cm⁻³ en el núcleo y $N_e < 1000$ cm⁻³ en las regiones HII). Las relaciones de abundancias iónicas $N(N^+)/N(S^+)$ y $N(N^+)/N(H^+)$ fueron calculadas mediante las expresiones dadas por Benvenuti *et al.* (1973) y Peimbert (1968) respectivamente. De los valores hallados, y suponiendo $N(N^+)/N(S^+) \sim N(N)/N(S)$ y $N(N^+)/N(H^+) \sim N(N)/N(H)$, se infiere que el nitrógeno es comparativamente más abundante en el núcleo que en las regiones HII.

De los datos fotométricos dados por Sérsic (1968) se determinó la distribución de luminosidad de la galaxia, y de la curva de rotación publicada previamente (Carranza y Agüero, 1977) se obtuvo la distribución de densidad de masa, utilizando el método de Perek (1962).

De los valores $M(r)$ y $L(r)$ así hallados se encontró la relación M/L en función de la distancia al centro (Tabla I).

La relación $M/L < 1$ indica que se trata de una galaxia con alta proporción de objetos jóvenes. La relación crece del centro hacia afuera y para $r > 69''$ casi no cambia, indicando que la composición estelar allí presente es muy similar. Los valores de M/L sugieren que la Población I, superpuesta a la población disco núcleo, está distribuida más o menos uniformemente en toda la galaxia, con cierto grado de concentración hacia el núcleo.

TABLA I
Elementos de los esferoides

a (arc sec)	r (arc sec)	V (km s ⁻¹)	$\rho_n \times 10^{23}$ (g cm ⁻³)	$\rho_{an} \times 10^{23}$ (g cm ⁻³)	$M(r)$ (g)	$M(r)$ ($\odot$)	L(r) ($\odot$)	M/L
9	7	24	78.53	88.71	0.008×10^{43}	0.04×10^9	0.15×10^9	0.27
77	69	77	9.52	10.18	0.369	1.86	3.20	0.58
204	160	64	0.66	0.66	0.651	3.22	6.03	0.54

REFERENCIAS

- Benvenuti, P., D'Odorico, S., Peimbert, M., 1973, *Astron. Astrophys.* 28, 447.
 Carranza, G., Agüero, E., 1977, *Astrophys. and Sp. Science* 47, 397.
 Peimbert, M., 1968, *Ap. J.* 154, 33.
 Perek, L., 1962, *Adv. Astron. Astrophys.* vol. 1, Academic Press, New York and London. Ed. Z. Kopal.
 Saraph, H.E., Seaton, M.J., 1970, *M.N.R.A.S.* 148, 367.
 Sérsic, J.L., 1968, *Atlas de Galaxias Australes*.

THE FOURCADE-FIGUEROA GALAXY

J.A. Graham

Cerro Tololo Inter-American Observatory*

ABSTRACT

The Fourcade-Figueroa object is a galaxy of low surface brightness near the peculiar galaxy NGC 5128. New observations are presented which were made with the 4-m telescope of the Cerro Tololo Inter-American Observatory. One plate taken with the prime focus camera shows the brightest stars of the system resolved and thus indicates that the distance is similar to that of NGC 5128. Weak extensions are seen over a distance of 15 arc minutes. A spectrogram taken with the spectrograph of the same telescope shows lines of $H\alpha$, [NII] and [SII] in emission in the central part of the galaxy and indicates a heliocentric velocity of $850 \pm 5 \text{ km sec}^{-1}$. This is to be compared with a heliocentric radial velocity of $547 \pm 5 \text{ km sec}^{-1}$ for NGC 5128. The velocity gradient in the central part of the Fourcade-Figueroa object along the major axis does not exceed $9 \text{ km sec}^{-1} \text{ arc min}^{-1}$.

With respect to NGC 5128, the Fourcade-Figueroa object may be a background galaxy at about twice the distance of NGC 5128. In this case, it is surprising that the bright stars are so well resolved and that the velocity gradient is so small. Alternatively, it may be a smaller galaxy at the same distance as NGC 5128 but unrelated to it. However the radial velocity is high and unlikely to arise from a pure Hubble expansion under this interpretation. There exists a third possibility in that the Fourcade-Figueroa galaxy may in fact be associated in NGC 5128 and that the large differential velocity is indicative of an unusual origin for this inconspicuous system.

* Cerro Tololo Inter-American Observatory, supported by the National Science Foundation under contract N° AST 74-04128.

OBSERVATION OF HI IN SOUTHERN GALAXIES

E. Bajaja

Instituto Argentino de Radioastronomía

I. THE OBSERVATIONS

The IAR radiotelescope has been equipped already in 1973 with 30 broad band (100 kHz) filters but only in 1975 we started systematic observations of galaxies. In spite of the instabilities present in the receiver, it has been possible to get positive results for most of the objects under observation. The list for this first part of the extragalactic work (Magellanic Clouds not included) consisted of 26 galaxies, the brightest in the southern hemisphere. Many of these galaxies were already observed from other observatories at the time when we started, and other results were published in the meantime.

The purpose of this work is then to check our results as compared with those from other observatories, to provide new results, and to add more information for the general knowledge of the HI content of galaxies.

The main characteristics of the observations are a spatial resolution of 0.5 deg. and a velocity resolution of 21 km/s. The channels are spaced 25 km/s so the 30 channels cover a velocity range of 750 km/s which is in general enough for most of the galaxies.

The observation procedure consisted in the observation of four points outside the galaxy and three times the center of it, with the sequence outside-center-outside-etc. The integration time on each point was 10.5 minutes. The subtraction of averages produced results that showed an r.m.s. of about 0.045 K (antenna temperature). Several observations were necessary for those cases where this value was still high. The calibration was done observing the south pole profile and a 10 K calibration signal.

II. RESULTS

Fig. 1 shows the profiles obtained for those galaxies where HI has been observed. Baseline corrections were done adjusting a straight line because of the short length left at both sides of the HI features.

Errors in the profile area were estimated from the r.m.s. on the baseline and the probable error in the baseline correction and in the calibration. In Table I the observed galaxies are

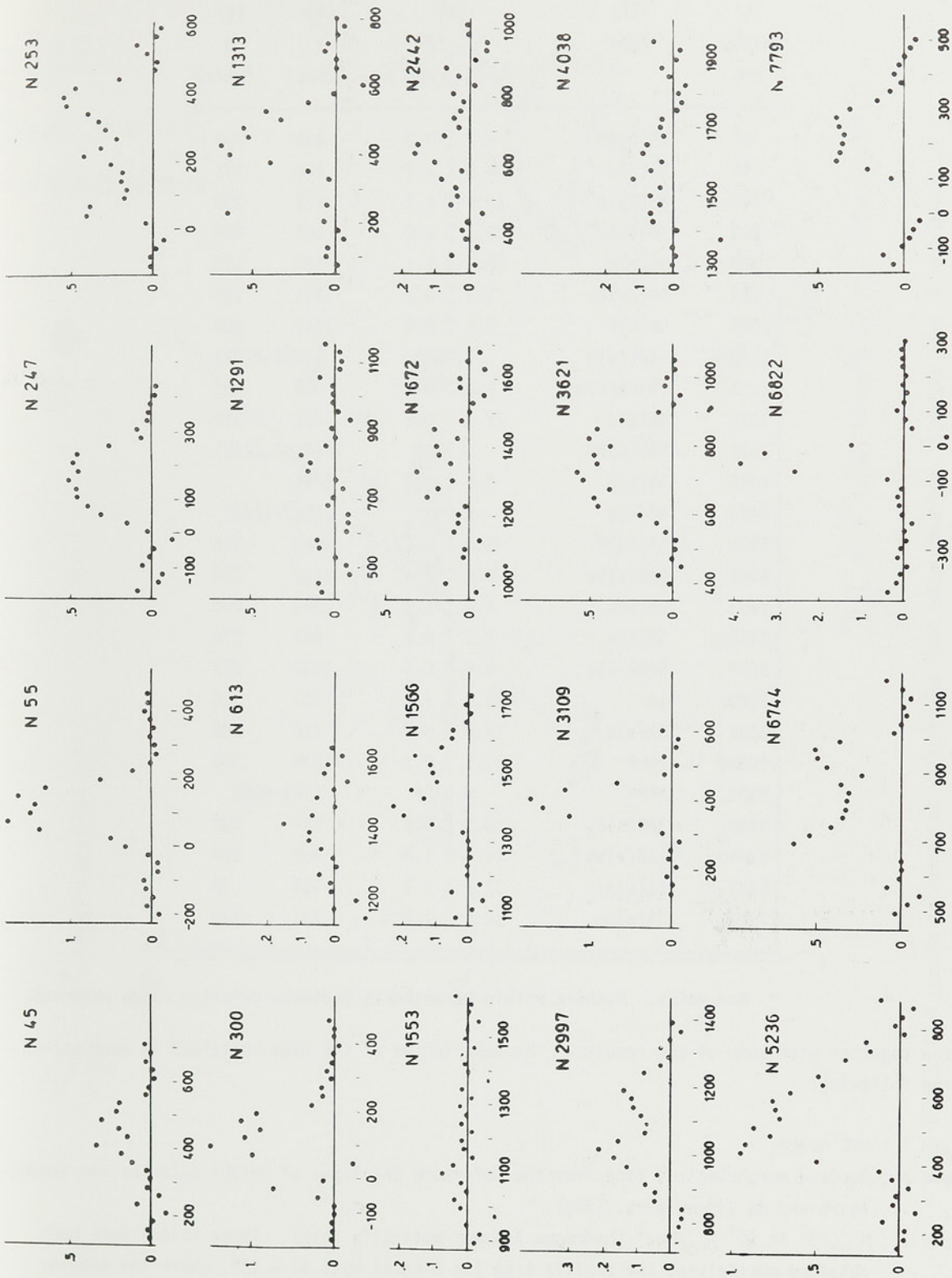


Fig. 1. HI profiles representing antenna temperatures (K) vs velocity (km/s w/r to sun).

TABLA I
Observed Galaxies and Derived Quantities

(1)	(2)	(3)	(4)	(5)
Galaxy	Type	M_{HI}/D^2	V	W
NGC		$(10^7 M_{\odot}/Mpc^2)$	(km/s)	(km/s)
45	SA(s)dm	4.7 ± 0.6	461	200
55	SB(s)m	30.0 ± 1.7	120	175
247	SAB(s)d	12.4 ± 1.1	172	235
253	SAB(s)c	13.5 ± 1.0	305	400
300	SA(s)d	20.1 ± 1.1	125	135
613	SB(rs)bc	1.2 ± 0.3	1431	155
1097	SB(s)b	2.1 ± 0.5	1343	205
1232	SAB(rs)c	0.059*	(1482-2207)	
1291	(R)SB(s)0/a	1.5 ± 0.5	839	65
1313	SB(s)d	11.0 ± 0.8	462	190
1316	SAB(s)0°	0.050*	(1507-2232)	
1365	SB(s)b	1.5 ± 0.7	1755	
1433	SB(r)a	0.043*	(617-1342)	
1553	SA(r)0°	0.7 ± 0.23	1080	125
1566	SAB(s)bc	4.2 ± 0.4	1480	290
1672	SB(s)b	4.4 ± 1.1	1368	285
2442	SB(s)b	2.7 ± 0.8	661	270
2997	SAB(rs)c	3.9 ± 0.5	1092	375
3109	Im	19.9 ± 1.2	407	110
3621	SA(s)d	14.8 ± 0.9	720	285
4038	IBmP	2.1 ± 0.3	1574	300
5102	SA0 ⁻	0.030*	(183-909)	
5236	SAB(s)c	25.3 ± 1.6	547	385
6744	SAB(r)bc	14.2 ± 1.0	849	300
6822	IB(s)m	31.5 ± 1.7	-59	70
7793	SA(s)dm	10.9 ± 1.0	231	220

* Rms value. Numbers within parenthesis indicate velocity range observed.

listed together with some of the results. The description of the data contained in each column is the following:

Column 1 : NGC number.

Column 2 : Revised morphological type from the Reference Catalogue of Bright Galaxies (de Vaucouleurs and de Vaucouleurs, 1964).

Column 3 : M_{HI}/D^2 in $10^7 M_{\odot}/Mpc^2$ (hydrogen assumed optically thin). These values have been obtained multiplying the profile area (in K km/s) by 1.12×10^6 , where the antenna gain is taken into account.

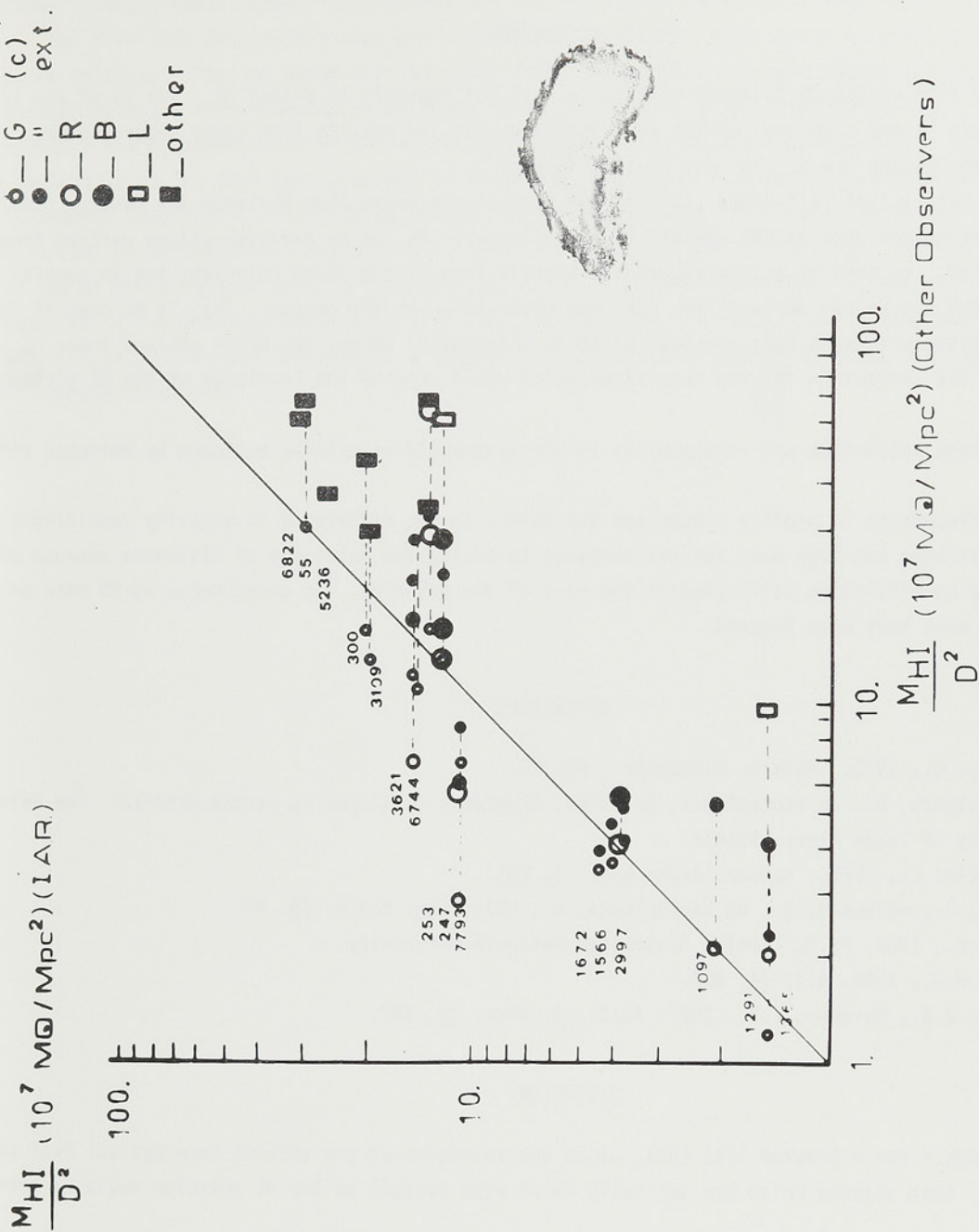


Fig. 2. IAR results as compared with results from other observers. Symbols code is as follows: WG: Whiteoak and Gardner (1977); G: Gougouenheim (1969); R: Roberts (1969); B: Balkowsky (1973); L: Lewis (1969).

Column 4 : Weighted mean velocity (with respect to sun), $V = \sum T_i V_i / \sum T_i$, where T_i is the temperature measured on each channel, and V_i its central velocity.

Column 5 : Total profile velocity width W , corrected for bandwidth.

III. DISCUSSION

Only in 4 of the 26 galaxies observed it was not possible to detect HI. For 16 of the 22 galaxies where HI was seen the results were compared with the results from other observatories. The comparison between the M_{HI}/D^2 can be seen in Fig. 2.

The values that fall quite close to our results are those from Whiteoak and Gardner (1977) from observations done at the centers of the galaxies. As can be expected values derived from observations on several points, covering the whole area of the large galaxies, are in general higher than our values derived from just one observation at the center. This is so even if the antenna pattern is such that the beam at 10 db attenuation covers the whole optical image of the galaxy. The correction for the beam attenuation would require the knowledge of the HI distribution.

Average velocities are very similar to the systematic velocities measured by Whiteoak and Gardner.

Discrepancies in profile widths are due mainly to the difference in velocity resolutions.

No attempt has been done for correlations involving the knowledge of distances because of the large uncertainties still present for many of the galaxies. In consequence no HI mass or indicative mass have been deduced.

REFERENCES

- Balkowsky, C., 1973, *Astron. Astrophys.*, 29, 43.
de Vaucouleurs, G., de Vaucouleurs, A., 1964, *Reference Catalogue of Bright Galaxies*, The University of Texas Press, Austin.
Gouguenheim, L., 1969, *Astron. Astrophys.*, 3, 281.
Heidmann, J., Heidmann, N., de Vaucouleurs, G., 1971, *Mem. R.A.S.* 75, 85.
Lewis, B.M., 1969, Ph.D. Thesis, Australian National University.
Roberts, M.S., 1969, *A.J.* 74, 859.
Whiteoak, J.B., Gardner, F.F., 1977, *Austr. J. Phys.* 30, 187.

DISCUSSION

BLAAUW.- For a program like this, would the selection of the objects from optical data imply the risk, that objects which are optically faint with respect to the HI emission would be overlooked?

BAJAJA.- The galaxies for these observations were selected mainly on the basis of their apparent magnitudes and their types. The brightest and the latest were chosen for this first survey, so there is certainly a selection effect. Faint galaxies have not been observed yet, even if there could be a chance of detecting HI, because in general there is no optical information about its velocity. This makes it a much more difficult job, because we have to search first over a broad range of velocities.

QUINTANA.- Observaciones del grupo Sculptor en HI han mostrado la existencia de nubes aisladas.

das de HI alrededor de algunas de las galaxias de ese grupo (Mathewson, Cleary and Murray, 1975; Haynes and Roberts, 1978). La dispersión interna de velocidades es aproximadamente 35 km/s, y las masas derivadas, 1 a $8 \times 10^8 M_{\odot}$. Dada la apertura del haz de 30', ¿es posible que los perfiles observados incluyan estas nubes? Esto podría dar una estimación mayor de la masa de HI en esas galaxias. Por otro lado ¿es posible observar estas nubes en el IAR, dado que su masa es parecida a la masa en galaxias? Hay que notar que las nubes tienen diferencias de velocidades con respecto a las galaxias de hasta aproximadamente 100 km/s, lo que permitiría separarlas en los perfiles.

BAJAJA.- Las componentes de HI en la cercanía de galaxias, y que no correspondan a éstas, quedarán englobadas en los perfiles obtenidos si están dentro del haz y si sus velocidades no están suficientemente separadas. Esto indudablemente conducirá a un error en la estimación del área total de la cual se derivarán las masas de HI y total a través del área indicativa. Vale la pena aclarar que el procedimiento para la obtención del perfil consistió en formar la diferencia entre los promedios de las observaciones sobre y fuera de la galaxia. Por tanto, si la componente no asociada a la galaxia es suficientemente extendida y con pequeño gradiente de velocidad, quedaría automáticamente cancelada.

ROTACION, DISTANCIA Y MASA DE IC 5152

J.L. Sérsic

Observatorio Astronómico, Córdoba

CONICET*, Buenos Aires

M.A. Cerruti

Observatorio Astronómico, Córdoba

RESUMEN

IC 5152 es una galaxia tardía clasificada por de Vaucouleurs como IA(s)m (1963) y como dSc⁺ por Sérsic (1968). Su disco aparente se extiende 5'5x4'6 en placas azules y presenta un alto grado de fragmentación, sin brazos espirales bien delineados. Tanto la resolución estructural del objeto, cuanto su baja velocidad de recesión han sugerido su posible pertenencia al Grupo Local (Yahil *et al.*, 1977). En base a dos espectrogramas tomados con el Espectrógrafo Rápido Page en Bosque Alegre, hemos construido la curva de rotación de esta galaxia. Un tercer espectrograma, de corta exposición, se usó para determinar la velocidad baricéntrica. Esta resultó ser $V_{\text{obs}} = 98 \pm 12$ km/s, en buen acuerdo con Evans (1963). La figura 1 ilustra la curva de rotación obtenida a lo largo del eje mayor del sistema ($AP=103^\circ$) y con una inclinación de la galaxia igual a 28° .

El análisis de la forma de esta curva evidencia claramente un grupo de puntos en $\Delta V \approx 120$ km/s y $R = 0.5$, característicos de los sistemas barreos (de Vaucouleurs y Freeman, 1969). Un análisis más cuidadoso de la apariencia del objeto confirma este hecho y explica por qué la mitad N-P tiene brillo superficial más elevado - pues corresponde al núcleo, barra y brazo más brillante - mientras que la otra mitad corresponde al brazo fragmentario (secundario) y, precisamente, es la que contiene los puntos anómalos en la curva de rotación.

De la amplitud $(\Delta V)_M$ y con $R_M = 0.45$ podría estimarse la masa total del sistema, si conociéramos la distancia. Dado que existe información en 21 cm de esta galaxia (Whiteoak y Gardner, 1977), es posible plantear las siguientes tres expresiones:

$$\log \frac{M_H}{M_T} = -1.96 + \log D$$

* Bajo contrato N°169.

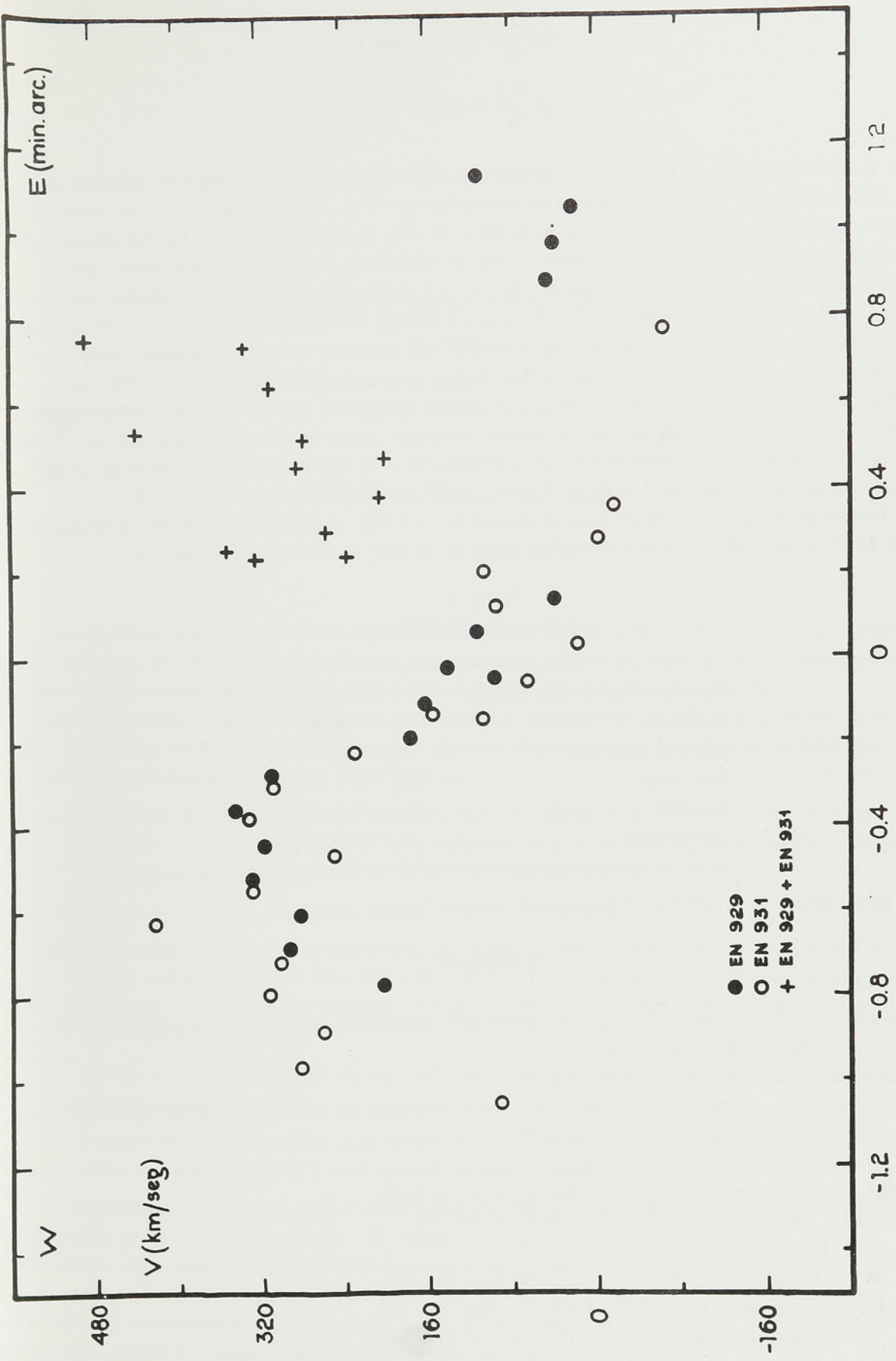


Fig. 1. Curva de rotación de IC 5152.

$$\log \frac{M_T}{L_B} = 1.77 - \log D \quad ,$$

$$\log \frac{M_H}{L_B} = -0.19 \quad ,$$

donde D es la distancia en Mpc y L_B la luminosidad computada en base a una magnitud aparente $m_T = 11.5$ (de Vaucouleurs, 1963) y una absorción galáctica $A_B = 0.3$. La masa total M_T - en unidades solares - se dedujo de nuestra curva de rotación y la masa de hidrógeno neutro (en las mismas unidades) de los datos de Whiteoak y Gardner. Como la relación $M_T/L_B \approx 1 \pm 0.3$ (Heidmann, 1969), mientras que Balkowski (1972) halla $\log M_H/M_T = -1.4 \pm 0.4$, las relaciones precedentes nos dan $\log D \approx 0.67$, $D = 4.6$ Mpc y $m-M = 28.6$. De esto se infiere una magnitud absoluta $M = -17.1$, lo que hace a este objeto una galaxia de baja luminosidad. Los datos de Whiteoak y Gardner (1977) permiten trazar groseramente la relación de Tully y Fisher para su muestra de galaxias. $\Delta V(0)$ es 114 km/s en caso de IC 5152 (con $i = 28^\circ$), y el módulo resultante $(m-M) = 28.6$ es totalmente compatible con el anterior. Una estimación grosera adicional puede hacerse observando que los diámetros de las regiones HII en este objeto son del orden de 3" y que las galaxias tardías de clase de luminosidad IV-V tienen $D(3) = 90$ pc (Sérsic, 1978) de donde inferimos $(m-M)_0 = 28$:

Adoptando $(m-M)_0 = 28.2$ resulta una distancia $D = 4.4$ Mpc, sensiblemente superior a la que postulan Yahil *et al.* (1977). Los principales datos de IC 5152 se resumen en la Tabla I.

TABLA I
Datos sobre IC 5152

Tipo morfológico (corregido)	$T = IB(s)m$
Distancia	$D = 4.4$ Mpc
Magnitud absoluta	$M_B = -16.9$:
Masa total	$M_T = 1.3 \times 10^{10}$
Masa HII	$M_H = 5.5 \times 10^8$
Luminosidad	$L_B = 8.5 \times 10^8$

Este trabajo será publicado "in extenso" en otro lugar.

REFERENCIAS

- Balkowski, C., 1972, *Etude statistique des propriétés intégrales des galaxies mesurées en raie 21 cm*. Thesis. Univ. de París.
- de Vaucouleurs, G., 1963, *Ap. J. Suppl.* 8, 31.
- de Vaucouleurs, G., Freeman, K.C., 1969, *The spiral structure of our Galaxy*. Breker and Contopoulos, ed. IAU Symp. N°38, p. 356. Basel.
- Evans, D.S., 1963, *M.N.A.S.S.A.* 22, 140.
- Heidmann, N., 1969, *Ap. Lett.* 3, 153. Thesis. Univ. de París.
- Sérsic, J.L., 1968, *Galaxias Australes*, Univ. de Cba. ed.
- _____ 1978. Esta conferencia.
- Tully, R.B., Fisher, J.R., 1977, *Astron. Astrophys.* 54, 661.
- Whiteoak, J.B., Gardner, F.F., 1977, *Austr. J. Phys.* 30, 187.
- Yahil, A., Tammann, G., Sandage, A.R., 1977, *Ap. J.* 217, 903.

SOBRE LA CINEMATICA DE NGC 5236

G. Carranza

Observatorio Astronómico, Córdoba
CONICET, Buenos Aires

E. Agüero

Observatorio Astronómico, Córdoba

Observaciones interferométricas y espectroscópicas de la radiación $H\alpha$ de NGC 5236 realizadas con el reflector de 150 cm de Bosque Alegre, han permitido relevar el campo de velocidades radiales de esta interesante galaxia hasta distancias al núcleo de casi cinco minutos de arco.

Las pronunciadas simetrías morfológica y cinemática perceptibles en NGC 5236 permitieron promediar los módulos de $V_R - V_0$ correspondientes a regiones opuestas. Las principales características que estas observaciones ponen de manifiesto son:

- a.- Las líneas de velocidad radial constante son casi normales a la dirección de la barra, en varios casos con ondulaciones bien marcadas; el gradiente de V_R en la región nuclear es del orden de 24 km/s/minuto de arco, y el lado más próximo es el np.
- b.- $|V_R - V_0|$ es mayor en los brazos que en el medio circundante.
- c.- Los extremos de $|V_R - V_0|$ se encuentran en varias regiones situadas en los cuadrantes primero y tercero ($0 < PA < 90^\circ$; $180 < PA < 270^\circ$) al exterior de los brazos que nacen en esos cuadrantes. Las más extensas (1.5×1.5) se hallan a casi 3 minutos del núcleo en las direcciones 60° y 240° .
- d.- También a casi tres minutos de arco del núcleo pero en dirección NS se encuentran regiones con $|V_R - V_0|$ pequeños.
- e.- A cuatro minutos del núcleo y en dirección de la barra las isovelocidades alcanzan un valor cercano a 85 km/s, y casi carecen de ondulaciones.

La interpretación de estos hechos no es inmediata debido a la indeterminación que hay sobre la ubicación de la línea de los nodos. Al respecto, aunque radioastronómicamente los extremos del campo de velocidades radiales se hallan en la dirección NS ("eje mayor cinemático") consideramos más apropiado dar mayor peso a la evidencia de regiones internas del cuerpo principal, que morfológica y cinemáticamente señalan como línea de los nodos a la dirección de la barra ($PA\ 45^\circ$). Aunque esto supone el riesgo de dejarse influenciar por la incipiente barra de NGC 5236, en otros

objetos se presentan deformaciones morfológicas y cinemáticas como las descritas que se atribuyen a distorsiones en las regiones más externas del plano principal de la galaxia.

Si el eje mayor coincide con la barra de NGC 5236, la distribución de velocidades radiales según el eje menor permite concluir que los movimientos internos concentran el medio HII en el borde interior de los brazos espirales observados, en donde se hallan las líneas de materia oscura. Otro hecho de interés es que las regiones de baja velocidad señaladas en d) coinciden aproximadamente con las zonas de la galaxia en las que las bandas de materia absorbente parecen pasar del interior de los brazos espirales al exterior.

Todos estos hechos son índice de apartamientos a los movimientos circulares puros que señalan fenómenos de circulación en gran escala, y cuyo estudio requiere una comprensión más precisa de la naturaleza de los fenómenos que generan la estructura espiral y su relación con el carácter barreado que exhibe la galaxia.

CLUSTERS OF GALAXIES

Invited Lecture

H. Quintana

National Radio Astronomy Observatory*, Green Bank
West Virginia

ABSTRACT: A critical review is presented of some areas in our current understanding of clusters of galaxies. In particular the classifications, galaxy content, luminosity functions and spatial structures are reviewed in detail. It is suggested that although the observational material today available is not sufficiently extensive or precise, the derived properties of clusters seem to be more diverse than normally believed. Some emphasis is given to optical work and to investigations carried out in the Southern Hemisphere. Likely areas for desirable future research are occasionally pointed out. The review is not meant to be complete and only very brief mention is made of radio or x-ray results.

I. INTRODUCTION

There has been an extraordinary increase in the interest and the number of studies of clusters of galaxies over the last few years. Developments of all-sky x-ray observations and the discovery that clusters of galaxies are the most common extragalactic x-ray sources, coupled to a better knowledge of the various types of radio sources in clusters are continually pressing for better data. The discovery of the intergalactic medium and the detection of its effects on the microwave background radiation are some examples of developments that call for better study of clusters at different distances. Theoretically, the calculations of strong evolutionary effects in galaxies inspire observers to look at clusters of higher and higher redshifts. Many surveys (optical, radio, x-rays) and various statistical analyses over large samples have been carried out.

*Operated by Associated Universities, Inc., under contract with the National Science Foundation.

The clusters fairly well studied, in their structure, luminosity function or dynamics, now reach some three dozen (with some overlap).

Essentially all the optical and radio work has been done in the northern skies, partly because of the availability of many more telescopes, but also to some extent because the preliminary survey work had already been done during the 50's and 60's (obviously due to the construction of the 48" Palomar Schmidt camera). Apart from the occasional study of a few bright nearby clusters in the South, work here is lagging far behind as compared to the North. The fact that the x-ray satellites scan the whole sky has led to the identification of many x-ray clusters in the southern skies, most of them not yet catalogued and largely never studied before.

In this review we shall survey some of the work done on clusters of galaxies in the last few years and will try to indicate lines of research likely to be explored in the next few years, with special emphasis on results in the southern hemisphere. Three timely reviews (Abell, 1976; Bahcall, 1977; van den Bergh, 1977) have recently appeared and comprehensively treat many aspects of the subject. Because of the short space available here, very often we will refer the reader to them.

At the recent Yale conference (Tinsley and Larson, 1977), I. King in the opening remarks listed a dozen problems in extragalactic astronomy, where he considered that new ideas and discoveries have come to challenge established wisdom. At least half of them are related to evolutionary, dynamical or other processes occurring in clusters. Some of them are the following: What is the missing mass? This is an old problem and after 45 years since the first work by Zwicky (1933), its solution is still central to our understanding of the contents of the universe, and of the early formation of clusters and galaxies. How does the galaxy population change in clusters? Various processes are possible and are beginning to be studied in detail: cannibalism and formation of cD galaxies, galaxy interactions and mergers, halos stripping (particularly in the central regions of clusters), gas sweeping from spirals and other galaxies, dependence on environment in the occurrence of active phenomena (explosive nuclei, radio sources, etc.). Other questions refer to the origin and the state of the intracluster gas. X-ray observations have conclusively shown its existence but it is not yet clear what is the configuration of the gas, or worse, its origin. Most of this gas should have been processed by stars to produce the near solar abundances (of Fe) observed in a few clusters. At what stage in the cluster, and galaxy, formation was this gas produced? How much more massive were galaxies then? Estimates show that there is as much mass in gas as in galaxies. The determination of the abundances present and the examination of the possible mechanisms and occasion for its production will certainly impose restrictions on theories of galaxy and cluster formation. One would hope that a detailed study of the characteristics of various types of clusters (such as luminosity functions or scale lengths) should point to the way the formation process occurred. Are clusters formed by gravitational clustering out of an already formed statistical sample of galaxies, or do large scale inhomogeneities separate early in the history of the universe and form gaseous proto-clusters, which fragment and condense to form galaxies at substantially later epochs? Some of these questions will very likely be answered in the near future while others perhaps will wait for many years to be resolved. But undoubtedly, the field of extragalactic astronomy, with necessary consideration of clusters of galaxies, is everyday more exciting and strongly investigated. Many important developments are likely to occur in the coming years.

In the past 15 years or so, many aspects of clusters have been investigated. Some general picture in those areas seems to be emerging. But the number of clusters studied in detail is still very small, and it looks today like some general characteristics, derived from that re-

restricted sample, are perhaps not so general as first believed. Very significant uncertainties remain that can only be solved by detailed observation of a larger sample. In particular, the universality of the luminosity function, the unique class division by morphological or galaxy content, the determination of core radii, the amount and nature of flattening are some areas which have been extensively investigated but still require a lot of work to get a clear picture. Without a better understanding of the structure of nearby clusters ($z \leq 0.2$) it is risky to try to assume similar properties (like sizes or core radii) for clusters at cosmological distances which are becoming accessible to observation with the new large telescopes. On the other hand, it is very exciting to be able to look at galaxy and cluster evolution over distances equivalent to $z \approx 1$. Identification and preliminary studies of very distant clusters ($0.2 \leq z \leq 1$) should start as soon as possible if for no other reason than just because large amounts of telescope time will be involved in their study which promises to be extremely rewarding. However, considerable effort still has to be directed to obtaining a unique and complete picture of nearer clusters ($z \leq 0.2$).

We shall first discuss the classification schemes, galaxy content, spatial structures and luminosity functions in Section II, that is the main body of the talk. In Section III, we briefly describe phenomena associated with dynamical evolution in clusters. Finally, in Section IV, we summarize results from radio and x-ray observations. A discussion is included of the recent detection of deformations in the microwave background radiation in the direction of clusters and of its implications.

II. DESCRIPTIVE AND STATIC PROPERTIES

To start studying an ensemble of objects one of the first things to do is to identify them (catalogue) and to devise morphological classifications which hopefully could prove useful in understanding the nature and physics of the objects. Most galaxies appear to be located in conglomerates of one type or another, from binary systems and groups, to clusters that may contain a few thousand visible members. Very few, if any, galaxies are really isolated. The dividing line between a group or a poor cluster is not defined. When talking about a poor cluster very often one talks about a group that has a few galaxies. The word cluster will include a very wide range of galaxy associations. Some classifications and definitions will refer only to the richer clusters.

Extensive identification and classification programs were carried out in the Northern Hemisphere by Zwicky and collaborators (Zwicky, 1957; Zwicky *et al.*, 1961-1968) using the 18" and 48" Schmidt cameras at Palomar, and by Abell (1958) who compiled a catalogue of rich clusters from the Palomar Survey Plates (out to a redshift ~ 0.2). Both of them introduced rough classifications in terms of morphology and structure of the clusters. Other classifications have been introduced in later years and we shall briefly mention them as they bear on future work to be done in the South. In the southern skies all of this comprehensive and preliminary work is missing. There are a number of partial listings (with descriptions) in restricted areas (Klemola, 1969; Sérsic, 1974; Rose, 1976) which have been drawn from inspection of plates taken with different and varied telescopes. A first, more systematic, list of groups and clusters has recently been published (Duus and Newell, 1977). It includes 770 entries from 97 ESO-B plates ($\delta \leq 27^\circ$, $|b^{II}| \geq 27^\circ$), and uses Zwicky classifications. But this is still not an homogeneous material. The proper survey should be carried out on the final SRC-ESO IIIaJ and red plates. This work is in progress at the ROE, where Abell and Corwin are examining the IIIaJ plates. Anyway, further

lists from the nearly completed ESO-B can be very useful for workers in the field.

CLASSIFICATIONS AND GALAXY CONTENT

Besides Abell and Zwicky classifications, there are three other schemes widely used in the literature. Two are based on the brightness contrast of the brightest galaxies, the Bautz-Morgan and Rood-Sastry classes, and the other on the galaxy content of clusters: the Oemler classification. These five schemes have been reviewed by Abell (1965, 1976), Bahcall (1977) and van den Bergh (1977), so we shall limit ourselves here to give the definitions and present some remarks.

Zwicky and Abell Classifications

Zwicky (ref. quoted) distinguished three types of clusters according to their morphology:

- a) Compact: clusters that contain a single outstanding concentration of its brightest galaxies, with at least 10 galaxies appearing in contact.
- b) Medium compact: existence of either a single concentration in which the 10 brightest galaxies are separated by several of their diameters, or several distinct concentrations.
- c) Open: no obvious condensations.

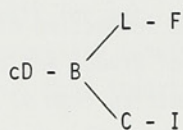
Abell's (1958, 1976) morphological classification takes into account the central concentration and the degree of symmetry of the clusters. The two classes are:

- a) Regular clusters: high central concentration, circular symmetry and a population of more than 1000 members in the brightest 6 magnitude interval.
- b) Irregular clusters: little or no spherical symmetry, no marked central concentration (possible multiple concentrations). Poor clusters are included in this class.

Obviously both classifications are not entirely independent, since the classification criteria have some common features. Zwicky's compact clusters are more or less equivalent to Abell's regular clusters, and Abell's irregulars comprise the medium-compact and open Zwicky clusters. Like all the other classifications to be discussed, they are based on the appearance of the clusters (and their galaxies) on the 48" plates or prints, which poses some restrictions. If one wants to apply Abell classes straight-forwardly to very distant clusters, the population requirements have to be reconsidered, since there is little hope of identifying galaxies down to 6 magnitudes fainter than the brightest on those plates.

The Rood-Sastry Classification

This is a refinement of the previous classifications for rich clusters (only), based on the morphology and the detailed distribution of the 10 brightest galaxies (Rood and Sastry, 1971). The tuning fork scheme formed by the six classes is:



with the definitions (Rood and Sastry, 1971):

- cD : cluster is dominated by a single cD galaxy. This central galaxy frequently has other smaller galaxies embedded in it. Its size should be ≥ 3 times that of any other galaxy in the cluster (A401, A2199).
- B (binary) : cluster has 2 supergiant galaxies separated by ≤ 10 diameters of the larger galaxy. Combined size of both ≥ 3 times that of any other member (Coma, A154).
- L (line) : cluster contains 3 or more of its brightest galaxies arranged in a line (A426).
- C (core) : 4 or more of top 10 brightest with comparable separations near the center (A2065).
- I (irregular) : the cluster galaxies are distributed irregularly, or without a well-defined center (A2151, A1228).
- F (flat) : several of the top 10 brightest and a large fraction of the fainter galaxies are distributed in a flattened configuration (A397).

Rood and Sastry (1971) classified all 111 Abell clusters for distance classes $D = 3$ or nearer with results: 21% cD's, 9% L, 14% C's, 18% F's, and 29% I's. From the definition itself it is apparent that the brightness of the brightest member varies systematically along the tuning fork, from an outstanding cD to a value near the average of the 10 brightest in classes F and I. The galaxy content along the two arms, for corresponding classes, seems to be similar in sizes, luminosity and form types. This classification, as well as the Bautz-Morgan (like any classification based on the distribution of a few bright galaxies), suffers from possible contamination by foreground galaxies, as well as distance effects, as discussed by Bahcall (1977) and especially van den Bergh (1977).

Bautz-Morgan Classification and Modifications

This classification (Bautz and Morgan, 1970) is a scheme of five classes based exclusively on the relative contrast of the brightest few galaxies to the other galaxies in each cluster. The defining criteria for the classes are: Class I: clusters containing a centrally located cD galaxy (A2199, A2029); Class II: clusters whose brightest galaxy or galaxies are intermediate in appearance between class cD and the Virgo-type giant ellipticals (A194, A1656, A2197); Class III: clusters containing no dominant galaxies (Virgo, A2065), and two intermediate classes.

There is no correlation between richness and B-M type. The absolute magnitude of the brightest is correlated with B-M class, and so are the differences between the few brightest as is clear from the definition (Sandage and Hardy, 1973). The classification has been extensively used in the literature to search for correlations between the type of cluster and other properties, like radio or x-ray luminosity, types of radio sources present and others (see reviews quoted).

Bautz and Morgan gave a set of standard clusters and other clusters are to be classified in reference to them as they appear on the Palomar Survey plates. The classification is empirical, with its resulting virtues and limitations, and not all clusters were originally supposed to be classifiable. Van den Bergh stresses this point (1977). On the other hand, Leir and van den Bergh (1977) classify in this system, 1889 Abell clusters. To do this, they had to extend the classification in distance by a photographic method which is subjected to a systematic distance effect: K-dimming would reduce the surface brightness of the envelopes of distant cD's relative

to other galaxies. This is a physical effect and not an inherent problem in the empirical classification (the same comment concerns the Rood-Sastry system). The way to proceed may be rather to define standards independently at different distances, and extend the classification in relation to them. Many clusters have been given B-M classifications by other workers and the referred reviews give large bibliographies. The classification is somewhat subjective. When comparing results from various observers, although the general agreement is good, there are sizable differences (see comparative study in Leir and van den Bergh). Great care is needed when classifying clusters from different plate material. One should have the standard clusters in the same plate material for a reliable comparison. In the South there are no Bautz-Morgan standards. From a comparison of the ESO-B, SRC-ESO IIIaJ and the Palomar plates, work is in progress (Quintana and White, 1978) to extend the classification to the South by defining suitable standard clusters.

Morgan, Kayser and White (1975) and White (1978) have introduced a modification of the B-M types, by refining and making more detailed the representation of the brightness differences between the brightest galaxies and by classifying them according to their Yerkes types and concentration classes. This permits the construction of brightness vs. concentration class graphs that give a representation of the B-M type, the bright end of the luminosity function and the degree of evolution of the nuclear components of the galaxies (White, 1978), most notably of the spiral content of clusters. Another nice feature of the method is that it allows a representation of poor clusters alongside rich clusters. In general terms, their representation does not differ much from those of rich clusters (i.e., of the bright end of their luminosity function). A drawback of this analysis is that (at least working on Palomar Schmidt plates) only fairly nearby clusters can be studied. With deeper, better scale IIIaJ plates the method could be extended to much greater distances.

Galaxy Content Classification

Morgan (1962), and more recently Oemler (1974), have proposed classifications based on the galaxy content of the clusters. Here we summarize Oemler's three group classification (essentially derived from a detailed study of about a dozen clusters). This scheme turns out to be fairly well correlated to the global morphological and structural appearance (as was already evident from the work of Abell, for instance) and, hence, to some of the previously introduced classifications. The three classes are defined in the following way:

cd clusters: dominated by one or two central supergiant galaxies, centrally concentrated clusters with a population dominated by ellipticals and S0 galaxies, with no spirals in their cores.

Spiral rich: dominated by spiral galaxies, with a population similar to that of the field. Mostly irregular in appearance, low mean densities with no central condensation.

Spiral poor: intermediate between cd and spiral rich clusters, composition dominated by S0 galaxies. Not so regular or concentrated as cd clusters.

In Table I we reproduce the percentage populations of the clusters studied by Oemler, plus average populations for each class and the field. In the same table we list the results of a similar study of 12 rich clusters by Dressler (1976). Some of these are somewhat richer and more distant than Oemler's and Dressler breaks the populations into only two types = "E" (assumed to be E's + 1/3 of S0's) and "non-E" (2/3 S0's + spirals). Although most clusters fit the classification by classes, in both samples there are a few anomalous cases whose percentage populations are devi-

ant from that of the class they are assigned on the basis of the remaining classification criteria, most notable A98, A1314 and A2670 (presence of dominant D or cD galaxy, central concentration or lack of it). It is also apparent from Table I that Dressler finds such a continuous range in his populations, that he questions the validity of the classification. This is an area where much more work is needed, with better large scale plate material to reliably classify galaxies. It is important to see if the deviant cases might not form separate classes that may be related to their formation or different evolutionary processes occurring in them.

TABLE I
Galaxy Content

Oemler 1974	Cluster	Type	E%	S0%	S%	Ellip	Non-Ellip
	Coma	cD	35	47	18	51	49
	A2199	cD	35	41	24	49	51
	A194	Spiral-poor	18	56	26	37	63
	A400	Spiral-poor	15	56	29	34	66
	A539	Spiral-poor	19	53	28	37	63
	A1314*	Spiral-poor	38	43	19	52	48
	A1228	Spiral-rich	14	25	63	21	79
	A1367	Spiral-rich	17	40	43	30	70
	Hercules	Spiral-rich	14	36	50	26	74
	A2197	Spiral-rich	19	36	45	31	69
		cD	35	44	21	48	52
	Average	Spiral-poor*	17	55	28	35	65
		Spiral-rich	15	35	50	27	73
	Field		15	25	60		
	(*A1314 not included in average)						

Dressler 1976

A2029	cD		47	53
A1413	cD		49	51
A2218	cD		48	52
A401	cD		57	43
A2670*	cD		37	63
A2256	Non-cD		42	58
A274	Non-cD		32	68
A168	Non-cD		39	61
A154	Non-cD		35	65
A98*	Non-cD		53	47
A1940	Non-cD		38	62
A665	Non-cD		39	61
Average	cD		48	52
	Non-cD		40	60

Other clusters classified by Oemler. cD's: A1413, A1904, A2670, Zw1545.1+2104. Spiral-poor: A665.

A new galaxy classification has been suggested by van den Bergh (1976, 1977) to single out a peculiar feature of spirals in clusters. He calls them anaemic. On large scale plates they have fuzzy spiral features that indicate that stellar formation is inhibited as compared to that occurring in spirals outside clusters. This effect can be interpreted as being caused by the sweeping of their gas by an intracluster gas as they move about in the cluster (Gunn and Gott, 1972). Very little gas would remain in them to power star formation. Would the end result of this process be the eventual transformation of all spiral galaxies into S0 galaxies in clusters? There is growing evidence that indeed this may be the case. Abell (1977) has plotted the positions of all spiral galaxies in the Coma cluster and the resulting distribution looks completely flat, with no noticeable clustering. Although velocity information would indicate these spirals belong to the cluster, their distribution shows no effect of the cluster on them. A similar result has been obtained from a study of the southern cluster CA 0340-538 (Quintana and Havlen, 1978) where the spirals show no sign of clustering.

Neutral Hydrogen in Spiral Galaxies Located in Clusters

It is expected, as was suggested by Gunn and Gott (1972), that if significant amounts of intracluster gas do exist in clusters, spiral galaxies will be stripped of their interstellar gas. Lea and De Young (1977) have calculated the hydrodynamical interaction of both gaseous components in great detail. The presence of large numbers of S0 galaxies in regular and compact clusters, the good correlation between x-ray luminosities and S0 populations in clusters (Melnick and Sargent, 1977) and the characterization of anaemic given to the Virgo cluster spirals by van den Bergh are observational facts that support this view.

For nearby clusters it is possible to directly measure the amount of HI in cluster spirals and to compare them to the HI present in isolated galaxies. Two surveys by Lewis and Davies (1973) and by Huchtmeier *et al.*, (1976) in a number of Virgo cluster spirals gave marginal results. Davies and Lewis found that, on the average, Virgo spirals have one-half of the HI content of field galaxies, but the individual values were within the normal range found in the latter. A similar, but non-conclusive, effect was found by Hutchmeier *et al.*, (1976), which could, however, be interpreted in terms of a selection effect since only the brightest galaxies were observed and these have proportionally smaller amounts of HI.

Haynes and Roberts (1978) are conducting a survey of spirals in most of the Abell distance class 1 (and a few $D = 2$) clusters on the NRAO 300-ft telescope. They also observe isolated galaxies with similar redshifts and angular sizes. Most of the galaxies actually detected (22 out of 90, in 15 clusters) were inside 0.5 Abell radius and had velocities consistent with cluster membership. Preliminary results (for about half the sample) show that the ratio of the mass M_H in HI to the total mass in cluster spirals belonging to elliptical dominated clusters is significantly different than for the isolated galaxies or in spiral clusters, which in turn show no significant difference between them. Although the sample is small, there are indications of a correlation with Bautz-Morgan or Rood-Sastry type. This indicates a likely correlation with the degree of central concentration. The critical correlation, or lack of it, with x-ray luminosity cannot be statistically tested yet because most of the $D = 1$ clusters are $R = 0,1$ class which have not yet been detected as x-ray sources. Deeper studies of the Coma, 1367 and Hercules clusters being carried out at Arecibo will illuminate some of these questions.

cD Galaxies and Poor Clusters

Essentially all classification and population studies have been done on rich clusters. Morgan and collaborators (Morgan, Kayser and White, 1975; Albert, White and Morgan, 1977) have searched for poor clusters containing cD galaxies. In a search that is far from complete they found a total of 23 such clusters. Subsequently White (1978) also studied another 42 poor ($D \leq 2$) clusters. From these studies it is apparent that the cD phenomena is far from exclusive of rich clusters. (The opposite is more the case). The presence of a cD is independent of the richness of a cluster. However, the size and spectacularity of them depend on the extent of the cluster (Oemler, 1976). More detailed work and quantitative studies are required on poor clusters.

Southern Clusters

Very few clusters have been studied in the South. The best studied is obviously the nearest rich cluster, that in Centaurus. Radial velocities are known for some 50 galaxies (not all of the published) and a preliminary population study yields percentages of 22% E's, 61% S0's and 17% S+Irr for the inner 1° . For the outer regions the populations are 19%, 24% and 57% respectively, indicating a spiral-poor core and a spiral-rich halo (Dawe, Dickens and Peterson, 1977). Another cluster partially studied is A1060, for which a velocity dispersion based on 15 galaxy velocities has been published (Vidal and Peterson, 1975).

The identification of many southern clusters with x-ray sources has prompted various optical studies of them. Apart from the two previous ones, the cluster CA0340-538 has been fairly well studied morphologically, photometrically and dynamically (Havlen and Quintana, 1978; Quintana and Havlen, 1978). Other clusters are presently being studied by three or four groups of workers: Klemola 44, Ser 40/6, and another half a dozen or so x-ray clusters. A very promising development is the entrance into operation of the COSMOS machine at the R.O.E. MacGillivray *et al.*, (1976) have already published a structural study of six distant clusters ($0.1 \leq z \leq 0.2$) from measurements in a small area of one UK Schmidt IIIaJ plate. Geometrical parameters have likewise been measured for another 83 clusters from another IIIaJ plate (out to a redshift of ≈ 0.3). It is obvious that with the advent of the automated measuring machines like COSMOS or the Cambridge machine, very large numbers of clusters will be analyzed.

What is the general picture that follows from these morphological studies?

Generally speaking, rich clusters can be fitted along a more or less continuous sequence, which can be characterized at its extreme points in the following way. At one extreme there are the regular, highly concentrated, symmetrical elliptical rich clusters. Some of them have cD (or D) galaxies at their centers, but not all (and a few cases exist of D galaxies not in the cluster cores). At the other end are the irregular, spiral dominated clusters that show no concentration or symmetries. And, roughly, there is a class of intermediate clusters. This situation is summarized in Table II (from Bahcall, 1977), where some other correlations are noted and will be discussed later.

One has to keep in mind that there are exceptions to these general trends, and that some strange cases exist. For instance, the richest cluster in the Abell catalogue, A665, shows a density minimum at what seems to be its center. A347 and A2666 are found (White, 1978) to be highly compact but rich in spirals. A1314 has no single outstanding galaxy and Oemler classifies it as spiral-poor. But it is an elliptical dominated cluster with a population similar to other cD clusters. And sometimes serious divergent assignments of classes exist. A2199 was classified by Oemler as a cD, one of the two cD clusters for which he gives detailed population and an

TABLE II
Classification Schemes of Clusters and Related Characteristics

Property/class	Regular (Early)	(Intermediate)	Irregular (Late)
Zwicky type	Compact	Medium-Compact	Open
Bautz-Morgan type	I, I-II, II	(II), II-III	(II-III), III
Rood-Sastry type	cD, B, (L, C)	(L), (F), (C)	(F), I
Content	Elliptical-rich	Spiral-poor	Spiral-rich
$\sim E:S0:S$ Ratio	3:4:2	1:4:2	1:2:3
Symmetry	Spherical	(Intermediate)	Irregular shape
Central Concentration	High	Moderate	Very little
Central profile	Steep gradient	(Intermediate)	Flat gradient
Mass segregation	Marginal evidence for $m-m(1) \leq 2$ mag	Marginal evidence for $m-m(1) \leq 2$ mag	No segregation
Radio emission (*)	$\sim 50\%$ detection rate	$\sim 50\%$ detection rate	$\sim 25\%$ detection rate
L_R	High	Low	Low
X-ray emission (+)	$\sim 33\%$ detection rate	$\sim 8\%$ detection rate	$\sim 8\%$ detection rate
L_X	High	Intermediate	Low
Examples	A2199, Coma	A194, A539	Virgo, A1228

Notes: (*) to 0.2 f.u. at 1.4 GHz (Owen, 1975). Abell clusters with $z \leq 0.07$
(+) from data on the 3U catalog (Giacconi *et al.*, 1974).

example of its class. However, White (1978) finds it to be spiral-rich both in form-type content and in the distribution of its brighter members. One source of uncertainty here is a possible contamination by the nearby spiral-rich A2197. The Abell radii of the two clusters overlap and they are at the same distance. A2199 and A2197 could form a more complex system. But this and other cases points to the ambiguity of the classification.

The presence of D and cD galaxies seems to be correlated with local density enhancements (White, 1978). Rich clusters that show no concentrations have no cD galaxies. Somewhat extended clusters, like A2199 that have a central condensation have one (in fact one of the largest known). On the other hand not all centrally condensed elliptical clusters have cD galaxies. The cD phenomena appears to be independent of the richness of the clusters. In fact there may be more cD galaxies per unit volume, in poor clusters than in rich ones.

MODELS OF CLUSTERS

Clusters of galaxies are, in first approximation, dynamical systems of nearly isolated particles interacting gravitationally. It was found by Zwicky (1957) and others that the classical equations describing isothermal self-gravitating gas spheres (Chandrasekhar, 1942) give a very good description of the radial dependence of the galaxies' density. In this way a representation of the cluster is obtained in terms of a few parameters. Some of these parameters can be related to other dynamical quantities. Apart from the isothermal spheres, a few other models and parametrizations have been used, mainly to describe the Coma cluster.

Because clusters of galaxies have memberships between 10^3 - 10^4 galaxies they are difficult objects to study dynamically. The membership is high enough to make computer simulations with ac-

tual numbers complicated and costly. On the other hand, the membership is not large enough to produce the smoother statistical behavior typical of systems with large numbers, such as globular clusters or elliptical galaxies (although no consistent statistical mechanical theory of gravitating particles has been formulated). By the same token, the limited membership implies that the observed surface densities in clusters span no more than about two orders of magnitude when going from the center to the periphery of the clusters, with important statistical uncertainties at any point. As a result it is difficult to select a model as more adequate than others, and even when considering a specific model, its parameters are determined with large uncertainties (Avni and Bahcall, 1976; Quintana and Havlen, 1978). An inherent limitation of most of the models proposed is the assumption of spherical symmetry. In spite of the fact that most of the clusters analyzed look regular, they have considerable ellipticities. The typical testing ground for all models, the Coma cluster (qualified by Zwicky (1957) as having remarkable spherical symmetry) has recently been shown to have a significant ellipticity (Schipper and King, 1978). On the other hand, for systems with much higher ellipticities, it is indeed remarkable that the models still fit the data so well.

Among the currently most used models are those suggested by King (1966, 1972), by de Vaucouleurs (1960) and the isothermal gas model (Zwicky, 1957; Bahcall, 1975). All three are empirically or semi-empirically derived models. They have different basic properties and some are more adequate for certain purposes than the others (for instance: study of the core size, study of the outer regions). The King and de Vaucouleurs models permit simple ways of estimating global dynamical quantities and have been used to study the Coma cluster (Rood *et al.*, 1972; de Vaucouleurs, 1960). For more details about those models see the reviews referred to previously. The isothermal gas sphere has an infinite mass and one needs to introduce a cut-off, C , to keep the mass finite. It has been applied to the Coma cluster by Zwicky (1957), Bahcall (1973) and Abell (1977). All three models fit the data fairly well within the uncertainties of the method.

The projected density in the isothermal model is given by:

$$\rho(r) = \alpha \rho_{\text{isoth}} \left(\frac{r}{\beta} \right)^{-\gamma},$$

where the parameters α , β and γ represent the central density, a structural length and a value related to the cut-off and background density ρ_{back} , $\gamma = \rho_{\text{back}} - \alpha C$, where $C \approx 0.1$ is the cut-off to make the sphere bounded. The usual way to proceed in the analysis of a cluster is to determine the density of galaxies in concentric rings and make a least-squares fit to the data. Three or two parameter (by fixing C arbitrarily) fits have been carried out on data for about 40 clusters, for a range of different redshifts. Like all other models, a typical scale length is derived and it has been suggested that such a length could be used as a standard yardstick for cosmological tests (see Bahcall, 1977 and references therein). For this to be feasible it is required that such a quantity (in the present case, the core radius = 3β : radius at half the central density) has a small dispersion for different clusters -- or at least for a class of them -- and that it should be simple and accurate to measure observationally.

Bahcall (1975) has claimed that this is the case from a sample of 15 clusters, measured in Palomar Schmidt IIIaJ or Survey plates. She counts galaxies to 3 ± 1 magnitudes fainter than the brightest. She obtains a core value of 0.25 Mpc with a very small dispersion of 0.04 Mpc, for clusters out to a redshift ~ 0.14 ($H_0 = 50 \text{ Mpc km s}^{-1}$). In Table III and Figure 1 we list and plot her results for the core radius values, alongside those of other workers (for the same and for all other studied clusters). Apart from Bahcall's, two other systematic studies have been

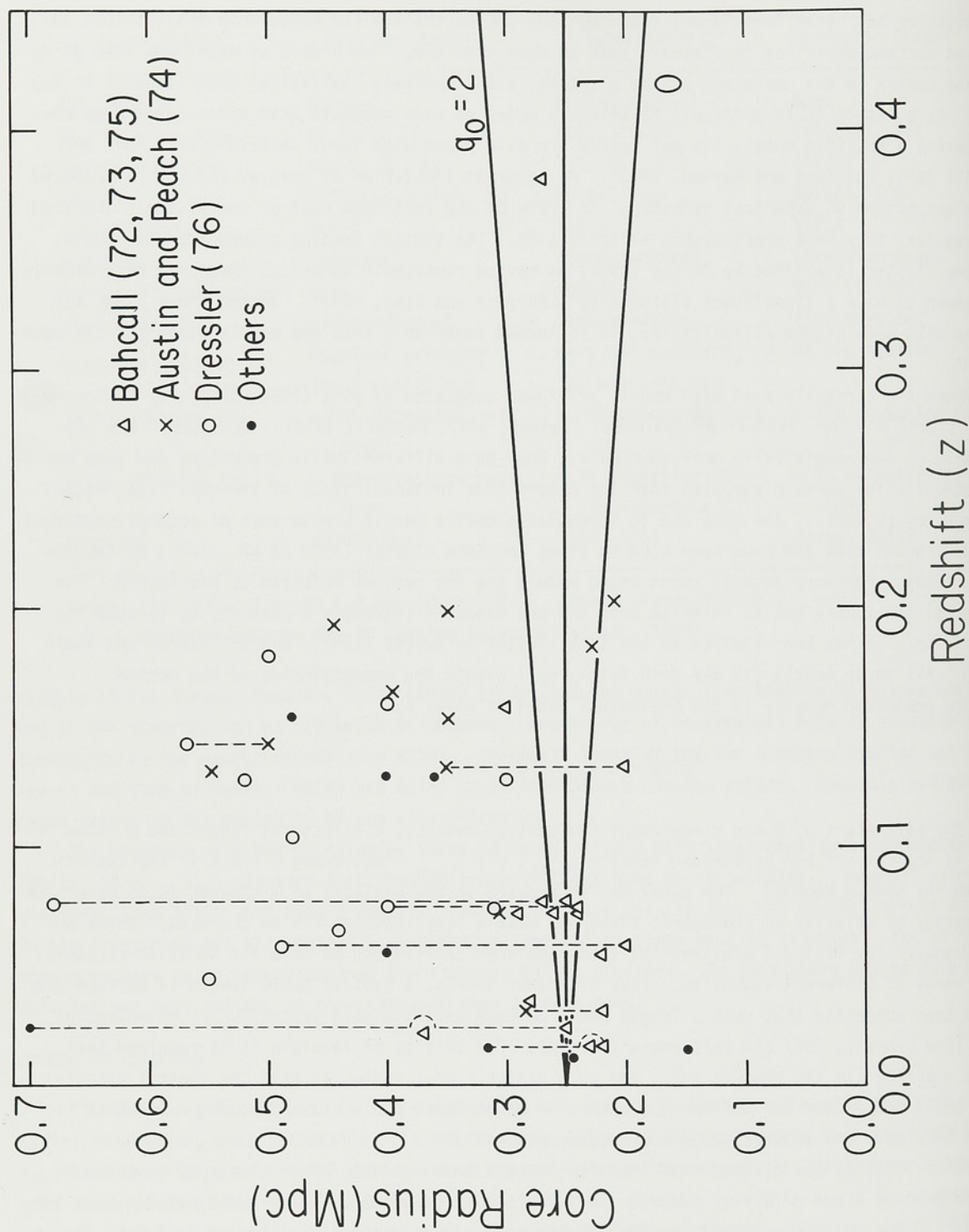


Fig. 1. Core radius vs. redshift data for all clusters. The broken lines join values of different determinations of the same cluster, by the authors as shown and for data of Table III. The solid lines indicate the values of a fiducial core radius 0.25 Mpc at

TABLE III
Isothermal Models - Core Radius (Mpc)

Cluster	z	R	R-S	Bahcall	A & P	Dressler	Others
A1656	0.023	2	B	0.25			0.80 (8)
A426	0.018	2	L	0.22			0.314 (4)
A194	0.018	0	L	0.23?			
A1367	0.022	2	F	0.37			
A2199	0.031	2	cD	0.22	0.285		0.28 (5)
A2052	0.035	0	cD	0.28			
A2319	0.055	1	cD	0.22?			
A2256	0.059	2	B	0.20		0.49	
A401	0.075	2	cD	0.24		0.40	
A1775	0.072	2	B	0.26			
A1904	0.072	2	B	0.24			
A2065	0.072	2	C	0.29	0.305		
A2029	0.077	2	cD	0.27		0.68	
A1795	~ 0.078	2	cD	0.25			
A1132	0.134	1	--	0.20	0.350		
A274	0.129	3		0.20		0.30	
A168	0.045	2	I			0.55	
A154	0.065	1	B			0.44	
A2670	0.075	3	cD			0.31	
A98	0.103	3				0.48	
A1940	0.139	3				0.52	
A1413	0.143	3	cD		0.501	0.57	
A665	0.18	5				0.50	
A2218	0.164	4	cD			0.40	
A1930	0.131	1			0.548		
A2100	0.153	3			0.348		
A1553	0.165	2			0.394		
A1677	0.183	2			0.233		
A801	0.192	2			0.445		
A1643	0.198	1			0.350		
A732	0.202	1			0.211		
A1060	0.011	1	C				0.243 (4)
Cancer	0.016	0					0.147 (4)
A31	0.159	2		(*) 0.30			
0024+1654	0.38	2		(*) 0.27			
CA0340-538	0.057	2	L				0.35 (6)
22129-3448	0.13		cD				0.40 (7)
22156-3525	0.155		B				0.48 (7)
22146-3457	0.13		F				0.36
Means				0.25 $\pm$.04	0.38 $\pm$.11	0.47 $\pm$.11	

TABLE III (Cont.)

NOTES: References:

- (1) Bahcall, 1972, 1973, 1975, 1977.
- (2) Austin and Peach, 1974.
- (3) Dressler, 1976.
- (4) Zwicky, 1957.
- (5) Clark, 1968.
- (6) Quintana and Havlen, 1978.
- (7) MacGilliwray *et al.*, 1976; MacGilliwray, 1978.
- (8) Abell, 1977.

singled out in Table III. That of Austin and Peach (1974) who also uses Palomar Schmidt IIIaJ plates, but who extended the counts to fainter magnitudes, and that of Dressler (1976) who counted galaxies on the Crossley 36" telescope plates. Both of the later authors have strictly magnitude limited samples, while Bahcall results are based on eye estimates. Two trends in values of the core radius are apparent in these results. Bahcall (and early on Zwicky) obtain results around 0.25 Mpc, with a small dispersion. Austin and Peach, Dressler and the rest of the workers listed in Table III obtain values around 0.4-0.5 Mpc, with larger dispersions, as is clear in Figure 1. It is important to elucidate the cause of this discrepancy and to reach a unique range of values for the core radii, if there exists such unique value. Any application to cosmology is hopeless until this situation is resolved. Among the possible causes of the effect, Dressler mentions the fact that Bahcall sample, being magnitude limited by eye estimates, may be subjected to different limits in the central and outer regions of each cluster. He suggests that a difference of 0.5 magnitudes is enough to produce the required difference in Bahcall counts to explain the effect (her counts run from a total of 38 galaxies for A2319 to 96 galaxies for A2029, Coma excepted, as compared to counts typically of a few hundred for other people). Abell points out that Bahcall (and Zwicky) small values for the core radius "results from their inclusion of counts very near the cluster center, where small differences in the numbers of galaxy images result in large differences in derived densities". His result in Coma, counting galaxies down to 5 magnitudes fainter than the brightest, gives a core radius more than three times as large as that of Bahcall (1973), although for Coma she also considered various magnitude limits but found no significant variation in the core radius with magnitude. Quintana and Havlen (1978) have found in their analysis of CA0340-538, that the value of the core radius changes as different magnitude limits are considered. At a level of 3.5 magnitudes fainter than the brightest they find the core radius to be about 0.40 Mpc. For brighter magnitude limits the core radius decreases. At 2.5 magnitudes fainter than the brightest its value turns out to be about 0.25 Mpc. More work is required to confirm this effect in other clusters. If found true, it would mean that more mass segregation exists in clusters than is usually recognized. Such possibility raises interesting questions concerning the cluster dynamics and evolution.

THE LUMINOSITY FUNCTION

The luminosity function describes the number of galaxies per unit volume having a specified luminosity. One expects that the luminosity function would partially reflect conditions at the time of galaxy formation, for instance the form of the spectrum of the initial mass perturbations. But it also reflects evolutionary processes occurring in galaxies, and in the present context, of galaxies in clusters.

Two different functions suggested as approximations to the observed luminosity function in clusters dispute the favor of today's observer and theoretician. The universality of both the form and the parametrization has been claimed in each case. These functions are Abell (1964) proposal for the integrated logarithmic luminosity function and Schechter (1976) form for the differential function. Both have a power law at faint magnitudes (with an equivalent value for the exponent) but differ in the shape of the bright end.

Abell function has the form of two power laws: $\log N(< m) = K + sm$, with $s_1 \approx 0.75$ for $m < m_*$ and $s_2 \approx 0.25$ for $m > m_*$, where m_* is the characteristic magnitude defined by the intersection of both straight lines in the $\log N$ - m plot. Abell has claimed that the absolute value of this magnitude is universal and a better standard candle than first ranked galaxies. This is fairly well supported by part of the data and Abell (1976) reviews arguments in favor of his proposal (he also reviews other earlier suggestions for the luminosity function). Although Abell form appears to be a good approximation for the integrated function, it is just an empirical formula. No direct interpretation in terms of conditions of galaxy formation was originally intended. The abrupt break in the slope at m_* cannot be physical (it implies a discontinuity in the differential function) and clusters show various degrees of rounding the "knee". However, this feature is represented by a local maximum in the differential form, and this is very interesting because some clusters definitively show that local maximum (but not all).

The second, and more recent proposal, is that of Schechter's (1976) approximation $\phi(L)dL$ for the number of galaxies with luminosities between L and $L+dL$:

$$\phi(L)dL = \phi_* \left(\frac{L}{L_*} \right)^\alpha e^{-\frac{L}{L_*}} d\left(\frac{L}{L_*} \right)$$

which has an exponential cut-off towards the bright magnitudes. The value of α gives the slope at the faint end. Schechter suggests a universal value $\alpha = -1.25$ (corresponding to Abell's $s_2 \approx 0.25$). L_* characterizes the region where the power law changes to the exponential (with a corresponding value for M_*) and ϕ_* is a normalization that is related to the richness of the cluster. Schechter fit his law to Oemler's (1974) data on 13 clusters and found that a value of $M_B^*(0) = -20.6$ ($L_* = 3 \times 10^{10} L_\odot$) described the cluster luminosities reasonably well. He found these same values when he fitted the data on the field galaxy luminosity. Felten (1977) has reconsidered all the photometric data on field galaxies from many observers and critically analysed their determinations of the luminosity function (obtained with different techniques and photometric systems). He found that, with the exception of one set of data, Schechter function describes all the data extremely well with that value of M_B^* and α . Schechter's form has the advantage of being continuous and one hopes it has a deeper meaning than Abell's for that reason, and because it describes the luminosity function of all galaxies. It fits some of the data better in one important respect than Abell's form. Many clusters show a progressive steepening in the luminosity function at the bright end, and Schechter's form gives a better account of this.

There are today about 40 rich clusters of galaxies for which photometry has been done with the aim of deriving the luminosity function. Hoffmann and Crane (1977) give references to most of these studies, to which one would add the recent work by Dressler (1976), by Abell (1977), Godwin and Peach (1977) and Quintana and Havlen (1978).

Most of the published data comes from five groups of observers (Abell and coworkers, Oemler, Peach and coworkers, Hoffman and Crane, Dressler). As far as one can see, three of them have done a homogeneous study of a fairly large number of clusters (Oemler: 15, Hoffman and Crane: 6,

Dressler: 12). But new studies are underway (Bucknell, *et al.*, 1978, and others) and one hopes that in a few years the number of clusters studied homogeneously will grow significantly.

Very recently two extensive photometric studies of the Coma cluster have been published in detail (at last!) by Abell (1977) and by Godwin and Peach (1977). They generally confirm earlier data, but show some new features. Godwin and Peach give V_{25} isophotal magnitudes of 923 galaxies (497 galaxies down to completeness limit of $V_{25} = 17.5$) in a square of 1.22×1.22 centered on the cluster. They find values of the Abell slopes of 0.64 ± 0.02 and 0.25 ± 0.005 , which compares well with Abell (1976) earlier determination of 0.75 and 0.25. A clear break in the luminosity function appears at $V_{25} = 14.92$ ($M_V^* = -20.98$). Two interesting details appear in the differential function. The local maximum around m_* is very significant, and any theory of cluster luminosity or evolution should explain it. By dividing the inner 1.2 Mpc into two zones they find that there is an excess of intermediate luminosity galaxies ($14 \leq V_{25} < 16$) and a deficit of bright and faint galaxies in the central region. Is this effect the result of the operation of the central cD galaxy? Abell (1977) goes much deeper, having photometered 1182 galaxies down to $m_V = 18.3$ in the central 7 sq. deg. area (in a smaller area, the completeness limit went to $m_V = 19.4$). Abell found that the integrated luminosity function (covering $\sim 8^m$ range) can be divided into three segments, approximated with slopes: $s_1 = 0.85$ ($m < m_V^* = 14.5$); $s_2 = 0.175$ ($14.5 < m_V \leq 17.5$); $s_3 = 0.34$ ($17.5 < m_V \leq 19.4$). Abell estimates from his errors that the existence of the third branch in the luminosity function is nearly certain, although one can not discount a serious systematic error in the evaluation of the background correction, crucial at those faint magnitudes.

What about the other clusters? How well do their luminosity functions follow Abell or Schechter functions? How are the departures from these forms to be interpreted? The older data was reviewed by Abell (1976). He finds that Coma, A2065, A151, A2199, A1377 and the Virgo clusters conform very well to his approximation. However, one can see that his data for A2065 implies a steep cut-off at the bright end.

Oemler (1974) and Dressler (1976) have studied about 12 clusters each with similar photographic photometry techniques. Dressler sample is somewhat richer and fainter than Oemler, but his plate scale was better. Generally speaking, most of these luminosity functions followed the Schechter and/or the Abell form reasonably well (in fact Schechter originally used Oemler data to fit his function). But in both cases, most notably in Dressler data, there are a few clusters that largely depart from any of those forms. For a few others, the best fit was obtained by different values of the parameters: this suggests these parameters may have a significant dispersion. In total, about half of Dressler data fitted the Schechter function well, the other half departed from it in one way or another.

A characterization of these departures is:

- A2670 ($z = 0.075$). Richness class 3. In Oemler's data it appears having a very flat faint end, and a steep bright end. Assuming these features to be due to unreliable photometry, Schechter did not include it in his composite of 13 clusters. Abell and Mottman (1977) get $s = 0.175$ for the faint end (flatter than 0.25) more in agreement with the middle branch of Coma. They give a revised richness class 2. Dressler confirms the flat faint end slope.
- A665 ($z = 0.18$). Richness class 5. The richest in Abell catalogue (Abell, 1958). Oemler and Dressler studied it: it has an even flatter faint end than A2670. The value of m_* is $0^m.66$ fainter than Schechter's value (Dressler, 1976).
- A274 ($z = 0.129$). Richness class 3. Originally catalogued by Abell in the same distance class as A2670, although the redshift is nearly double. Excepting the cD in A2670, the brightest galaxies in A274 are a whole magnitude brighter than those in A2670. There are relatively

fewer faint galaxies than in other clusters. In Dressler data the cluster luminosity seems to rise abruptly and then level off, the faint end being consistent with $\alpha = 0$. The m_* value is a full magnitude brighter than Schechter's.

- A168 ($z = 0.045$). Richness class 2. An extreme case of discrepancy, as shown by Dressler. No reasonable fits can be obtained. The luminosity function is like that of A274 but exaggerated: many galaxies appear suddenly at the same magnitude and thereafter the luminosity function has zero slope. It has a very different shape than Schechter's or Abell's. Also, even though the cluster has a regular appearance and a well-defined core, it is dominated by spirals.
- A2029 ($z = 0.077$). Richness class 2. The unusually bright cD is about 2 magnitudes brighter than the second brightest. It fits well the shape of Schechter function but has an $m_* 0.75$ fainter than the canonical value. It seems this is a clear case where some physical process is making grow the cD at the expense of the rest of the cluster. The bright end of the data looks quite steep.
- A401 ($z = 0.075$). Richness class 2. This cluster shows a very flat faint end and $\alpha = -1$ gives a good fit (Dressler, 1976). At the bright end the data is very steep, as in A2670. Both of these clusters are examples having a "too steep bright end -- too flat faint end" luminosity function.

One can summarize the evidence from the data in the following way. There are some clusters where a power law is a better approximation than Schechter exponential form for the bright end (A2256, A98, A154). On the other hand there are clusters that can not be fitted by a power law and are much better described by an exponential (A2029, A2218). It seems quite likely that the form of the bright end has a continuous range depending on the importance of some physical process. The most deviant cases are the richest clusters studied (A2670, A665, A274, A2218 : $R \geq 3$). It is conceivable these effects did not appear in Oemler (1974) work because only 3 out of 15 clusters of his sample had $R \geq 3$. Are some processes operating that depend heavily on the richness of the clusters? There is independent data, to be discussed later, that show very rich clusters as having large quantities of intracluster gas. It seems important to study optically those other rich clusters (particularly those with $R = 4$) to confirm a general departure from Schechter function for very rich clusters. Dressler (1976) suggests that it is quite likely that no specific form of the luminosity function is adequate to describe all clusters.

A different question is whether or not all the differences in the luminosity function are explainable as being due to evolutionary processes or are some due to varying initial conditions? The evidence seems to point mostly to evolutionary processes, but there is some data that suggests that initial conditions are still traceable in the luminosity functions. These are the cases of the clusters whose luminosity functions depart radically from Schechter form, for instance A168. Also, an example like A274 is difficult to explain by evolution. Just too many very bright galaxies are present. Are there more cases like this?

III. DYNAMICS AND EVOLUTION

The study of the dynamics of clusters of galaxies is an old subject in extragalactic astronomy. Since Zwicky (1933) and Smith (1936) concluded that the mass-to-light ratios in the Coma and Virgo clusters were orders of magnitude larger than those of individual galaxies, the so called "missing mass" problem has haunted astronomers. It remains as one of the oldest enigma of astronomy to this day. In spite of drastic changes in the distance scale and in other areas of our knowledge, we find that current determinations of the M/L ratios in large clusters are 10-20 times larger

than those of the visible individual galaxies.

Present day studies of the dynamics of cluster of galaxies encompass many new areas other than the classical virial mass determinations. But even in this area many new analysis of large bodies of data on groups and binary systems have been published. Velocities are being measured not only in clusters themselves, but in their surroundings. Dynamical studies of superclusters are under way. The large number of galaxy velocities now available in a few clusters, make it possible to study the causes of cluster flattening: rotation or anisotropic velocity distribution. Perhaps the most exciting developments in this area are the studies of various evolutionary processes that seem to be operating in clusters. An important fraction of this work has been mostly theoretical, but recently a significant number of observations describing evolutionary effects are appearing in the literature.

MASS-TO-LIGHT RATIOS AND THE INVISIBLE MATTER

Under the assumption of stationarity for the cluster, the virial theorem can be applied to obtain an estimate of the total mass in the system. This determination relies on two observational quantities. The velocity dispersion and the gravitational radius. The measurement of the first is a straightforward process. If a large number of velocities is available, the major source of uncertainty derives from the assumption of isotropy of the velocity field (a $\sqrt{3}$ spherical projection factor is normally assumed). On the other hand the estimate of the gravitational radius is a very uncertain business. The key problem derives from the evaluation of the background (which is very lumpy) and the fact that the cluster slowly dissolves into it making difficult to fix a boundary. The gravitational radius is defined as the mass-weighted mean harmonic radius. An application of the definition requires a knowledge of the member masses and the cluster membership, as regards individual galaxies. Operational procedures have been suggested (Schwarzschild, 1954) and have been used in the past (Rood *et al.*, 1972), but they do not reduce the uncertainties. It seems that gravitational radii are estimated to no better than about 50%. The most promising method is to relate the gravitational radius to the scale length of some model. Dressler (1976) has shown that a fairly good correlation exists between the derived global radii and core radii for his sample of 12 clusters. These findings should be confirmed by other homogeneous studies. Another way to derive a value for the cluster mass is via the fitting of a model to the mass weighted counts. The de Vaucouleurs (1960) model could be particularly suited for this job, but it has rarely been used.

The other quantity needed to derive M/L ratios is the determination of the cluster total luminosity. Assuming a reliable photometry, the major problems are the estimate of the total luminosity of the very faint members and the background (where corresponding luminosity functions have to be determined or assumed), and of the diffuse light detected in many clusters (in some cases this includes partially or totally the light from the cD central galaxy). This last correction can be very significant, and it is unclear whether it has been included in some results published.

The range of M/L values for rich clusters is usually taken to be 150-400 $M_{\odot}/L_{\odot}$, but one should keep in mind the uncertainties discussed above. Van den Bergh (1977) and Bahcall (1977) review in detail some of the older data, in particular that on Virgo. Some more recent results are those of Dressler (1976) for 12 clusters whose M/L values span the range mentioned and that of Abell (1977), where he obtains a new value of $M/L \sim 120$ for the Coma cluster, lower than the early value of ~ 200 (Rood *et al.*, 1972). More intriguing is the recent determination of $M/L \sim 36$ in A194 by Chincarini and Rood (1977).

There is a growing body of data that suggests that M/L values increase as larger dimensions

are considered. Central regions of galaxies have $M/L \sim 3-10$ (Williams, 1977, and references there). Rotation curves of spiral galaxies show that the mass increases linearly with radius over regions more than twice the visible dimensions (Roberts, 1976). Total M/L values of those galaxies should grow as larger radii are considered. Galaxies in groups seem to have rather large values ($M/L = 60$) as derived from statistical analysis of large samples of binary systems and groups (Gott and Turner, 1977; Kirshner, 1977), although some controversy exists on that matter. Finally, the large clusters have the high M/L values already discussed.

Dynamical arguments (Ostriker, Peebles and Yahil, 1974) suggested that spiral galaxies have large underluminous halos, required to stabilize their disk components. Efforts to photometrically detect these halos have had little success, but this only puts limits on the luminosity of their material. The mass in halos can not be gaseous (Bergeron and Gunn, 1977). Consequently it should be in condensed bodies, the prime candidate being low mass stars, or neutral particles (Gunn *et al.*, 1978; Steigman *et al.*, 1978). Recently Gunn (1977) has calculated the structures the halos would have if they are formed by material that falls on the galaxy during its formation and he has shown, assuming the process to be dissipationless, that their densities would have a nearly r^{-2} radial form (the mass would vary linearly with radius). All galaxies should have similar halos. If the halos are formed by heavy neutral particles they would have similar shapes. In fact the ratio of the dark material to visible matter should be the same when whole bounded structures that form in dissipationless collapse are considered (partial substructures where dissipation has taken place will have varying proportions of neutral particles, Steigman *et al.*, 1978). In large clusters most of the matter in the halos (whatever their nature) would be stripped from the galaxies during the period of violent relaxation. This material, plus any other dark matter originally belonging to the cluster as a whole would acquire an isothermal distribution as a result of violent relaxation. The dark matter would have a smooth distribution that would follow the galaxy distribution. White (1976) from computer simulations of Coma has shown that the mass in dark material has to be smoothly distributed in the clusters. It can not be in galaxy-masses type objects or much more mass segregation than is observed would occur.

DYNAMICAL EVOLUTION

Clusters are believed to be formed by the collapse of density perturbations developing after recombination, $z \leq 1000$ (Gunn and Gott, 1972). It is not clear at what stage in the collapse the galaxies form and acquire their individualities: masses, types...etc. The collapse is followed by a process of violent relaxation (Lynden-Bell, 1967) and virialization, which Peebles (1970) showed to be essentially complete by 1.5-2 collapse times. The time taken by large clusters like Coma to gain a regular virialized structure is calculated to be somewhat less than the age of the universe. However, it is speculated that irregular, low density clusters may have not yet completely collapsed, or relaxed, what would explain their appearance. If galaxies were point particles, very little else would have subsequently happened apart from two-body relaxation (Chandrasekhar, 1942). But galaxies have finite sizes. The ratios of galaxy sizes to galaxy separation in clusters are much greater than similar ratios for other stellar dynamical systems, such as globular clusters or elliptical galaxies, where stellar radii are an insignificant fraction of the interparticle distances. Galaxy collisions have a pronounced effect in the dynamical evolution of the cluster and on the appearance of the galaxies themselves. We have already mentioned halo stripping, but more complex interactions seem to occur. Here we shall give a very short description of some of them.

a) Two-body relaxation. The extended nature of galaxy makes collisions differ from that occurring

in other stellar systems (Richstone, 1976). The main result is the tendency to equipartition, whereby the more massive galaxies lose some of their energies to lighter ones. More massive galaxies drift toward the central regions while lighter ones move out to the periphery. Although the effect is not too marked in the time available, observations suggest that mass segregation in Coma is $\leq 20\%$, but these results (Bahcall, 1973; Rood *et al.*, 1972) could be revised. The soft nature of the galaxies' potentials prevents the formation of tightly bound binaries, that are important in other stellar systems.

- b) cD formation. The observed cD phenomena may be produced by a combination of various processes:
 - i) During encounters, galaxies strip each other of part of their material (halos, disks...). This material, stars and whatever else, would fall to the bottom of the cluster mean potential, where it piles up (Gallagher and Ostriker, 1972; Richstone, 1976). Because the falling stars would essentially have the galaxy velocities (with $\Delta V \approx 1000 \text{ km s}^{-1}$) they form an extended nearly isothermal distribution. If a massive galaxy is sitting near the bottom of the potential, this distribution would contribute to its envelope. Both entities would interact by means of their potentials forming one object.
 - ii) Galaxies passing through the central regions should suffer the effect of the higher densities and the friction in the envelopes of the larger galaxies or the cD. Galaxies will merge and smaller ones will effectively be eaten by the larger ones. The observations of central cD's with double or multiple cores are examples of this phenomena. Also, it is common to find many faint galaxies embedded in the envelopes of cD's. Ostriker and Hausman (1977) have shown how the merging of galaxies in clusters will form cD galaxies, and calculated the evolution of these types of objects.
- c) Evolution of cluster members. We have already seen the effects of evolution on the luminosity function. But the dynamical processes can have a deep effect on the internal structure of galaxies in the cluster. Strom and Strom (1978) have carried out detailed photometric observations in the Coma cluster. They find that there is a fundamental difference between the ellipticals in the central region as compared to those in the outer regions. They find, for instance, that the central ellipticals have brighter (higher surface brightness) cores and less extended envelopes than do ellipticals in the periphery. The absence of envelopes can be explained in terms of the higher rates of stripping to which the central galaxies are subjected. But the data also shows that the nuclear regions are also affected. It seems that environment can play a key role in the structure and evolution of galaxies.
- d) Galaxy sweeping. We already mentioned the effect that an intracluster gas would have on the gas content of galaxies: they would be swept clean of their interstellar gas. This process would be most marked in galaxies moving through the central, higher density regions. As discussed, the effect on spirals would be to devoid them of any star forming gas, transforming them into SO's. For SO's and ellipticals the effect is to stop any possible accretion of gas by their nuclei, thus cutting off the power source of possible energetic phenomena, such as radio emission. The evidence for this will be briefly discussed in the next section.

All the processes mentioned so far are examples that show that dynamical and galaxy evolution in clusters are intimately linked, and seem to be faster than once believed. Most of these processes or their effects are observable. In fact, some of them are spectacularly observable, as cD's attest. In view of the importance and rate of these processes, it seems that large evolutionary effects could be observed by investigating clusters at increasing redshifts, and research is moving in that direction.

IV. RADIO AND X-RAY EMISSION

Clusters as a whole and individual galaxies in clusters are known as sometimes being the source of radio and x-ray emission. Both of these areas are the subject of intensive investigation. In x-ray astronomy particularly, the field is changing very rapidly. Due to the limited space available here we will not review these developments, but only mention a few points. Van den Bergh (1977) has reviewed the optical properties of radio sources in clusters.

RADIO SOURCES IN CLUSTERS

There are essentially three types of radio sources in clusters:

- a) from dominant galaxy. They are powerful sources. More common in B-M Type I clusters (contain the most dominant galaxies). The radio structure is either that of small doubles (~ 50 kpc separation) or wide angle tails. They have steep spectra: $\alpha \geq 1.2$.
- b) from other member galaxies (a prominent bright galaxy). Not very powerful sources. The morphology of the radio sources is: i) wide angle, medium, or narrow tails; ii) "classical doubles", out of the central regions. The tails mostly point away from the cluster centers. The intermediate angle ($20^\circ - 90^\circ$) always do. The fainter galaxies show long narrow double tails ($0.1 - 1$ Mpc), and are located in the borders of the clusters.
- c) low frequency cluster sources. These are extended low surface brightness sources, most prominent at frequencies of $20 - 600$ MHz.

About 60% of radio sources in clusters show distortion or misalignment. Some of the features of radio sources in clusters support the existence of intracluster gas, and can be understood on this hypothesis. The radio morphology of D or cD galaxies (type a) above) is explained by: 1- High confinement of the gas in the central regions. 2- Small relative velocities to the gas. 3- Time for synchrotron and inverse Compton losses to age the electrons, thus steepening the spectra. In b) above, higher velocities imply higher angle tails, and differential ram pressure or the buoyancy of the lobes in the inhomogeneously surrounding gas accounts for the direction of the tails. If the galaxies are in the periphery the gas influence is small and near classical doubles are the outcome. Radio galaxies that move rapidly through the gas leave behind the long tails. There is a lack of faint sources in the central regions: perhaps they are swept clean of gas that may power the radio source (by accretion presumably): in the outer regions small galaxies would have time to replenish their gas. Clusters of galaxies detected as x-ray sources usually contain one or more radio galaxies, and some at least, contain the low surface brightness low frequency radio halos.

How many radio sources are in clusters and how many outside? It is difficult to say because a large number of radio sources are at cosmological distances. Of the rest we only know about catalogued clusters, essentially the Abell catalogue. Many sources can be in less rich clusters or groups, and still their properties may be affected by that. It was thought that head-tail (narrow tail) sources only existed in rich clusters. Ekers *et al.*, (1978) have recently found two such sources in poor clusters.

Systematic studies of radio sources in clusters have been carried out by various groups. Rudnick and Owen have surveyed Abell clusters with the NRAO interferometer. (Rudnick and Owen, 1977 ; Owen, Rudnick and Peterson, 1977). Mills and Hoskins (1977) observed Abell clusters at a frequency of 408 MHz with the Molonglo telescope. With the 1-mile and 5-km telescope in Cambridge, McHardy (see his review, 1976) has also been studying Abell clusters. Much work has been done at Westerbork and is reviewed by Harris (1976). The extended emission was found in Coma by Jaffe, Perola and Valentijn (1976). Similar sources have been detected in A2319 (Harris and

Miley, 1978) and A2256. Haslam *et al.*, (1978) suggest that they are also present in A754 and A2142. The source in the Perseus cluster has not been confirmed in new observations. The large sizes of these sources present intriguing problems regarding the origin of the electrons, the strength of the intracluster magnetic fields and their general relationship to cluster x-ray sources.

We want next to discuss some new radio observations, that seem to confirm the presence of hot gas in rich clusters.

DEFORMATION OF THE MICROWAVE BACKGROUND IN THE DIRECTION OF CLUSTERS OF GALAXIES

A necessary consequence of the existence of hot gas in rich clusters of galaxies, as required by the thermal bremsstrahlung origin for their x-ray emission, is the Compton scattering of the microwave background photons (with a blackbody spectrum at 3.0° K) by the high energy hot electrons. Some of the microwave photons are heated and the background is slightly shifted to higher temperatures. At a fixed frequency on the Rayleigh-Jeans regime there is a decrease in the photon population and a diminution of the intensity of the background radiation: a "cold spot". Above a critical frequency λ_{cr} , calculated by Gould and Rephaeli (1978) at $\nu_{cr} = 0.14$ cm the effect changes sign and on the Wien regime there is an increase in the intensity of the background. If the x-ray emission from clusters is due to the inverse-Compton process, no changes in the temperature of the background is expected, although source models require some amounts of gas for confinement, implying a small microwave background deformation.

The magnitude of the change in the photon population is proportional to the line of sight integral of the product of the electron density n_e and temperature T_e : $\Delta\bar{n}/\bar{n} \sim \int n_e T_e dl$, in the Rayleigh-Jeans regime. This quantity is model dependent, and its value for typical parameters of gas clouds associated with cluster x-ray sources is of the order of 1 m°K. The results of experiments designed to measure the flux of the background radiation from clusters are important not only because they would prove the presence of hot gas, but also because they provide an independent measure of a different function of n_e and T_e than do x-ray fluxes (and spectra). The x-ray spectral flux at energy ϵ_x is a volume integral of $n_e^2 \times T_e^{-1/2} \exp(\epsilon_x/kT_e)$. A convenient way to model the radial dependence of the gas (and electron) density (Lea *et al.*, 1973) is: $n_e(r)/n_e(0) = (1 + r^2/a^2)^{-3/2}$, where a is a scale length (the core radius). For Coma, the fitting of this model to the x-ray observations gives $a = 16' \pm 3'$ (0.58 Mpc). Taking the value of the observed flux at 10 keV, $S = 1.0 \times 10^{-2} \text{ cm}^{-2} \text{ s}^{-1}$ and a temperature $kT_e = 8.7$ keV we can derive a central electron density of $2 \times 10^{-3} \text{ cm}^{-3}$. With these values one can calculate (for a similar gas model) the background depletion $\Delta\bar{n}/\bar{n} = -1.6 \times 10^{-4}$, or the decrease in brightness: $(\Delta T) (\text{Coma}) = -0.43 \text{ m}^\circ\text{K}$. These values are model dependent. For polytropic models ($\gamma = 5/3$) of Coma, Bahcall and Sarazin (1977) calculated $\Delta T \approx -0.5$ to $-0.9 \text{ m}^\circ\text{K}$. One can express the ΔT in terms of the x-ray observable parameters if a model is assumed. Taking an isothermal model, for instance, one finds that $\Delta\bar{n}/\bar{n} \sim (\bar{n}_e/n_e^2)^{1/2} (L_x/a)^{1/2}$. If the length scale has similar values from cluster to cluster then $\Delta\bar{n}/\bar{n}$ scales with $L_x^{1/2}$ (no inhomogeneities in the gas). Also, by using various other suggested dependences of temperature and velocity dispersions other scalings are possible (Rudnick, 1978), in particular $\Delta T \sim (\Delta V)^4/a$ or $\Delta T \sim (L_x/a)^{1/2} (\Delta V^3)^{1/2}$.

In Table IV we list the results from three recent experiments at different telescopes by Gull and Northover (1976), Lake and Partridge (1977, 1978) and Rudnick (1978). In the last column the predictions for some clusters are given based on the prediction for Coma (using the two scalings given above). Previously, Pariiskii (1973) had reported the detection of the effect in Coma with a value of $-1.5 \text{ m}^\circ\text{K}$, following a suggestion of Sunyaev and Zeldovich (1972), but there are doubts on its reliability. Gull and Northover (1976) also claimed the detection of the effect in Coma

TABLE IV
Change in Microwave Background Temperature in the Direction of Clusters

Abell No.	Z,D	R	R-S	ΔV	$L_x 10^{44}$ (6)	Observations m°K			Theory	
						Gull & Northover 10.6 GHz (1)	Lake & Partridge 33 GHz (2)	Rudnick 15 GHz (3)	(a)	(b)
376	3	0	I			0.13 $\pm$ 0.66				
478	6	2			5.4 U	+0.33 $\pm$ 0.52				
576	2	1	I			-0.71 $\pm$ 0.57	-0.0 $\pm$ 0.21	-0.0 $\pm$ 0.21		
401	0.07	2	cD	1400	22 A		-0.4 $\pm$ 0.61	-0.4 $\pm$ 0.04	-3	-1.7
1656	0.02	2	B	900	4.5 U	-1.51 $\pm$ 0.40*	+0.25 $\pm$ 0.21	+0.4 $\pm$ 0.6	-0.6	
1689	6	4					-1.06 $\pm$ 0.46			
2079	3	1	cD				-0.33 $\pm$ 0.19			
2125	6	4					-3.1 $\pm$ 0.34			
2199	0.03	2	cD	840	1.7 U			0.6 $\pm$ 0.5	-0.5	-0.3
2218	0.16	4	cD			-1.94 $\pm$ 0.54	-2.6 $\pm$ 0.23			
2255	0.08	2	C	470(4)				0.7 $\pm$ 1.2	-0.04	
				1230(4)					-2.0	
2319	0.05	1	cD	870(5)	11 U	-0.13 $\pm$ 0.41	-0.08 $\pm$ 0.19	0.8 $\pm$ 0.9	-0.5	-8
				1630(5)					-6	-2
2666	0.027	0	cD		3	-0.27 $\pm$ 0.35	-0.1 $\pm$ 0.3			

NOTES: (*) This value should be multiplied by ~ 1.5 for comparisons (see text). (a), (b) Scalings from Coma as discussed in the text. (1) Gull and Northover, 1976. (2) Lake and Partridge, 1977, 1978. (3) Rudnick, 1978. (4) Faber and Dressler, 1976. (5) Tarenghi and Scott, 1976. (6) A: values from the Ariel V catalogue, U: from the 4U catalogue.

at the same level. To make this number comparable to the other two values from the experiments listed, a correction of $\sim 50\%$ (Gould and Rephaeli, 1978) should be applied to account for cluster size (different models). These two results are in contradiction with results by Rudnick (1978) and Lake and Partridge (1978), who did not detect a significant effect in Coma (consistently with the predictions). Lake and Partridge (1977) confirm the detection in A2218 by Gull and Northover (1976) at a level of -2.5 mK. They also reported positive detections in another two very rich clusters. These three clusters are $R = 4$, $D = 6$, so it is quite possible that $n_e T_e$ is strong function of richness (although an apparent size effect may play a role if the gas were spread somewhat more broadly than expected). These clusters are too far away to have been detected as x-ray sources yet (but A2218 has recently been detected). Some other remarks are worth being made on the results in Table IV. On account of the large x-ray luminosity reported in the 4U and Ariel catalogues for A401, it is surprising its null detection. In two other cases, suggestions have been made that there are two clusters in projection, which imply smaller velocity dispersions (cases of A2319 and A2255). The observations rule out the high velocity dispersion scaling, and support the suggestion that in both cases two clusters are actually seen.

The detection of the microwave background deformation in clusters promises to be a useful indicator of the physical conditions in the intracluster gas, as already mentioned. To obtain a

consistent unique picture, one also needs the results of x-ray observations--luminosities and gas temperatures--plus some optical data, particularly velocity dispersions and structural parameters necessary to evaluate virial masses, shape and strength of potential wells, etc. With this information one can check on models of the gas configuration--isothermal, adiabatic or otherwise-- and on theories of the physical mechanisms involved. The discrepancies already apparent in Table IV clearly show the urgency with which better velocity dispersions are needed: they are critical in estimating the expected theoretical values, some of which are in conflict with present experiments (A401, A2319?). It is expected that new radio observations could lower the detectability limits to the 0.5 m°K level, when most of the presently known x-ray clusters should be detected. On the other hand, the present data fully justifies a complete optical study of all $R = 4$ clusters.

X-RAY EMISSION

Soon after the launching of the first x-ray satellite it was realized (Gursky *et al.*, 1971) that sources located in clusters form a large proportion of the x-ray extragalactic sources. After seven years, during which a number of other x-ray satellites have been launched, the original finding is still valid. A lot has been learnt about the properties of these x-ray sources and a large fraction has been conclusively identified with clusters. A general review is given by Gursky and Schwartz (1977).

Let us just summarize the most salient points in these areas.

1 - Two catalogues of x-ray sources have been published.

- a) The 4U UHURU catalog (Forman *et al.*, 1977), a revision of the 3U catalog. It covers most of the sky to a limit of about 2 counts s^{-1} , but was complete to about 10 counts s^{-1} . Typical sizes of 90% error boxes for clusters are about 0.1-0.5 square degrees. Typical intensities for clusters are a few UHURU counts s^{-1} .
- b) The 2A Ariel V catalogue (Cooke *et al.*, 1978) for high latitude galactic sources ($|b^{II}| \geq 10^\circ$). It is complete to a limit around 1.2 Ariel counts s^{-1} (~ 3.2 UHURU counts s^{-1}) but includes many sources down to 0.3 counts s^{-1} .

The 4U and the 2A list 198 and 107 sources with $|b^{II}| \geq 10^\circ$, respectively. Of these 40 and 34 are tentatively associated with clusters with $D \leq 4$. About 25 clusters sources have been observed by both satellites, most of which can be considered certain identifications. Besides that, both sets of data have been specially searched for sources that could be associated with Abell clusters (Jones, Forman and Tucker, 1978; Ricketts, 1978). No significant results were obtained and the few extra identifications are somewhat uncertain.

The typical luminosities range from about 2×10^{43} to about 10^{45} erg s^{-1} . Excepting QSO's, and superclusters (if they do emit x-rays), clusters of galaxies are the most luminous sources detected.

2 - In a number of cases the good angular resolution of the x-ray observations (that includes rocket x-ray telescopes and other satellites) permitted maps to be drawn and the extent of the sources have been measured (for the Virgo cluster see for instance : Gorenstein *et al.*, 1977. Also the review by Gursky and Schwartz, 1977). The core sizes of the x-ray emitting region (see previous section) have generally been found to be somewhat larger than the optical core radius as determined by Bahcall (1977), but see the previous discussion about those determinations. The recent launching of the first HEAO satellite that has a good angular resolution, should greatly improve these determinations.

3 - In some nearby clusters containing very active galaxies, such as Virgo, Perseus, Centaurus, a central point component has been detected. This is interpreted as a contribution from a compact

source associated to the very extended radio and optical halo of M87, NGC 1275 or NGC 4696, rather than to the cluster as a whole.

4 - The OSO-8 satellite has measured the spectra from 20 sources in clusters, in the 2-20 keV energy range (Mushotzky *et al.*, 1978). The UHURU and Ariel V satellites have also determined spectra in the ranges 2-10 keV, and 2-18 keV. Softer spectra have also been measured for some clusters using rocket observations. Because the spectra in the 2-10 keV look nearly straight and in view of the limited statistics, in most cases it is impossible to decide whether a power law or a thermal spectrum is more appropriate. But the 10-20 keV data now moderately favours a thermal spectra. So does the observation of x-ray emission lines (see below). The amounts of gas required in rich clusters is of the order of $10^{14} M_{\odot}$ in the thermal interpretation.

5 - The temperatures derived for the emitting gas are mostly in the 4-10 keV. A few require somewhat higher temperatures and A2142 needs $T > 30$ keV (Mushotzky *et al.*, 1978). Ariel data (Mitchell *et al.*, 1977) and UHURU data (Jones and Forman, 1977) confirm most of these temperatures. There are no large discrepancies in their determinations.

6 - The presence of Fe lines, at ~ 7 keV, has been detected in at least 8 clusters. The derived abundances are always of the order of $Fe/H \sim 1.4 \times 10^{-5}$ by number. The observation of these lines again support the thermal source of the x-rays. They also imply that, at least partially, the origin of the intracluster gas is not primordial. A significant fraction of this gas should have been processed by stars to produce the near solar abundances. The estimated emission measures, $n_e n_H Vol$ are proportional to the central density of galaxies in the clusters. This favours a model where gas is coming out of the galaxies. DeYoung (1977) has shown that no serious discrepancies occur in a model where most of the gas was produced by massive stars during the early evolution of galaxies, if the galaxies were originally more massive than today, say with $10^{12} M_{\odot}$ or slightly less, typically.

7 - Some correlations are appearing in the data. It seems certain that $T_x \sim (\Delta V)^2$. Also L_x is strongly correlated with T_x : $L_x \sim T_x^{5.5}$. Some other correlations have also been suggested, although their physical interpretation is not yet clear (Mushotzky *et al.*, 1978; Mitchell *et al.*, 1977). It is still uncertain which is the form of the correlation between L_x and ΔV . The various propositions, most notably the Solinger and Tucker (1972) proposal, are consistent with the data. Apart from the uncertainties in the x-ray fluxes the velocity dispersions in some clusters are poorly known, and for some of the new identifications they are totally missing. Of special importance in the correlation are those for the low luminosity x-ray clusters. However, it has been suggested that x-ray luminosities in these low luminosity clusters is partly or entirely due to a single galaxy. If this is the case, the correlation will not be valid for this type of sources. Anyway, more (slow) optical work on velocity determination is badly needed.

8 - Various correlations between optical morphological parameters and L_x have also been suggested. Bahcall (1977) reviews the evidence for her suggestions in terms of the Rood-Sastry type and central densities. The correlation with richness class has also been claimed (Jones and Forman, 1977). These correlations can be very helpful when considering alternative clusters for a possible identification. It is not yet clear what is the reality and meaning of the proposed correlations.

9 - It has recently been claimed (Murray *et al.*, 1978) that superclusters are also detected by the UHURU satellite as x-ray sources. The masses involved in the hypothetical, low density, very extended gas would be of the order of $10^{16} M_{\odot}$. They would have an extraordinary effect in the total mass of the universe. These sources have not been confirmed by Ariel V observations (Ricketts, 1978).

Of the around 40 clusters identified with x-ray sources, there are some 15 clusters in the southern skies. Due to the lack of cluster catalogues, most of them had to be identified singly. With the exceptions of the nearby A1060 and the cluster in Centaurus (HMS1247-4102), they were largely unstudied. This situation is improving rapidly due to the efforts of various groups. Preliminary identifications and morphological studies were carried out by a number of people (Vidal, 1975; Melnick and Quintana, 1975; Lugger, 1978; Bahcall, 1977; Maccagni *et al.*, 1978; Maccararo *et al.*, 1977; and others). No results of detailed studies of these clusters have been yet pub-

TABLE V
Southern X-ray Clusters of Galaxies

2A source	I_x counts s^{-1}	Error box sq. deg $^{-1}$	T_x keV	Cluster	D,R (1)	z (1)	RS (2)
0039-096	1.2	0.075		A85	4,1	0.066	cD
0102-222	0.4	0.700		A133	4,0	0.07	cD
0102-242	0.3	1.000		A140	6,3	0.18	cD
0316-443	0.5	0.210		SC0316-441	4,1	0.09	cD
0343-536	0.7*	0.110		CA0340-538	3,2	0.057	L
0430-615	1.1*	0.077		Ser40/6	3,3	0.06	C
0431-136	0.9	0.067		A496	3,1	0.036	cD
0626-541	0.8	0.162	6.3	SC0627-544?	3,3	0.050	C
0906-095	1.6	0.085		A754	3,2	0.054	cD
1033-270	0.7	0.182	3.1	A1060	0,1	0.011	C
1058-226	0.5	0.377		A1146	5,4	0.139	cD
1246-410	2.4	0.094	5.3	Centaurus		0.011	I
1251-290	1.8	0.228	9.4	SC1251-288	3,(3)	0.056	cD
1326-311	1.2	0.314	8.2	SC1325-311	3,(3)	~ 0.05	cD
1344-325	2.8	0.101		SC1344-323	3,(0)	(0.06)	cD
2009-569	1.2	0.072		SC2008-569	3,(2)	(0.06)	L
2155-609	0.8	0.515		SC2155-606?		~ 0.2	
2312-21(3)	0.3	2.000		A2554	5,3		
2344-285	0.7	0.142		Klemola 44	2,2	0.027	(F)

NOTES: a -(*) I_x variable according to 2A catalogue: identification very uncertain.

b -(?)SC2155-606 : suggested identification with this faint very rich cluster from catalogue of Duus and Newell (1977).

SC0627-544 : identification from Vidal, 1975. There are two other clusters in area, but less rich.

c - Temperatures of the x-ray emitting gas from OSO-8 (Mushotzky *et al.*, 1978).

d -(1)D,R, observed z values as given in literature : Abell catalogue and others.
Values in parenthesis estimated by Bahcall (1977 b,c) or Lugger (1978).

e -(2)Rood-Sastry type given by Bahcall (1977 c).

(3)From Ricketts (1978).

lished, except those of CA0340-538 (Haylen and Quintana, 1978; Quintana and Haylen, 1978). However, the identification of this cluster, as well as that of Ser 40/6, is uncertain in view of the x-ray variability reported in the 2A catalogue in both cases. Given the low fluxes involved, one should await better data to confirm these reports.

In Table V we list the identified, or most likely candidates, x-ray clusters with $\delta < -10^\circ$ and $b^{\text{II}} \geq 10^\circ$, and give the available data on each source and cluster. The x-ray data is taken from the Ariel V catalogue and OSO-8 observations.

ACKNOWLEDGEMENTS: In the course of the preparation of these notes, many persons made available unpublished results and I am grateful to them. I want to thank for many illuminating discussions, M. Roberts and M. Haynes, L. Rudnick, D. De Young, E. Hardy, J. Melnick, G. Steigman, C. Sarrazin, W. Jaffe, G. Chincarini, and R. White.

REFERENCES

- Abell, G.O., 1958, *Ap. J. Suppl.* 3, 211.
 _____ 1964, *Ap. J.* 140, 1624.
 _____ 1965, *Ann. Rev. Astron. Astrophys.* 3, 1.
 _____ 1976, In *Galaxies and the Universe*, ed. A. Sandage, M. Sandage, J. Kristian, Chicago University Press.
 _____ 1977, *Ap. J.* 213, 327.
 Abell, G.O., Mottman, J., 1977, *Ap. J.* 218, 53.
 Albert, C.E., White, R.A., Morgan, W.W., 1977, *Ap. J.* 211, 309.
 Austin, T.B., Peach, J.V., 1974, *M.N.R.A.S.* 167, 437.
 Avni, Y., Bahcall, N.A., 1976, *Ap. J.* 209, 16.
 Bahcall, N.A., 1972, *A. J.* 76, 995.
 _____ 1973, *Ap. J.* 183, 783.
 _____ 1974, *Ap. J.* 193, 529.
 _____ 1975, *Ap. J.* 198, 249.
 _____ 1977, *Ann. Rev. Astron. Astrophys.* 15, 505.
 _____ 1977b, *Ap. J.* 217, L19.
 _____ 1977c, *Ap. J.* 217, L77.
 Bahcall, J.N., Sarrazin, C.L., 1977, *Ap. J.* 213, L99.
 Bautz, L.P., Morgan, W.W., 1970, *Ap. J.* 162, L149.
 Bergeron, J., Gunn, J.E., 1977, preprint.
 Bucknell, M.J., Godwin, J.G., Peach, J.V., 1978, preprint.
 Carpenter, R.L., Gulkis, S., Sato, T., 1973, *Ap. J.* 182, L61.
 Chandrasekhar, S., 1942, *Stellar Dynamics*, Chicago.
 Chincarini, G., Rood, H.J., 1977, *Ap. J.* 214, 351.
 Clark, E.E., 1968, *A. J.* 73, 1011.
 Cooke, B.A., et al., 1978, *M.N.R.A.S.* 182, 489.
 Dawe, J.A., Dickens, F.J., Peterson, B.A., 1977, *M.N.R.A.S.* 178, 675.
 de Vaucouleurs, G., 1960, *Ap. J.* 137, 585.
 De Young, D.S., 1977, preprint.
 Dressler, A., 1976, Thesis, University of California.
 Duus, A., Newell, B., 1977, *Ap. J. Suppl.* 35, 209.
 Ekers, R.D., Fanti, R., Lari, C., Ulrich, M.H., 1978, preprint.
 Faber, S.M., Dressler, A., 1976, *Ap. J.* 210, L65.

- Felten, J.E., 1977, *A. J.* 82, 861.
- Forman, W. *et al.*, 1977, preprint.
- Gallagher, J.S., Ostriker, J.P., 1972, *Ap. J.* 77, 288.
- Giacconi, R. *et al.*, 1974, *Ap. J. Suppl.* 27, 37.
- Godwin, J.G., Peach, J.V., 1977, *M.N.R.A.S.* 181, 323.
- Gorenstein, P., Fabricant, D., Topka, K., Tucker, W., Harnden, F.R., 1977, *Ap. J.* 216, L95.
- Gott, J.R., Turner, E., 1977, *Ap. J.* 213, 309.
- Gould, R.J., Rephaeli, Y., 1978, *Ap. J.* 219, 12.
- Gull, S.F., Northover, K.J., 1976, *Nature*, 263, 572.
- Gunn, J.E., 1977, *Ap. J.* 218, 592.
- Gunn, J.E., Gott, J.R., 1972, *Ap. J.* 176, 1.
- Gunn, J.E., Lee, B.W., Lerche, I., Schramm, D.N., Steigman, G., 1978, preprint.
- Gursky, H., Kellogg, E.M., Leong, C., Tananbaum, H., Giacconi, R., 1971, *Ap. J.* 167, L81.
- Gursky, H., Schwartz, D.A., 1977, *Ann. Rev. Astron. Astrophys.* 15, 541.
- Harris, D.E., 1976, *Highlights of Astronomy*, Vol. 4, Part 1, 321.
- Harris, D.E., Miley, G.K., 1978, preprint.
- Haslam, C.G., Kronberg, P.P., Waldthausen, H., Wielebinski, R., Schallwick, D., 1978, *Astron. Astrophys. Suppl.* 31, 99.
- Havlen, R., Quintana, H., 1978, *Ap. J.* 220,
- Haynes, M., Roberts, M.S., 1978, in preparation.
- Hoffman, A.W., Crane, P., 1977, *Ap. J.* 215, 379.
- Huchtmeier, W.K., Tamman, G.A., Wendker, H.J., 1976, *Astron. Astrophys.* 46, 381.
- Jaffe, W.J., Perola, G.C., Valentijn, E.A., 1976, *Astron. Astrophys.* 49, 179.
- Jones, C., Forman, W., 1977, preprint.
- Jones, C., Forman, W., Tucker, W., 1978, preprint.
- Klemola, A.R., 1969, *A. J.* 74, 804.
- King, I.R., 1966, *A. J.* 71, 64.
- _____ 1972, *Ap. J.* 174, L123.
- Kirshner, R.P., 1977, *Ap. J.* 212, 319.
- Lake, G., Partridge, R.B., 1977, *Nature*, 276, 502
- _____ 1978, in preparation.
- Lea, S.M., Silk, J., Kellogg, E., Murray, S., 1973, *Ap. J.* 184, L105.
- Lea, S.M., De Young, D.S., 1977, preprint.
- Leir, A.A., van den Bergh, S., 1977, *Ap. J. Suppl.* 34, 381.
- Lewis, B.M., Davies, R.D., 1973, *M.N.R.A.S.* 165, 213.
- Lugger, P.M., 1978, *Ap. J.* 221, 745.
- Lyndell-Bell, D., 1967, *M.N.R.A.S.* 136, 101.
- Maccararo, T., Cooke, B.A., Ward, M.J., Penston, M.V., Haynes, R.F., 1977, *M.N.R.A.S.* 180, 465.
- Maccagni, D., Tarengi, M., Cooke, B.A., Maccararo, T., Rye, J.P., Ricketts, M.J., Chincarini, G., 1978, *Astron. Astrophys.* 62, 127.
- MacGilliwray, H.T., 1978, private communication.
- MacGilliwray, H.T., *et al.*, 1976, *M.N.R.A.S.* 176, 649.
- McHardy, I., 1976, *Highlights of Astronomy*, Vol. 4, Part 1, 311.
- Melnick, J., Quintana, H., 1975, *Ap. J.* 198, L97.
- Melnick, J., Sargent, W.L.W., 1977, *Ap. J.* 215, 401.
- Mills, B.Y., Hoskins, D.G., 1977, preprint.

- Mitchell, R.J., Ives, J.C., Culhane, J.L., 1977, *M.N.R.A.S.* 181, 25p.
- Morgan, W.W., 1962, *Ap. J.* 135, 1.
- Morgan, W.W., Kayser, S., White, R.A., 1975, *Ap. J.* 199, 545.
- Mushotzky, R.F., Serlemitsos, P.J., Smith, B.W., Bolt, E.A., Holt, S.S., 1978, preprint.
- Murray, S.S., Forman, W., Jones, C., Giacconi, R., 1978, *Ap. J.* 219, L89.
- Oemler, A., 1974, *Ap. J.* 194, 1.
- Ostriker, J.P., Hausman, M.A., 1977, *Ap. J.* 217, L125.
- Ostriker, J.P., Peebles, P.J.E., Yahil, A., 1974, *Ap. J.* 193, L1.
- Owen, F.N., 1975, *Ap. J.* 195, 593.
- Owen, F.N., Rudnick, L., Peterson, B.M., 1977, *A. J.* 82, 677.
- Pariiskii, Yu. N., 1973a, *Sov. Astron.* 17, 291.
- _____ 1973b, *Ap. J.* 180, L47.
- Peebles, P.J.E., 1970, *A. J.* 75, 13.
- Quintana, H., Havlen, R., 1978, preprint.
- Quintana, H., White, R.A., 1978, in preparation.
- Richstone, D.O., 1976, *Ap. J.* 204, 642.
- Ricketts, M.J., 1978, preprint.
- Roberts, M.S., 1976, in IAU Symposium 69, *Dynamics of Stellar Systems*.
- Rood, H.J., 1965, Thesis, University of Michigan.
- Rood, H.J., Sastry, G.N., 1971, *P.A.S.P.* 83, 313.
- Rood, H.J., Page, T.L., Kintner, E.C., King, I.R., 1972, *Ap. J.* 175, 627.
- Rose, J.A., 1976, *Astron. Astrophys. Suppl.* 23, 109.
- R. O. E., report, 1977, *Q.J.R.A.S.* 18.
- Rudnick, L., 1978, preprint.
- Rudnick, L., Owen, F.N., 1977, *A. J.* 82, 1.
- Sandage, A., Hardy, E., 1973, *Ap. J.* 183, 743.
- Schechter, P., 1976, *Ap. J.* 203, 297.
- Schipper, L., King, I.R., 1978, *Ap. J.* 220, 798.
- Schwarzschild, M., 1954, *A. J.* 59, 273.
- Sérsic, J.L., 1974, *Astrophys. and Sp. Science* 28, 365.
- Silk, J., 1974, *Ap. J.* 194, 215.
- Smith, S., 1936, *Ap. J.* 83, 23.
- Solinger, A., Tucker, W., 1972, *Ap. J.* 175, L107.
- Steigman, G., Sarrazin, C., Quintana, H., Faulkner, J., 1978, preprint.
- Strom, S., Strom, K., 1978, *A. J.* 83, 73.
- Sunyaev, R.A., Zeldovich, Ya. B., 1972, *Comments on Astrophys. and Sp. Science* 4, 173.
- Tarengi, M., Scott, J., 1976, *Ap. J.* 207, L9.
- Tinsley, B.M., Larson, R.B., 1977, *The Evolution of Galaxies and Stellar Populations*, Yale.
- van den Bergh, S., 1976, *Ap. J.* 206, 883.
- _____ 1977, *Vistas in Astronomy* 21, 71.
- Vidal, N.V., 1975, *P.A.S.P.* 87, 625.
- Vidal, N.V., Peterson, B.A., 1975, *Ap. J.* 196, L95.
- White, R.A., 1978, preprint.
- White, S.D.M., 1976, *M.N.R.A.S.* 174, 19.
- Williams, T.B., 1977, *Ap. J.* 214, 685.

Zwicky, F., 1933, *Helv. Phys. Acta.* 6, 10.

_____ 1957, *Morphological Astronomy*. (Springer)

Zwicky, F., Herzog, E., Wild, P., Karpowicz, M., Kowal, C.T., 1961-1968, *Catalogue of Galaxies and Clusters of Galaxies* (Cal Tech).

DISCUSION

ALCAINO.- ¿Está Ud. al tanto de alguna búsqueda sistemática de cúmulos de galaxias basada en el "ESO Guide Survey" del sur, fuera del trabajo recién publicado por Duus y Newell (1977, *Ap. J. Supp.* 35, 209), en el cual clasificaron 700 cúmulos en 400 campos, o sea aproximadamente un 15% del cielo entre declinaciones -25° al polo?

QUINTANA.- No, no se han publicado otros trabajos todavía.

WIELEBINSKI.- The briefly mentioned coincidence of radio halo in a cluster and an x-ray source seems to be now well established. In a survey of over 30 clusters with the 100-m radio telescope we find this correlation. The haloes are non-thermal. They are distributed around dominant cD galaxies. The thermal x-ray sources seem to have the same extent. Thus I believe that we will be able in the near future to understand the evolution process.

QUINTANA.- I did not know that work from Bonn. As you say, these results are very important.

PACHECO.- Pode comentar sobre posiveis diferenças nao dispersões de velocidades radiais de espirais e elípticas observadas em alguns aglomerados?

QUINTANA.- En cúmulos ricos dominados por elípticas y que aparecen simétricos y relajados no se han detectado diferencias significativas entre las espirales y las elípticas. Por el contrario, en algunos cúmulos más irregulares y dominados por espirales (Virgo y A 1367, por ejemplo) parece ser que la dispersión de las espirales fuera mayor que la de las elípticas, pero la evidencia es sólo marginal (ver, por ejemplo, el Review Paper de van den Bergh). En todo caso, estos cúmulos tienen una estructura más compleja, con nubes y grupos que parecen estar asociados a ellos. El caso de A 1367 ha sido estudiado recientemente por Gregory y Thomson (preprint).

FEINSTEIN.- ¿Cómo se ubica el Grupo Local en el esquema de clasificación de los cúmulos de galaxias?

QUINTANA.- El Grupo Local tiene alrededor de 20 galaxias. Es un cúmulo pobre y por lo tanto no es considerado por la mayoría de las clasificaciones propuestas. Es un cúmulo irregular en el sistema de Abell. Dado que el Grupo Local está dominado por dos galaxias espirales, si se lo quisiera representar en un diagrama brillo-clase de concentración, tendría una forma muy distinta de los cúmulos previamente estudiados por Morgan y colaboradores.

VELOCIDADES RADIALES DE GALAXIAS AUSTRALES

J.L. Sérsic

Observatorio Astronómico, Córdoba

CONICET*, Buenos Aires

J.C. Arias y A. Araujo

Observatorio Astronómico, Córdoba

RESUMEN: Se dan las velocidades radiales de varias galaxias australes como parte de un programa de rutina en marcha en Córdoba para galaxias con corrimiento al rojo no observadas.

I. INTRODUCCION

Desde fines de 1975 venimos desarrollando un programa sistemático de observación de espectros de galaxias australes que carecen de determinaciones de velocidad radial. Dicho programa comprende los objetos situados al sur de la declinación -30° y el instrumento empleado es el Espectrógrafo Rápido Page provisto de un tubo intensificador de imágenes WL 30677 con óptica de fibras.

Como elemento dispersor se dispone de dos redes Baush y Lomb de 400 y 800 líneas/mm que conducen a dispersiones recíprocas de 460 y 230 Å/mm en primer orden respectivamente. El programa se desarrolla básicamente con 460 Å/mm y solamente cuando surgen objetos de interés específico se han tomado espectros adicionales con la red de 800 líneas/mm. La exposición típica para objetos de moderado o bajo brillo superficial (Sc-Im) es de 30 m con una tensión de sólo 7 Kv en el tubo intensificador. Tensiones más elevadas degradan la definición de las imágenes (Calderón, 1976).

Los objetos de programa se han seleccionado del RGG y se han empleado las colecciones de fotografías de galaxias australes disponibles en el Observatorio para confeccionar cartas de identificación.

Especial cuidado se ha tenido en dejar claramente establecida la forma en que se ha dispuesto la ranura del espectrógrafo sobre la imagen de la galaxia, indicándose además, la estrella de guía. Si el objeto presenta una elongación aparente, la ranura se ha dispuesto siempre a lo largo del eje mayor.

El rango espectral cubierto por nuestras placas es $\lambda\lambda 5000$ a 7000 Å y el espectro de compara-

* Bajo contrato N°169.

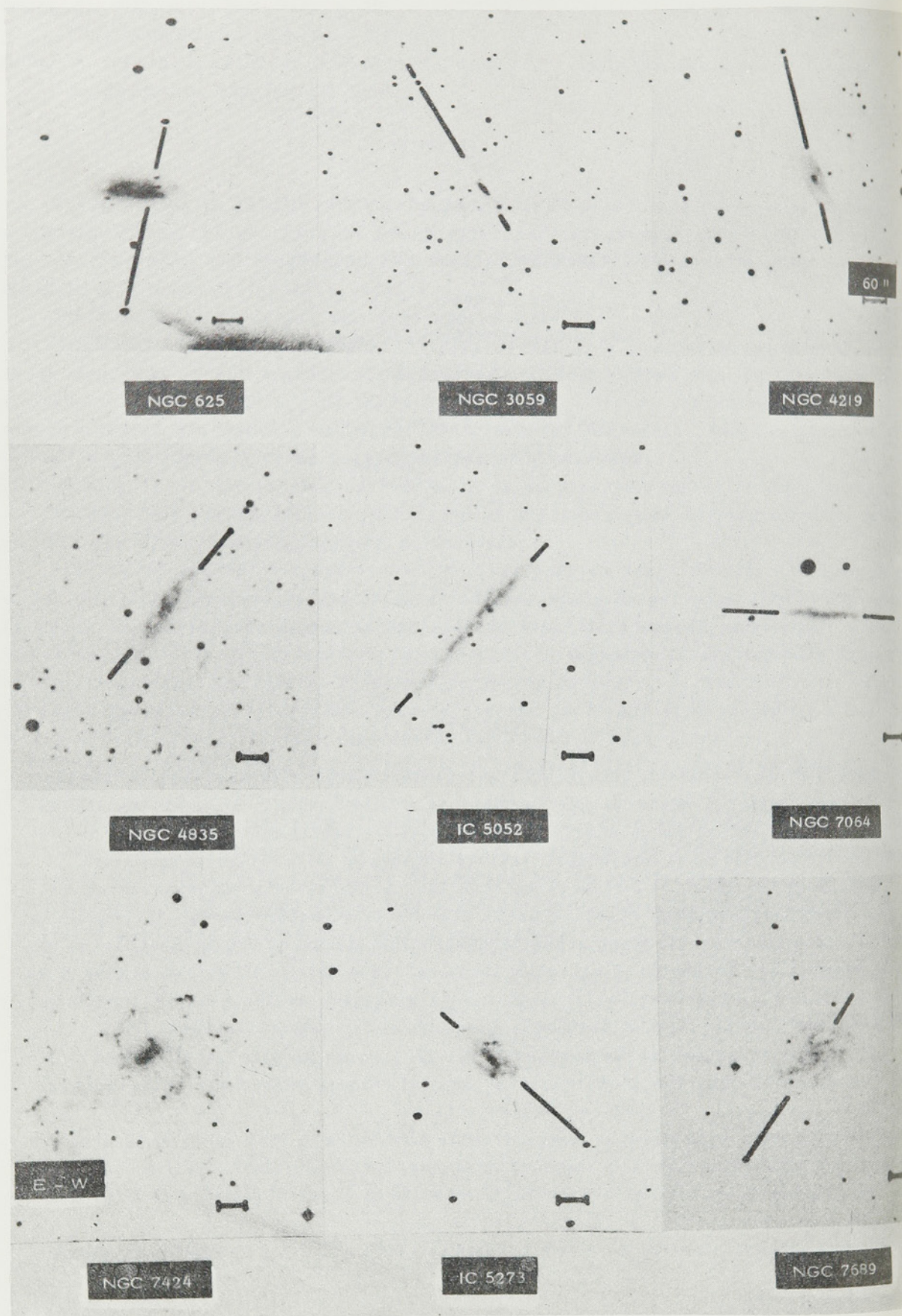
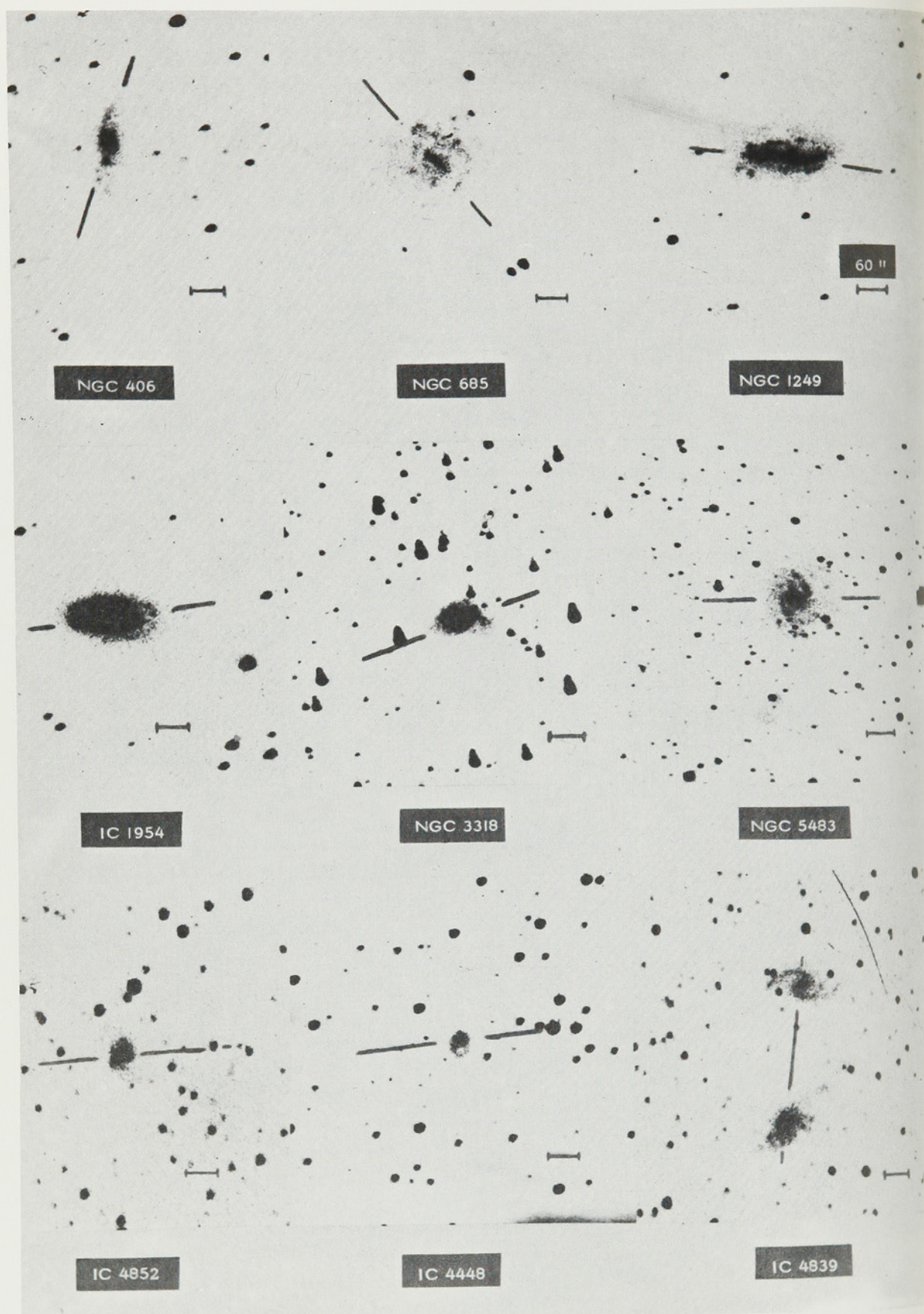


TABLE I

NGC IC*	Tipo	m_c	H α	NII	SII	V_R	V_R^{+e}	Notas
406	SA(s)c	12.67	1575			1575	1575	CR
625	SBm	12.58	433		266	350		
			453		320	387		CR
			492			492	410^{+43}	
685	SAB(r)c	12.06	1416			1416	1416	CR
1249	SB(s)cd	11.96	948		1190	1069	1069^{+120}	CR
1954*	SBb	12.25	978			978	978	
3059	SB(rs)bc	12.11	1390	1070	1527	1329	1329^{+135}	$V_o = 1033^{+33}$ km/s, West, 1976
3318	SAB(rs)bc	12.77	2670	2607	2358	2605	2605^{+38}	
4219	SAbc	12.43	1678		1717	1698	1698^{+20}	
			1235					Em. patch 29"5 SW of nucleus
			1056					Em. patch 41"3 WE of nucleus
4835	SAB(rs)bc	12.71	2272			2272	2272	
5483	SA(s)c	12.20	1660			1660	1660	
4444*	SAbc	12.64	2076		1947	2012	2012^{+65}	
4448*	SB(s)m		4496		4672	4584	4584^{+88}	
6669	SAB(s)b	12.75	3220			3220		$V_R = 3420$, Martin, 1976
			3652			3652	3636^{+214}	
4839*	SB(s)b		2695			2695	2695	
4852*	SAc		4773			4773	4773	
5092*	SB(rs)c		3509	3433		3471	3471^{+38}	
5052*	Sd	12.47	183			183	183	CR
5152*	IBm	11.5:	110			110	98^{+12}	CR; $V_R = 78^{+30}$, Evans, 1963;
			86			86		$V_R = 122$, Whiteoak, Gardner, 1977
7064	SB(s)c	12.91	966			966	966	CR
5201*	SB(rs)cd	11.72	594			594	594	Em. patch 0'72 SW of nucleus
			644			644	644	Em. patch 2'28 NE of nucleus
7424	SAB(rs)cd	11.13	797			797	797	CR; $V_o = 862^{+17}$, Sandage, 1975
5273*	SB(rs)c	12.17	1105		934	1120	1120^{+85}	CR
7689	SAB(rs)cd	12.40	1445			1445	1445	Línea muy ancha
7713	SBcd	11.92	1035		993	1014	1014^{+21}	CR
7764	IB(s)m	12.97	1725		1566	1646	1646^{+79}	CR
7764a	Sp		9077			9077		
7764			8881	8721		8801	8939^{+137}	
			9073	9074	9098	9082	9082^{+10}	Red 800
7764a/E			7777	7877		7827	7827^{+71}	Red 800 Compañera E



ción usado fue Ne + Hg, expuesto antes y después del objeto.

La medición de los espectrogramas se efectuó con la máquina MANN a dos coordenadas del Observatorio. Cada línea de comparación se midió en tres niveles a ambos lados y se la representó con una regresión cuadrática. Para las líneas del objeto se midieron los puntos en el entorno del continuo y se redujeron con una regresión lineal basada en las correspondientes interpolaciones de las líneas de comparación. El número de estas últimas usado en las reducciones fue siempre de 3 a 5.

II. RESULTADOS

La tabla I lista las galaxias observadas. La columna 1 da la identificación de los objetos, en las 2 y 3 damos el tipo morfológico y la magnitud m_c tomadas del RGC. Las columnas 4, 5 y 6 dan las velocidades medidas para las líneas $H\alpha$ ($\lambda 6562.8$), NII ($\lambda 6562.6$) y $[SII]$ ($\lambda \lambda 6717.0-6731.3$) respectivamente.

En la columna 7 figura el promedio de los valores precedentes para cada placa (si hubiere más de una) y en la 8 se da el promedio general y su respectivo error medio. Si no hubiera más que un espectro para el objeto, el error corresponde al interno de la placa.

Las notas dan las referencias a otros valores aparecidos en la literatura con posterioridad al comienzo del programa, así como indicaciones referentes al espectro. El símbolo CR indica que la línea $H\alpha$ es larga y adecuada para estudios de la rotación del sistema.

Las figuras 1 y 2 muestran los objetos observados, la orientación y extensión de la ranura y la escala correspondiente.

REFERENCIAS

- Calderón, J.H., 1976, *Bol. Acad. Nac. Cienc. Cba.* Tomo 52, entr. 1-2, 171.
Evans, D.S., 1963, *M.N.A.S.S.A.* 22, 140.
Martin, W.L., 1976, *M.N.R.A.S.* 175, N°3, 638.
Sandage, A.R., 1975, *Ap. J.* 202, N°3, Part 1, 570.
West, R.M., 1976, *Astron. Astrophys.* 53, 435.
Whiteoak, J.B., Gardner, F.F., 1977, *Austr. J. Phys.* 30, 187.

RADIO CONTINUUM OBSERVATIONS OF NEARBY GALAXIES

R. Wielebinski

Max-Planck-Institut für Radioastronomie, Bonn

The radio continuum emission observed in galaxies is produced either by the thermal emission process in ionized regions or is the nonthermal emission from relativistic electrons spiralling in the magnetic fields of a galaxy. Thus measurements with good angular resolution of nearby galaxies at a number of radio frequencies should enable us to understand the energy distribution. Polarization measurements give us details of the magnetic fields.

Recent observations at low frequencies (e.g. 610 MHz Westerbork maps) and at high radio frequencies (e.g. 4800 MHz Effelsberg data) have similar angular and intensity resolutions. Hence in the disks of a number of nearby galaxies (M31, M33, IC342, M101, NGC 6946, etc.) spectral variations could be definitely identified. These in turn could be shown to be due to the mixing of thermal and nonthermal radiation. Using optical $H\alpha$ data the thermal emission from these HII regions can be predicted. The difference gives the amount of thermal emission from sources below the $H\alpha$ sensitivity. Observations of the tenuous radio continuum emission at the edges of galaxies has shown a dramatic steepening of the spectral index. This must be attributed to the truncation of the electron energy spectrum.

For many years the only radio data on normal galaxies was the total flux of some of the brightest of these objects. The first definitive detection of a normal galaxy was the determination of the total flux of M31 by Hanbury Brown and Hazard (1951) at 159 MHz. Surveys by Leslie (1960) and Heeschen and Wade (1964) further established that normal galaxies were relatively weak radio emitters. A recent compendium of radio continuum flux of bright galaxies has been provided by Haynes *et al.*, (1975). The mapping of the structure of normal galaxies was shown to be possible for a limited sample of nearby objects by de Jong (1965, 1966) at 750 and 1415 MHz. It was the increase in angular resolution that ushered a new stage in the possibilities of investigating galaxies at radio frequencies. The pioneering work of Pooley (1969) gave the first map of a galaxy, M31, at 408 MHz which clearly showed the spiral structure at radio frequencies remarkably similar to the distribution of optical light. The radio continuum map of M51 made by Mathewson *et al.* (1972) at 1415 MHz showed the details of ridges of radio continuum emission coincident with the dark lanes seen in optical plates, as predicted from magnetic field compressions in the density wave theory. Increase of the observing frequency (e.g. 2695 MHz map of M31 by Berkhuijsen and

Wielebinski (1974) or 4800 MHz map of IC 342 by Baker *et al.* (1977)) paved the way to separate the thermal emission in the spiral arms and disk from the nonthermal emission in some of the galaxies. Maps of comparable angular resolution are now becoming available for galaxies at frequencies as low as 150 MHz and as high as 23 GHz. Maps of edge-on galaxies made with high dynamic range allow the studies of weak emission at considerable distances from the plane of the galaxy.

The present paper does not tackle the question of radio continuum emission from the Magellanic Clouds. These objects are not typical for nearby galaxies and are a subject of study of their own. The work discussed includes the nearby spiral galaxies starting with M31 but stops with M82.

To study the radio intensity distribution of a galaxy a radio telescope must have sufficient angular and temperature resolution. The angular resolution criterion requires the half power beamwidth to be of the order of one-fifth on the Holmberg diameter of a galaxy. This criterion quickly determines the number of galaxies which are accesible at a particular frequency for each radio telescope. The temperature criterion, on the other hand, is intimately connected with the spectral index of the galaxies and the confusion limit of a telescope. At low radio frequencies the Westerbork Synthesis Radio Telescope has an ~ 1 arc min beam and a typical plotted contour is 2.5 mJy/beam area (e.g. de Bruyn, 1977). At high radio frequencies the Effelsberg radiotelescope has a 2.6 arc min beam and the limit is 4 mJy/beam area (e.g. von Kap-herr *et al.*, 1975). This allows the determination of comparable contours with the spectral index with $\alpha = 0.8$ ($S \propto \nu^{-\alpha}$). A summary of the recent maps of radio distribution of galaxies for which the above angular and temperature resolution criteria have been met is given in Table I (completed results up till December 1977). An important review of radio continuum emission of spiral galaxies was published by van der Kruit and Allen (1976).

TABLE I
Maps of Nearby Galaxies

Galaxy	Wavelength (cm)							
	73.5	49.5	21	11	6	3	2	1.3
M31	I	I	I,Q,U	I,Q,U	I			
M33			I,Q,U	I,Q,U	I			
M101		I	I	I	I			
M81		I	I	I	I			
M51		I	I	I	I,Q,U	I,Q,U	I	
NGC 253	I			I	I	I		
NGC 4258		I	I		I			
NGC 4631		I	I	I	I			
NGC 891	I	I	I	I	I	I		
NGC 6946		I	I	I	I	I		
NGC 7331		I	I	I	I			
IC 342		I	I	I	I			
Maffei 2		I	I	I	I	I		
M82				I		I		I

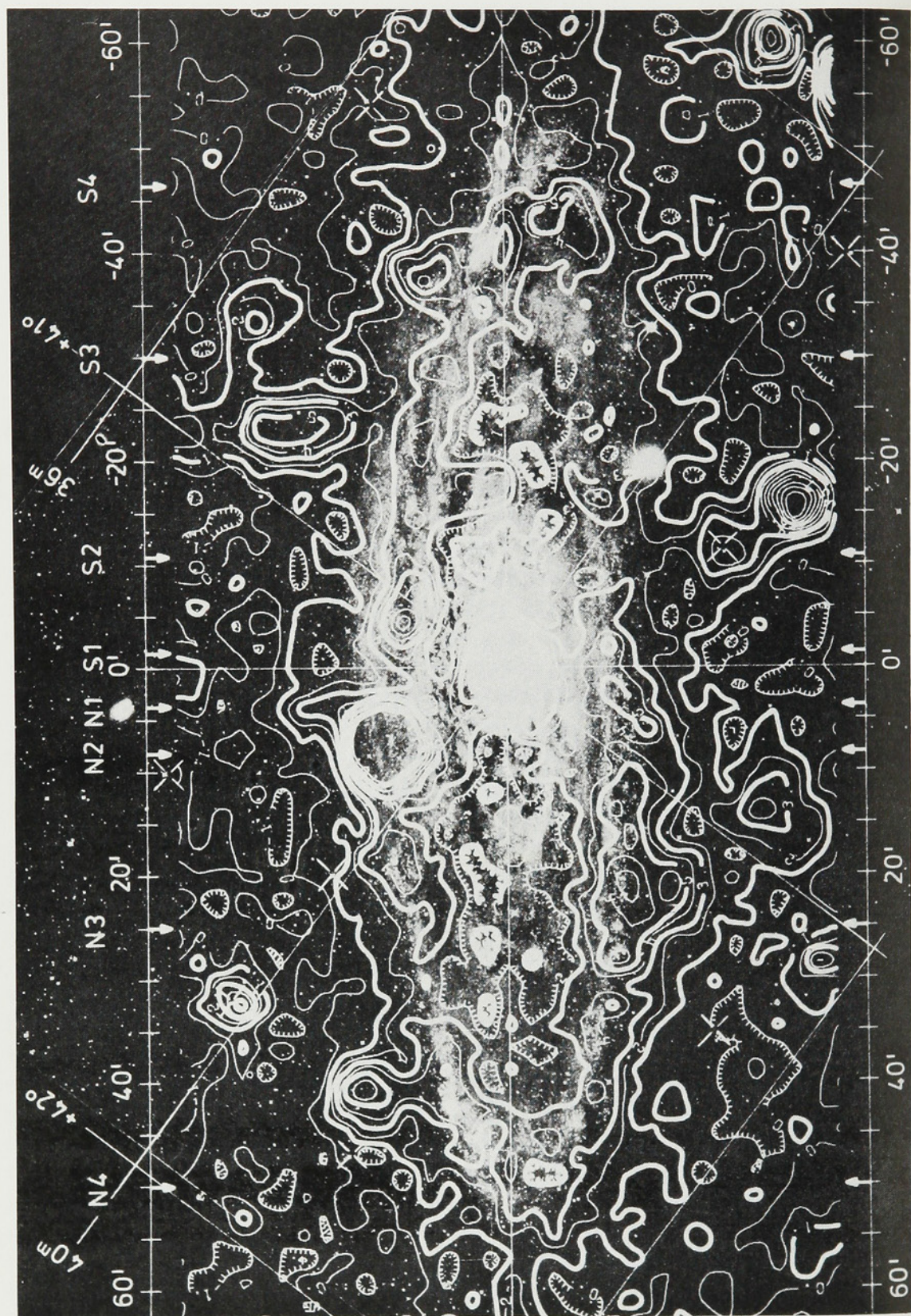


Fig. 1. A typical radio contour map of the Andromeda Nebula, M31, overlaid onto an optical photograph of the Lick Observatory. The radio map was made with the 100-m radio telescope by Berkhuysen and Wiebeinski at $\lambda 11.1$ cm. Contours are in

The maps of the radio continuum distribution in nearby galaxies show certain similarities. In all galaxies emission follows the spiral arm structure. At low frequencies the peaks of emission are always coincident with the dark lanes, where the compression of the magnetic fields is strongest. Hence these are the regions of predominantly non-thermal emission. At high radio frequencies emission associated with thermal HII regions predominates. Optically visible HII regions have been detected at radio frequencies, but their intensities are only just above the limits of detection with the present radio telescopes. Here it is necessary to mention that some of the most intense HII regions in our Galaxy would give signals of only a mJy at a distance of a few megaparsecs. However, multi-frequency studies of M31 and M33 can give us a good picture of the distribution of the various objects in these galaxies (see Berkhuijsen, 1977).

In addition to the spiral arm structure in all galaxies extended emission is observed. It may be attributed to a disk with specific differences between galaxies being observed. In studies of edge-on galaxies the following conclusions can be reached. The galaxy with the most intense nucleus, NGC 253, has also the most intense non-thermal emission envelope at high frequencies at high z distances. In the case of NGC 4631 we have an intermediate case. The edge-on galaxy NGC 891 is the extreme case of no nuclear source and no "halo". Translating this results to face-on galaxies we see that M81 with an intense nuclear source has an intense disk, while M33 with only a minimal nuclear source has the most thermal spectrum.

Magnetic field distribution should be deduced from mapping of the linear polarization. So far only sporadic attempts have been made to study M31, M33 and M51. The results are still inconclusive but instrumental improvement may give soon the long-awaited answer.

REFERENCES

- Baker, J.R. Haslam, C.G.T., Jones, B.B., Wielebinski, R., 1977, *Astron. Astrophys.* 59, 261.
 Berkhuijsen, E.M., 1978, in IAU Symposium N°77, *Structure and Properties of Nearby Galaxies*, eds. E.M. Berkhuijsen, R. Wielebinski, Reidel Publishing Co. Dordrecht, p. 149.
 Berkhuijsen, E.M., Wielebinski, R., 1974, *Astron. Astrophys.* 34, 173.
 Brown, Hanbury R., Hazard, C., 1951, *M.N.R.A.S.* 111, 357.
 Bruyn, A.G. de, 1977, *Astron. Astrophys.* 58, 221.
 Haynes, R.F., Huchtmeier, W.K.H., Siegman, B.C., Wright, A.E., 1975, *A Compendium of Radio Measurements of Bright Galaxies*, CSIRO Radiophysics Division.
 Heeschen, D.S., Wade, C.M., 1964, *A. J.* 69, 277.
 Jong, M.L. de, 1965, *Ap. J.* 142, 1333.
 Jong, M.L. de, 1966, *Ap. J.* 144, 533.
 Kap-herr, A. von, Jones, B.B., Wielebinski, R., 1975, *Astron. Astrophys.* 41, 115.
 Kruit, P.C. van der, Allen, R.J., 1976, *Ann. Rev. Astron. Astrophys.* 14, 417.
 Leslie, P.R.R., 1960, *Observatory* 80, 216.
 Mathewson, D.S., Kruit, P.C. van der, Brouw, W.N., 1972, *Astron. Astrophys.* 17, 468.
 Pooley, G.G., 1969, *M.N.R.A.S.* 144, 101.

DISCUSSION

MENDOZA.- What criteria do you use to remove sources not connected with Andromeda?

WIELEBINSKI.- In the first instance spectral index. Secondly, source counts are consulted. Thirdly, the sources removed are so intense that (with a non-thermal spectrum) they would be 100 times more luminous than Cassiopea A.

LASKER.- With respect to the possible filling of the interstellar matter by relativistic electrons that escape from supernova remnants, how do these electrons escape? Are any theories appearing or is the picture basically a semi-empirical one?

WIELEBINSKI.- Yes, there is work by Scheuer in Cambridge for example, who considers the interaction of filaments, both radio and optical, with the interstellar matter and develops a theory which describes the later stages of supernova remnants activity.

ESPECTROSCOPIA DE CANDIDATOS A CUASARES EN LA ZONA $\delta < -75^\circ$

L.E. Campusano* y M. Pedreros*

Observatorio Astronómico Nacional, Cerro Calán
Departamento de Astronomía
Universidad de Chile

RESUMEN: Se presentan los primeros resultados de un programa de observaciones espectroscópicas de nuevos candidatos a QSOs, incluyendo objetos seleccionados ópticamente o por ser contrapartidas de radiofuentes. Se encontraron cuatro objetos con líneas de emisión, utilizando el SIT-vidicon con el telescopio de 1.5 m de CTIO. Se discute la identificación de las líneas y los corrimientos al rojo asociados. Se evalúa brevemente la efectividad de la búsqueda de candidatos a cuasares mediante la Cámara Maksutov, para radiofuentes en la zona entre $\alpha = 0^h$ y $10^h 30^m$, utilizando toda la información espectroscópica disponible.

ABSTRACT: We report the first results of a program of spectroscopic observations of new QSO-candidates, including both radio and optically selected objects. Four emission-line objects were found with the SIT-vidicon spectrometer on the 1.5 m telescope at CTIO. Their line identifications and redshifts are discussed. A brief evaluation of the optical survey of QSO-candidates of radio sources between $\alpha = 0^h$ and $10^h 30^m$ with the Maksutov Camera is done with all the available spectroscopic information.

I. INTRODUCCION

Hacia 1976 se habían propuesto contrapartidas ópticas solamente para 14 de las 454 radiofuentes que contiene el Estudio de Parkes en 2700 MHz, Cuarta Parte (Shimmins y Bolton, 1972) que cubre la zona del casquete polar sur con declinaciones menores que -75° . Este número reducido de identificaciones estaría relacionado, según una sugerencia de Bolton (1972) y Shimmins y Bolton

* Astrónomo Visitante, Observatorio Interamericano de Cerro Tololo, financiado por la National Science Foundation bajo contrato No. AST 74-04128

(1972), con un oscurecimiento considerable que se extendería desde el plano galáctico hacia el casquete polar sur.

Sin embargo, Anguita y Pedreros (1977) (Trabajo I) han iniciado con éxito un programa de identificación óptica de radiofuentes en la zona mencionada anteriormente, utilizando la Cámara Maksutov de la Estación Astronómica de Cerro El Roble, de la Universidad de Chile. Ellos encontraron 8 nuevas contrapartidas ópticas con exceso ultravioleta ($U-B \lesssim -0.5$) y de apariencia estelar en la región comprendida entre 0^h y 10^h30^m en ascensión recta, que denominan "candidatos a cuasares", además de dos que habían sido sugeridas anteriormente.

En esta comunicación se presentan los primeros resultados de un programa de espectroscopía de candidatos a cuasares en la zona $\delta < -75^\circ$. Los objetos se seleccionaron de la lista de Anguita y Pedreros (1977), de una lista en preparación de Anguita *et al.*, y de una lista de objetos con líneas de emisión seleccionados en placas tomadas con prisma objetivo. Además, con los resultados espectroscópicos disponibles se evalúa brevemente la efectividad de la búsqueda de cuasares utilizando la Cámara Maksutov.

II. OBSERVACIONES Y RESULTADOS

Las observaciones se realizaron con el SIT - vidicon montado en el espectrógrafo Cassegrain del telescopio de 1.5 m del observatorio Interamericano de Cerro Tololo. Osmer y Smith (1976) dan una breve descripción del sistema SIT - vidicon. La respuesta del fotocátodo en la sección de intensificación es del tipo S-20.

Se trabajó con una ranura de entrada de $6.9 \times 109''$, manteniendo centrados los objetos durante toda la exposición. Dicho ancho de la ranura minimiza las pérdidas de luz y permite calibrar la espectrofotometría en forma absoluta. El largo de la ranura garantiza una medida del brillo del cielo que se utiliza en la extracción de la señal del objeto. Todas las observaciones se hicieron con una dispersión en el detector de aproximadamente $200 \text{ \AA/mm}$, cubriéndose el rango espectral $3600\text{--}6100 \text{ \AA}$ con elementos fotosensibles de $6.5 \text{ \AA}$. El ancho total del perfil instrumental en la mitad del máximo es de 2.5 elementos, es decir, $16 \text{ \AA}$ en la dirección de la dispersión.

En la Tabla I se especifican los objetos para los cuales se ha determinado el parámetro z ,

TABLA I
Observaciones

Objeto óptico (asociado)	Mag. (B)	Fecha	Rango espectral (A)	Tiempo de exposición (min)	Tipo de objeto	Carta de búsqueda
PKS 0621-786	17.	13-I-77	3600-6100	40	UVX	(1)
PKS 0858- 77	17.5	13-I-77	3600-6100	40	UVX	(1)
PKS 2302-783	16.5	7-X-77	3600-6100	20	UVX	(2)
0411-789	16.	{ 5-X-77 7-X-77	3600-6100	30 30	Emisión en pl. prisma objetivo	(3)

(1) Anguita and Pedreros (1977)

(2) Anguita *et al.*, en preparación.

(3) Campusano, en preparación.

cada uno con la respectiva estimación de su magnitud en el azul (B), la fecha de observación, el tiempo de la(s) exposición (es), la razón por la cual se ha seleccionado el objeto óptico, y la referencia a la carta de búsqueda.

En la Tabla II se detallan las mediciones de las líneas observadas en cada uno de los espectros, las identificaciones sugeridas y los correspondientes valores de z inferidos.

TABLA II
Medición de Líneas e Identificaciones Sugeridas

Objeto	Parámetro z	Longitud de onda observ. λ_o (Å)	Identificación	Longitud de onda emitida λ_e (Å)	$\lambda_o/(1+z)$	Notas
PKS 0621-786	0.93	3689	CIII]	1909	1911	(1)
		5019	?	-	2600	
		5179	?	-	2683	
		5332	MgII	2798	2763	
		5399	MgII	2798	2797	
PKS 0858- 77	0.493	4185	MgII	2798	2803	(2)
		4260	[ArIV]	2854, 2869	2853	
		5092	[NeV]	3426	3411	
PKS 2302-783	0.127:	5475	HI	4861	4858	(3)
		5595	[OIII]	4959	4964	
		5640	[OIII]	5007	5004	
0411-789	0.019	3802	[OII]	3727	3731	(4)
		3950	[NeIII]	3869	3876	
		4051	HI	3970	3975	
		4421	HI	4340	4339	
		4948	HI	4861	4856	
		5050	[OIII]	4959	4956	
		5100	[OIII]	5007	5005	

Notas : (1) 0621-786 También observado por Wright (1977) con $z=0.942$. Las líneas en $\lambda 5019$ y $\lambda 5179$ son de absorción. La línea de CIII] es relativamente débil y está situada en un extremo del rango espectral.

(2) 0858- 77 Posiblemente esté presente línea $\lambda 3727$ del [OII], pero existe confusión con la línea del cielo en $\lambda 5577$.

(3) 2302-783 Adoptando el parámetro $z=0.127$, quedan por lo menos tres líneas de absorción sin identificar. Por lo tanto la posibilidad que sea un objeto estelar no puede ser totalmente descartada hasta tener una confirmación adicional.

(4) 0411-783 Las líneas del [OIII] y $H\beta$ no aparecían resueltas en la placa tomada con prisma objetivo, por ese motivo se había sugerido este objeto como candidato a cuasar.

Así PKS 0621-786, PKS 0858-77, y PKS 2302-783 quedarían asociados a QSOs con los corrimientos al rojo señalados en la Tabla II. Por otra parte, el objeto 0411-789, que fue seleccionado utilizando un "prisma delgado" en el telescopio Curtis-Schmidt de CTIO, no tiene un espectro de QSO, y probablemente se puede asociar a una galaxia compacta.

III. OBJETOS UVX VERSUS CONFIRMACION ESPECTROSCOPICA COMO QSO

En la Tabla III aparecen los 10 objetos de apariencia estelar que fueron seleccionados por su exceso ultravioleta (UVX) como candidatos a QSOs en la búsqueda de contrapartidas ópticas del Trabajo I, con sus correspondientes magnitudes en el azul, las densidades de flujo en 2700 MHz, la información espectroscópica disponible, y las referencias de la espectroscopía.

TABLA III
Información Espectroscópica de Objetos UVX del Trabajo I

PKS	mag. (B)	S_{2700} (Jy)	Espectroscopía	Referencia sobre espectro
0010-840	17.	0.09	Espectro continuo o posiblemente estelar	(1)
0047-832	17.	0.28	$z=1.112$	(1)
0057-819	18.	0.20	Sin información	
0101- 76	17.5	0.43	$z=(0.659)$, dudoso por estar basado en una sola línea	(1)
0110-842	17.5	0.12	Espectro continuo o posiblemente estelar	(1)
0127- 81	17.	0.45	Espectro continuo o posiblemente estelar	(1)
0312- 77	16.5	0.50	$z=0.223$	(1)
0621-786	17.	0.16	$z=0.93$	(1),(2)
0842- 75	18.5	2.15	$z=0.524$	(3)
0858- 77	17.5	0.42	$z=0.493$	(2)

Nota : $1 \text{ Jy} = 10^{-26} \text{ W m}^{-2} \text{ Hz}^{-1}$

Ref. : (1) Wright (1977)

(2) Este trabajo

(3) Browne y Savage (1977)

De los 9 objetos UVX con espectroscopía, 6 han sido confirmados como QSOs y los tres restantes presentan un espectro continuo o posiblemente estelar. De manera que por lo menos el 66% de los candidatos a cuasares encontrados con la Cámara Maksutov corresponden a QSOs, demostrando que este instrumento puede ser empleado con buen éxito en la búsqueda de QSOs por criterio de color a pesar de su transmisión relativamente baja en el ultravioleta.

REFERENCIAS

- Anguita, C., Pedreros, M., 1977, *A.J.* 82, 102.
- Anguita, C., Campusano, L., Torres, C., Pedreros, M., en preparación.
- Bolton, J.G., 1972, *Conference on the role of Schmidt Telescopes in Astronomy*, U. Haug, ed. Hamburger Sternwarte, Hamburg, p. 81.
- Browne, I.W.A., Savage, A., 1977, *M.N.R.A.S.* 179, 65 P.
- Campusano, L., en preparación.
- Osmer, P.S., Smith, M.G., 1976, *Ap. J.* 210, 267.
- Shimmins, A.J., Bolton, J.G., 1972, *Austr. J. Phys. Astrophys. Suppl.* 26, 1
- Wright, A., 1977, comunicación privada.

DISCUSION

LASKER.- The line ratios are quite unusual in 0411-789. That $([OII]\lambda 3727)/([OIII]\lambda 5007) \ll 1$ implies a high degree of ionization, but that we hardly (if at all) see $[OIII]\lambda 4363$ means that the emitting region is cool. Surely this galaxy deserves further study.

CAMPUSANO.- We plan to continue further study on this object.

THE EFFECT OF HYDROGEN $\text{Ly}\alpha$ ON THE HeII EMISSION LINES*

S.M.V. Aldrovandi and A.A. Natale

Instituto Astronômico e Geofísico U.S.P.

São Paulo

I. INTRODUCTION

For several types of emission-line objects, like nuclei of galaxies, QSOs, planetary nebulae, the HeII 4686 line observation is important to He abundance determination and also as an indicator of the ionizing source spectrum, since its intensity relative to $\text{H}\beta$ gives information about the number of photons with energy greater than 54.4 eV emitted by the source of ionization. In both cases good theoretical results are necessary in order to compare with observational material.

The HeII 4686 line corresponds to the transition between the quantum levels $n = 4$ and $n = 3$. Generally the population of a level is calculated considering the following mechanisms: radiative recombinations, cascades from higher levels and to lower levels, and thermal collisions (Seaton, 1959a). However, the HeII transition $n = 2$ to $n = 4$ has almost the same energy than hydrogen $\text{Ly}\alpha$, so that $n = 4$ level could be populated by $\text{Ly}\alpha$ absorption.

In this paper the results of HeII emissivities, taking into account the $\text{Ly}\alpha$ absorption, by level $n = 2$ of HeII, are given. Firstly the energy density of $\text{Ly}\alpha$ is taken as a free parameter in order to know the effect of such a mechanism on the HeII lines for different physical conditions of the emitting gas. The equations are presented in §II and the results and discussion in §III. In §IV an astrophysical application is made using the QSO model given by Davidson (1972).

II. METHOD OF CALCULATION

The level populations, at non-LTE condition, necessary to obtain the HeII line emissivities, are given by the solution of the statistical equilibrium equations. After some calculations and except for level $m = 2$ for which ℓ -degeneracy is taken into account, the equation for a level n can be written as (Seaton, 1959a; Aldrovandi and Péquignot, 1972):

*Partially supported by FAPESP, Brazil

$$n^2 b_n \exp(\chi_n) = \left\{ \frac{T^{3/2}}{K_1} \left[\frac{N_1}{N_i} S_{1n}(T) + \alpha_n(T) \right] + \sum_{m=n+1}^M m^2 b_m \exp(\chi_m) A_{mn} + b_M f(n, t) \right\} / \sum_{n'=2}^{n-1} A_{nn'}, \quad (1)$$

where b_n is the departure from thermodynamic equilibrium, T : the electronic temperature, χ_n : the ratio between the energy of level n and kT , N_1 : the level $n = 1$ population, N_i : the number density of HeIII, $S_{1n}(T)$: the collisional excitation coefficient from $n = 1$ to n (Mewe, 1972), $\alpha_n(T)$: the radiative recombination coefficient to level n (Seaton, 1959b), A_{nm} : the radiative transition probability from n to m , M : the principal quantum number of the level above which the cascade term can be approached by an integral corresponding to the function $f(n, T)$ (Menzel and Baker, 1937; Gerola and Panagia, 1968), and $K_1 = 4.140 \times 10^{-16}$.

Following Gerola and Panagia (1968) the equations for 2s and 2p levels took also into account the collisional transitions between these two levels (Brocklehurst, 1971) and the de-excitation of 2s by two-photon emission.

The term corresponding to the hydrogen Ly α absorption is $N_{2\ell} B_{2\ell,4} \mu_{\text{Ly}\alpha}$, where $N_{2\ell}$ is the population of 2s or 2p, $B_{2\ell,4}$ the Einstein coefficient and $\mu_{\text{Ly}\alpha}$ the total energy density for hydrogen Ly α . This term can be written as a function of the oscillator strength $f_{2\ell,4}$ and appears in the level equations for $n = 4$, 2s and 2p. After some calculations, we obtain for $n = 4$:

$$\left[n^2 b_n \exp(\chi_n) \right]_{n=4} = \left[n^2 b_n \exp(\chi_n) \right]_{n=4}^{\text{Eq. 1}} + (E_s + E_p) / (A_{43} + A_{42}), \quad (2)$$

where

$$\begin{aligned} E_s &= K_2 (b_{2s} \exp(\chi_2)) f_{2s,4}, \\ E_p &= K_2 (3b_{2p} \exp(\chi_2)) f_{2p,4}, \end{aligned} \quad (3)$$

and

$$\begin{aligned} K_2 &= 7.3665 \times 10^{11} \mu_{\text{Ly}\alpha} / T^{1/2} / Z^4, \\ Z &= 2. \end{aligned}$$

Assuming that $N_1 \approx N(\text{HeII})$ and giving T , $N(\text{HeII})/N(\text{HeIII})$, N_e and $\mu_{\text{Ly}\alpha}$, the set of equations (1) can be numerically solved, beginning from level $M=50$. A first solution is obtained assuming thermodynamic equilibrium between $n=2$ sublevels. Following, an iterative method is used to solve the coupled equations for $n=4$, $n=3$, 2s and 2p levels.

III. RESULTS AND DISCUSSION

To test the computer program, the set of equations (1) (without considering the effect of $\text{Ly}\alpha$ absorption) was solved and the results compared to those given by Seaton (1959a) using the scaling-law:

$$b_n(Z, T) = b_n(1, T/Z^2) \quad (4)$$

A perfect agreement was obtained.

In order to study the $\text{Ly}\alpha$ effect on the HeII 4686 line a large number of calculations was made taking the input parameters: T , N_e , $N(\text{HeII})/N(\text{HeIII})$ and $\mu_{\text{Ly}\alpha}$, in a large range. For each parameter the variation interval was chosen according to values found in emission-line regions. As a matter of fact, the parameter $\mu_{\text{Ly}\alpha}$ corresponds to the energy density really absorbed by the level $n=2$ of HeII. So, if the $\text{Ly}\alpha$ luminosity of a given object is $L_{\text{Ly}\alpha}$, the characteristic size of the emitting region R , we get :

$$\mu_{\text{Ly}\alpha} = (1 - \exp(-\tau_R)) L_{\text{Ly}\alpha} / (4\pi R^2 c) \quad (5)$$

where τ_R is the optical depth in $\text{Ly}\alpha$ line relative to the absorption by HeII.

In Fig. 1 the curves $[n^2 b_n e^{x_n}]_{n=4}$ versus T are given for different values of the electronic density N_e . For each N_e , the curves are labelled by the $\mu_{\text{Ly}\alpha}$ value (in units of erg/cm^3). It can be seen that, at a given temperature T , the effect of $\text{Ly}\alpha$ absorption on $n=4$ population is strongly dependent on N_e and $\mu_{\text{Ly}\alpha}$. For increasing N_e the value of $\mu_{\text{Ly}\alpha}$ giving an important effect increases. In fact, the absorption of $\text{Ly}\alpha$ photons is principally made by 2p-level which has a greater population relative to 2s at lower N_e , far from LTE condition. As N_e increases the 2s and 2p populations tend to the LTE values and $\mu_{\text{Ly}\alpha}$ must become greater to give a non-negligible effect. In Fig. 1 all curves correspond to $N(\text{HeII})/N(\text{HeIII}) = 0.1$. However, this ratio is of little consequence for the results. A factor 10 changing modifies only the 2s population by less than 2%.

For the other levels the effect of $\text{Ly}\alpha$ absorption is less important than for level $n=4$. This fact could provide an observational test to this mechanism. The HeII 1640 line ($n=3$ to $n=2$ transition) emissivity is less modified than HeII 4686 emissivity if the mechanism takes place.

Some calculations were made considering the stimulated emission of HeII $n=4$ to $n=2$ due to hydrogen $\text{Ly}\alpha$. An additional term appears in the equations for $n=4$, 2s and 2p levels. This process was proposed by Chan and Burbidge (1975) to explain the low intensity of HeII 4686 from some QSOs. However, it revealed to be negligible, at least under the approximations made in this paper.

IV. A QSO MODEL AND THE $\text{Ly}\alpha$ EFFECT

Assuming that $\text{Ly}\alpha$ emissivity $\epsilon(\text{Ly}\alpha)$ is about 40 $\epsilon(\text{H}\beta)$, and so $L_{\text{Ly}\alpha} \approx 40 L_{\text{H}\beta}$, and considering information about N_e and R given by observational data, the QSOs seem to be good candidates to have the $\text{Ly}\alpha$ effect working on. From Fig. 1 it can be seen that this effect must be unimportant for planetary nebulae since $N_e \approx 10^3 - 10^4 \text{ cm}^{-3}$ and $\mu_{\text{Ly}\alpha} \approx 10^{-11} - 10^{-12} \text{ erg/cm}^3$. For

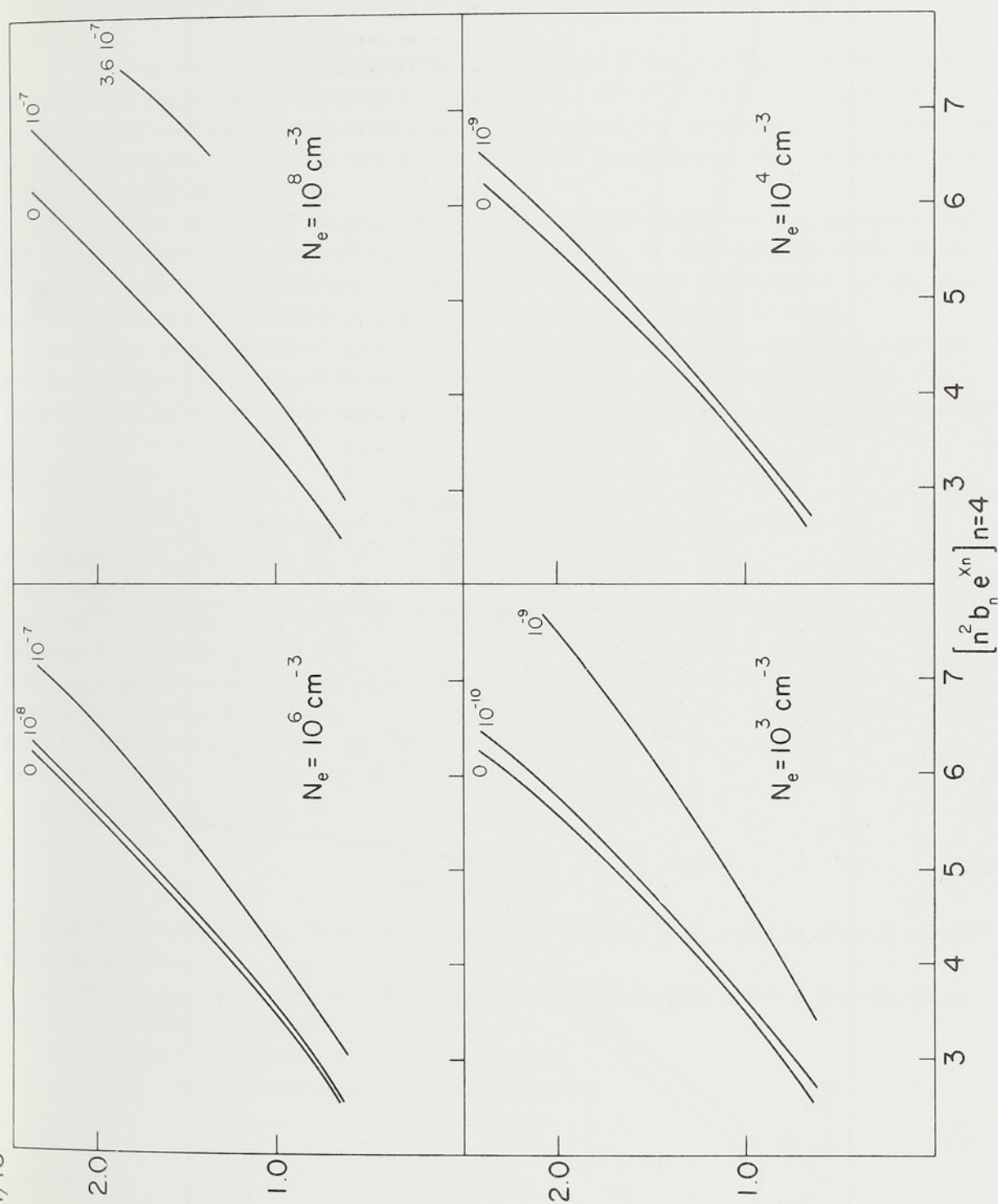


Fig. 1

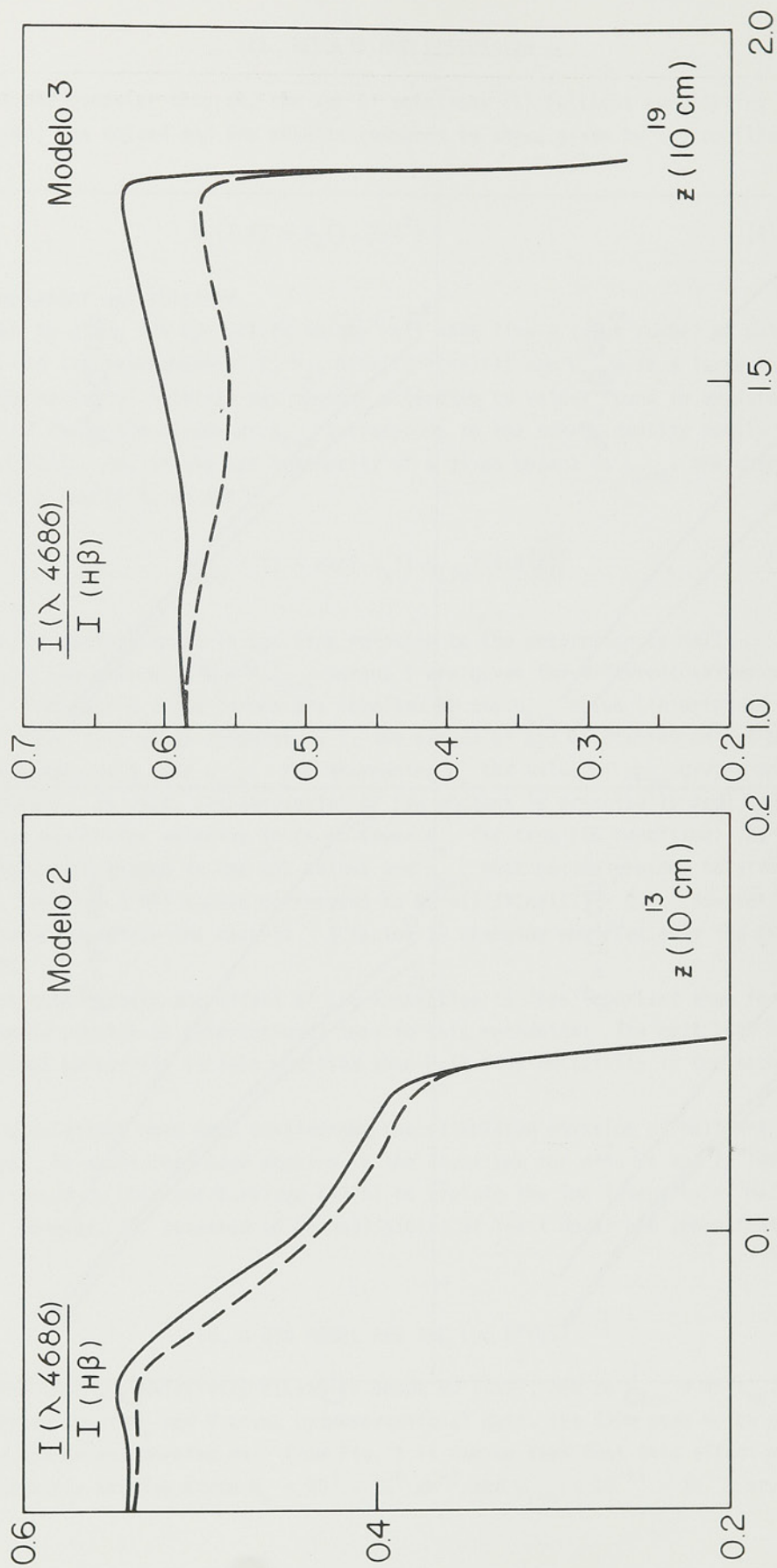


Fig. 2

Seyfert nuclei the effect could increase the HeII 4686 emissivity by at most 1%.

Considering the ionization curves of HII, HeII, HeIII and that of N_e given by Davidson (1972) the HeII 4686 line intensity relative to H β was calculated for model 2 and model 3, taking into account the Ly α effect. The intensity ratio was computed by integrating the emissivities over the whole volume of the gas cloud assuming $\epsilon(\text{Ly}\alpha) = 40 \epsilon(\text{H}\beta)$ and neglecting Ly α resonance scattering.

In Fig. 2 we give the ratio $I(4686)/I(\text{H}\beta)$ as a function of the distance z from the illuminated boundary of the gas cloud, for Davidson's model 2 ($N_e \approx 10^8 \text{ cm}^{-3}$) and model 3 ($N_H = 3 \times 10^4 \text{ cm}^{-3}$). The solid lines correspond to calculations taking into account the Ly α absorption and dashed lines to the results without considering this effect. In model 2 the intensity ratio increases of about 2.7% and in model 3 of about 5.4%.

Following Davidson (1972) the best fit to typical observed intensities is a composite model: 85% of line emission coming from model 2 and 15% from model 3. In this case, the effect of Ly α is to increase the ratio $I(4686)/I(\text{H}\beta)$ of about 4.4%. The effect on $I(1640)/I(\text{H}\beta)$ is less than 0.5%. Presently the observational accuracy does not allow to detect such an effect.

In future, an improvement of observational accuracy could justify new calculations of the effect of hydrogen Ly α absorption on the HeII line intensities, with less approximations. For example, future calculations must take into account ℓ -degeneracy and treat the Ly α transfer problem.

REFERENCES

- Aldrovandi, S.M.V., Péquignot, D., 1972, *Astron. Astrophys.* 17, 88.
Brocklehurst, M., 1971, *M.N.R.A.S.* 153, 471.
Chan, Y.W.T., Burbidge, E.M., 1975, *Ap. J.* 198, 46.
Davidson, K., 1972, *Ap. J.* 171, 213.
Gerola, H., Panagia, N., 1968, *Astrophys. and Sp. Science.* 2, 285.
Menzel, D.H., Baker, J.G., 1937, *Ap. J.* 86, 70.
Mewe, R., 1972, *Astron. Astrophys.* 20, 215.
Seaton, M.J., 1959a, *M.N.R.A.S.* 119, 90.
_____, 1959b, *M.N.R.A.S.* 119, 81.

DISCUSSION

BLANCO.- Si entendí bien, la emisión en Ly α afecta el valor de N_e y por lo tanto la recombinación de HeII ¿correcto?

ALDROVANDI.- La emissão Ly α do Hidrogenio afeta a emissão do HeII devido a absorção de Ly α pelo nível $n = 2$ de HeII, povoando o nível $n = 4$.

BLANCO.- ¿Se ha observado el efecto que predice Ud?

ALDROVANDI.- Não, as observações atuais não o permitem.

ASTROPHYSICAL CONSEQUENCES OF THE EXISTENCE OF HEAVY
NEUTRAL LEPTONS IN THE UNIVERSE

H. Quintana

National Radio Astronomy Observatory*, Green Bank
West Virginia

High energy neutrino experiments at Fermilab have revealed new types of particle events in which three leptons are produced and at SPEAR a new heavy lepton (called τ^-) may have been detected. The interpretation of the trimuon events (Benvenuti *et al.*, 1977) requires in some gauge theories the presence of new heavy leptons with masses around a few GeV(+). The standard, very successful SU(2)xU(1) gauge theory of weak and electromagnetic interactions originally proposed by Weinberg (1967) and Salam (1967) has to be enlarged to accept the new particles. Lee and Weinberg (1977a) proposed an extended gauge theory based on the group SU(3)xU(1). A new family of heavy leptons appear in the theory, all of them highly unstable (decay rates proportional to m^5) excepting the lightest, odd internal parity lepton, that by symmetry is required to be absolutely stable. If such a particle exists, and there are strong reasons to believe so since the results are valid in any gauge theory that incorporates new leptons, an important fraction of the mass of the universe could be formed by it.

Cosmological arguments about neutrinos in the Universe are not new. Cowsik and McClelland (1972) showed that the present upper conservative limits on the cosmological mass density, $\rho \leq 2 \times 10^{-29} \text{ g cm}^{-3}$, places an upper limit of $\sim 50 \text{ eV}$ for the neutrino mass. But the restriction is a double-valued function, and in the above form is valid only for $m \ll 1 \text{ MeV}$. In fact, the same argument, but applied to heavy particles (i.e., $m \gg 1 \text{ MeV}$), which are non-relativistic at the time the annihilation rates are longer than the expansion rate, can be used to put a lower limit on the mass of such particles: $m_L \geq 2 \text{ GeV}$ (Lee and Weinberg, 1977b). If such massive neutrinos exist and the Universe reached equilibrium at temperatures $\geq 10^{12} \text{ }^\circ\text{K}$ (at which temperatures

* Operated by Associated Universities, Inc., under contract with the National Science Foundation.

+ Note : For a short account of the present experimental situation see *Physics Today* 1977, 30, 17.

they would decouple), then such neutrinos must contribute to the mass density of the Universe. The importance of the contribution depends on the mass of the particle (here called "heavy neutrino"). If $m_L > 10$ GeV their density is small, but for $2 \text{ GeV} < m_L < 10 \text{ GeV}$, they will be the dominant contribution to the Universe mass. The uncertainties are large but the trimuon experiments suggest masses around 2, 3.5 and 7 GeV. The neutral stable lepton would have a mass in the neighborhood of 2 GeV that makes it all important astrophysically (assuming the correctness of the gauge theories). On the other hand, if one assumes that heavy neutrinos cluster with galaxies in clusters (as is argued below) and one also supposes that clusters of galaxies are fair samples of the Universe, then much stricter limits can be put on the mass density of the Universe (Gott *et al.*, 1974). For this case one deduces $m_L > 10$ GeV. If laboratory experiments show that $m_L < 10$ GeV, then the above arguments have to be revised, or the general underlying assumption that particle-antiparticle symmetry is obeyed in the Universe have to be abandoned (because the lepton mass restrictions are no longer valid). In fact, there are arguments that already suggest the Universe is not baryon symmetric (Steigman, 1976). If there is no lepton-antilepton symmetry either, standard results in Big Bang nucleosynthesis are also drastically changed, in particular those concerning deuterium production.

Gunn *et al.* (1978) have discussed the history of the early Universe on the assumption of the existence of heavy leptons (plus particle-antiparticle symmetry). They find that standard results (Weinberg, 1972) are not much affected, with one notable exception. In the standard Big Bang nucleosynthesis if deuterium is cosmological in origin, its abundance puts strong limits on the baryon density, suggesting a value $\Omega \sim 0.1$. But if heavy neutrinos are present the total density can have any value, and the presently most restrictive argument for a low-density Universe disappears. It is amusing to think that the answer to these far-reaching cosmological questions is to be found in high-energy particle experiments.

If heavy neutrinos exist in the Universe in appreciable quantities a question is of primary interest. Could such particles participate in the formation of astrophysical structure (stars, galaxies, clusters of galaxies) through gravitational collapse? In a recent work, Steigman *et al.* (1978) consider this matter in detail. They show that heavy neutrinos would undergo dissipationless collapse and violent relaxation along with ordinary matter. Therefore they would contribute to the mass of clusters of galaxies. And they would do so keeping their universal ratio to baryonic matter. Violent relaxation and virialization leads to isothermal structures for galaxies and heavy neutrinos in clusters. Heavy neutrinos will have a diffuse distribution and closely follow the distribution of galaxies. Thus, they are an ideal component to constitute the missing mass in clusters (by today's estimates about 70-80% of the mass).

If early formation of galaxies is dissipationless, and elliptical galaxies are thought to be formed essentially in this way (Gott, 1977), heavy neutrinos will also form isothermal halos around galaxies. Halo sizes would be about half the radius at maximum expansion. Large, isolated galaxies should have halos typically of a few hundred kiloparsecs in radius.

In dissipative collapse, when the collapse time t_c is longer than the free fall time t_f , Steigman *et al.* (1978) show that heavy neutrinos are left behind. Therefore a small proportion of heavy neutrinos are to be found in structures formed with substantial dissipation. The disks of spiral galaxies should be in this situation. Inner regions of elliptical galaxies also should have smaller proportions of heavy neutrinos depending on the amount of dissipation involved. But in every case, galaxies should be surrounded by nearly isothermal halos of heavy neutrinos in which the mass grows linearly with radius. Therefore, the M/L ratios should essentially grow linearly with radius in the outer parts (if luminosity of baryonic matter were constant).

Stars are formed in highly dissipative slow collapse. Steigman *et al.* (1978) show that the ratio of heavy neutrinos to protons is of the order $N_L/N_P \sim 10^{-12}$. This is as well since even a small contribution of heavy neutrinos can have drastic effects in stellar structure because they would be very efficient energy transporters due to their large mean free paths. A small ratio $N_\nu/N_P \sim 10^{-10}$ would imply that the center of the Sun would be isothermal enough to reduce the output of normal neutrinos under the present limits (Davis *et al.*, 1971) set by the solar neutrino experiments. But, calculations show that heavy neutrinos will have densities at least two or three orders of magnitude below that needed to be a solution to the solar neutrino problem.

If heavy neutrinos form the halos of galaxies (assuming matter-antimatter symmetry) there is a potentially observable effect. Heavy neutrino-antineutrino pairs decouple very early in the history of the Universe when the annihilation rates become longer than the expansion rate. But when aggregates collapse the density goes up by at least a factor of 8 from that at maximum expansion. In these cases, γ -rays from annihilation would be produced. Gunn *et al.* (1978) argue that the halo of the Galaxy should be such a source of γ -rays, with a spectrum and flux consistent with present limits on the γ -ray background. But future experiments should be able to detect the halo radiation with its specific spectrum and angular dependence.

Most of the work reported here has been carried out in collaboration with J. Faulkner, C. Sarrazin and G. Steigman, and is being reported at length elsewhere (Steigman *et al.*, 1978).

REFERENCES

- Benvenuti, A., *et al.*, 1977, *Phys. Rev. Letters* 38, 1110.
 Cowsik, R., McClelland, J., 1972, *Phys. Rev. Letters* 29, 669.
 Davis Jr., R., Rogers, L.C., Radeka, V., 1971, *Bull. Amer. Phys. Soc.* 16, 631.
 Gott, J.R., 1977, *Ann. Rev. Astron. Astrophys.* 15, 235.
 Gott, J.R., Gunn, J.E., Schramm, D.N., Tinsley, B.M., 1974, *Ap. J.* 194, 543.
 Gunn, J.E., Lee, B.W., Lerche, I., Schramm, D.N., Steigman, G., 1978, *Ap. J.* 223, 1015.
 Lee, B. W., Weinberg, S., 1977a, *Phys. Rev. Letters* 38, 1237.
 _____ 1977b, *Phys. Rev. Letters* 39, 165.
 Salam, A., 1967, in *Elementary Particle Physics*, ed. N. Svortholm.
 Steigman, G., 1976, *Ann. Rev. Astr. Astrophys.* 14, 339.
 Steigman, G., Sarrazin, G., Quintana, H., Faulkner, J., 1978, *A. J.* 83, 1050.
 Weinberg, S., 1967, *Phys. Rev. Letters* 19, 1264.
 _____ 1972, *Gravitation and Cosmology*, Wiley, N.Y.

DISCUSSION

WALBORN.- ¿Existen posibles efectos observacionales de la presencia de estas partículas?

QUINTANA.- Obviamente, si se detectan estas partículas en aceleradores, y se determina su masa, se pueden considerar como efectos observacionales, en el campo astronómico, todos los casos de "missing mass". De los efectos directos, realmente casi no los hay. Uno de los pocos es la posible detección de los rayos γ derivados de la aniquilación de pares en el halo de la galaxia. Cálculos muy preliminares (dado el desconocimiento de las eventuales constantes de acoplamiento) indican que el flujo esperado puede ser detectado con la nueva generación de satélites. Gunn *et al.*, 1978, discuten esta posibilidad en más detalle.

KUNKEL.- ¿Participan estas partículas en procesos de fricción dinámica como fue postulado por S. Tremaine (causando fricción con la cual las galaxias enanas caen en órbitas espirales hacia las

galaxias más masivas)?

QUINTANA.- La importancia de la fricción dinámica es función de la diferencia de masas entre la masa que la sufre y el resto de las partículas del medio en que se mueve (al formar una estela gravitacional). Los leptones mismos no sufren este efecto en forma significativa. Las galaxias en cúmulos o las estrellas en halos, moviéndose en un medio de leptones, sufrirán fricción. Sin embargo, dadas las densidades que el medio tendría, la magnitud esperada no tendría un efecto en la distribución de galaxias mayor que el observado (S. White, M.N.R.A.S., 1976, 1977).

SEGUNDA PARTE
ASTRONOMIA GALACTICA

GALACTIC STRUCTURE

Invited Lecture

A. Blaauw

Leiden Observatory

Developments in research on galactic structure during the past decade were reviewed, reminding the audience of the situation as it was when the volume *Galactic Structure*, in the series *Stars and Stellar System*, appeared. The most striking development since then is the emphasis on aspects of galactic evolution. Another one is the mapping of structural features as revealed by molecular line observations. A question of considerable debate is that of the total mass of the galactic halo.

The framework within which virtually all discussion of galactic evolution takes place assumes that the present properties of the galactic constituents, stars and interstellar medium, are the product of an interplay of dynamical evolution - shaping the space distribution of stars and gas, and leading to the present state of rotational and random motions - and chemical evolution, i.e. the process of star formation and rejection of metal enriched matter, leading to the present abundance distribution in the interstellar medium and the present distribution of the abundances in stars as a function of stellar mass and location in the Galaxy. Aspects of galactic evolution have been reviewed recently, notably in IAU Colloquium No. 45 *Chemical and Dynamical Evolution of our Galaxy*, see the report edited by Basinska-Grzesik and Mayor (1977); in the *Yale Observatory Conference on the Evolution of Galaxies and Stellar Populations*, see the report edited by Tinsley and Larson (1977); and in review articles of which we mention Trimble (1975) and Audouze and Tinsley (1976). We shall therefore not repeat the reviews here. In the present introductory talk, after briefly reviewing the basic assumptions implicit in most of this work, attention was given to the problem of the "Initial Luminosity Function". Virtually all work on the galactic evolution deals with the ILF as a given distribution function of bolometric luminosities, or rather as a distribution function of stellar masses at the time of their formation. The adopted ILF is then derived from the observed luminosity function as determined by Luyten and van Rhijn, see the account by van Rhijn (1965), and taking into account some data provided by open clusters. So far, the assumption of a uniform ILF, independent of time and location in the Galaxy, has not led to serious contradiction, but it is, all the same, an ad hoc hypothesis. The importance was stressed of more refined investigation of the shape of the luminosity function among populations of differ-

ent regions of origin, for instance as a function of distance from the galactic plane; also the need for better understanding of why the ILF has the shape as observed was underlined.

On the subject of molecular line surveys, a useful review article has appeared recently (Burton, 1976). We mention especially the results concerning the large-scale distribution of gas as they have emerged from work on ^{12}CO at $\lambda 2.66$ mm and the new work on OH at 18.6 cm. After the now already classical surveys of HI which represents the most dominant specimen of extreme population I in the Galaxy, we now possess in these new surveys information on a phase which is an even better tracer of the large-scale distribution of areas of star formation. The importance of CO as an indicator of regions of star formation is evident from the close relation of CO clouds to the young OB associations; see for instance the review of this work by Thaddeus and others in the IAU Symposium *Star Formation* (de Jong and Maeder, 1977).

With regard to over-all distribution, the most striking result is the considerable difference between the galactic radial extent of HI and CO. Whereas the former occurs with approximately uniform (smeared-out) density between $R = 4$ and 14 kpc and on both sides of this interval drops steeply, the CO distribution has peak density between 4 and 7 kpc and drops more or less gradually on both sides (and in this respect resembles somewhat more the very peaked distribution of the ionized Hydrogen at $R = 5$ kpc). This result suggests that the most active domain of star formation in the Galaxy now lies well within the distance of the sun from the center, and that such by-products of star formation as supernovae bursts should have their maximum occurrence also in this domain. Direct evidence on this, notwithstanding the difficulty of locating the distance of supernova shells from the sun, seems to confirm this.

For results from OH line observations, we refer particularly to recent work by Baud and Winnberg (Baud, 1978). It appears that OH sources can be subdivided according to the velocity separation ΔV between the two components into which the OH line at $\lambda 18.6$ is resolved, and that there is a close correlation between ΔV and the peculiar velocity dispersion of the sources. For large ΔV (> 28 km/sec) this velocity dispersion does not exceed the value we usually encounter for the very youngest objects known, like the OB stars. Accordingly, here again we are dealing with a tracer of the locations of star formation in the most inner regions of the Galaxy.

The problem of the total mass of the galactic halo and disk, controversial at this moment (and only briefly referred to in my introduction at the Conference), is approached from two sides: by attempting direct mass density determination within the Galaxy on the basis of dynamical considerations, and by studying analogies between the Galaxy and other stellar systems for which estimates of total masses including their entire halo are feasible - for instance in double or multiple galaxies. In the context of the former approach, we want to emphasize the importance of improvement and extension of the work on the local mass density in the solar neighbourhood. The most powerful, classical, method, explored since almost sixty years now, is that of determining the force $K(z)$ perpendicular to the galactic plane as a function of distance z to the plane. From this field of force, the local mass distribution causing the force is derived and hence the local density. It should be pointed out, that we do not yet know the force $K(z)$ with the desired accuracy beyond 700 pc, and that it is quite uncertain already beyond $z = 1$ kpc. Yet, what we need now is also mass densities at these larger distances from the plane. Improved determination of $K(z)$ beyond 1 kpc requires time consuming, but quite feasible, investigations of the density distribution and the velocity distribution of selected classes of stars in the distance range between 500 and 1000 pc, for which late F dwarfs and K giants may be the most suitable choice.

REFERENCES

- Audouze, J., Tinsley, B.M., 1976, *Ann. Rev. Astron. Astrophys.* 14, 43.
- Basinska-Grzesik, E., Mayor, M., 1977, *Chemical and Dynamical Evolution of our Galaxy*, IAU Colloquium N° 45, Geneva Observatory.
- Baud, B., 1978, Thesis Leiden University; to be published in *Astron. Astrophys.*
- Burton, W.B., 1976, *Ann. Rev. Astron. Astrophys.* 4, 275.
- de Jong, T., Maeder, A., eds., 1977, *Star Formation*, IAU Symp. N° 75, p. 37.
- Tinsley, B.M., Larson, R.B., 1977, *The Evolution of Galaxies and Stellar Populations*, Yale Univ. Observatory.
- Trimble, V., 1975, *Reviews of Modern Physics*, 47, 877.
- van Rhijn, P.J., 1965, *Classical Methods for the Determination of Luminosity Function and Density Distribution*, in *Galactic Structure*. ed. A. Blaauw and M. Schmidt, p. 27.

DISCUSSION

WALBORN.- The diagram of the CO distribution is striking. Could you give more information about where the work was done and the interpretation of the phenomena near longitude zero?

BLAAUW.- The remarkable velocity distribution in the region close to the center ($l \sim 0^\circ$) must be due to at least two causes. First of all, the change from systematically negative to positive values at $l = 0^\circ$ is to be interpreted as due to fast rotation in a small disk. Superposed on this are irregular, perhaps expansive phenomena of a nature not uncommon in galactic nuclei in general.

LASKER.- In your opinion, how should we use our knowledge of the galaxy to pick up the thread of understanding the structure of the Magellanic Clouds?

BLAAUW.- A difficult question. I should think that it is in the field of population studies that there is a natural extension of galactic studies to the Clouds or viceversa.

A SEARCH FOR HI IN THE CHAMAELEON T-ASSOCIATION

E.M. Arnal*

Instituto Argentino de Radioastronomía
Observatorio Astronómico, Universidad Nacional de La Plata

M.L. Franco+

Instituto Argentino de Radioastronomía

I. INTRODUCTION

The T-Association in Chamaeleon situated at 115 pc from the sun (Grasdalen *et al.*, 1975) at a galactic latitude $b \sim -15^\circ$, is embedded in a dark cloud and is an ideal object to be observed in the 21 cm line.

Observations of this object were carried out with the 30 m dish of the I.A.R., with an angular and velocity resolution at 1420 MHz, of $0.5'$ and 2 km/s, respectively.

II. OBSERVATIONAL RESULTS

The general appearance of 21 cm profiles observed in the region of the association are displayed in Fig. 1a and 1b. An extension of the original grid of observations towards the galactic plane, showed that the component at -20 km/s increases its importance towards lower galactic latitudes. Therefore, we believe that this component corresponds to an HI concentration associated with the galactic plane.

A careful analysis of the isophotes, the column densities of the HI in several ranges of velocities, and the individual profiles, did not show evidence of structures that could be connected with the Chamaeleon T-Association.

Therefore, we have to conclude that if there exists HI associated with the T-Association, it can not be detected with our equipment.

* Member of the Carrera del Investigador Científico del Consejo Nacional de Investigaciones Científicas y Técnicas de Argentina.

+ On leave of absence at International Centre for Theoretical Physics, Strada Costiera 11 - P.O.B. 586-34100 Trieste-Italy

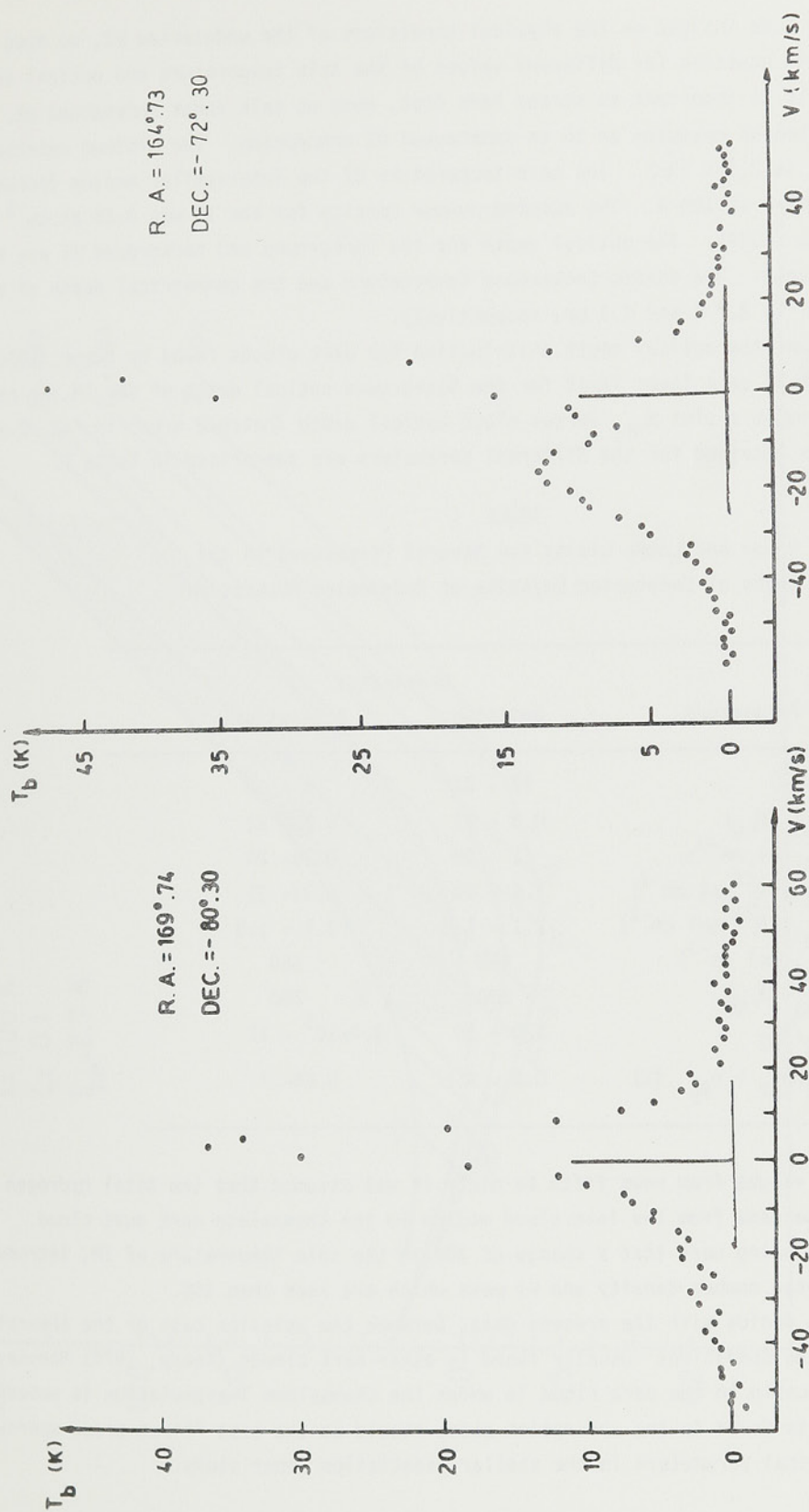


Fig. 1. a) Neutral hydrogen profile in the direction of the Chamaeleon

T-association. α (1975.0) = $169^\circ 74'$; δ (1975.0) = $-88^\circ 30'$.

b) Same for α (1975.0) = $164^\circ 73'$; δ (1975.0) = $-72^\circ 30'$.

III. ANALYSIS

In order to get some insight on the physical conditions of the undetected HI, we have solved the radiative transfer equation for different values of the spin temperature and optical depth of the undetected HI. It is important to stress here that, when we talk about undetected HI, we refer either to an undetected HI emission or to an undetected HI absorption. The minimum detectable temperature per channel is 2.5 K (3σ). The spin temperature of the interstellar medium (hereafter referred as IM) is taken as 100 K. The adopted number density for the IM was 0.25 at.cm^{-3} as given by Jenkins and Savage (1974). The optical depth for the foreground and background HI are taken as 0.1 and 0.4 respectively. The cosmic background temperature and the geometrical depth of the dark cloud are taken equal to 2.7 K and 4.3 pc, respectively.

Taking into account the optical depth distribution for dark clouds found by Knapp (1974), and assuming a value of 0.12 as a lower limit for the background optical depth of the IM, we can delimit some special regions in a plot M_{HI} versus cloud optical depth (hatched areas in Fig. 2 and 3). The numerical results obtained for the different parameters are summarized in Table I.

TABLE I
Upper and Lower Limits for Several Parameters in the
Cases of Undetected Emission or Undetected Absorption

Parameters	Undetected	
	Emission	Absorption
T_S (K)	17 - 67	6 - 32
M_{HI} ($M_{\odot}$)	0.9 - 27	0.2 - 21
n_{HI} (at.cm^{-3})	1 - 30	0.25 - 24
N_{HI} ($10^{19} \text{ at.cm}^{-2}$)	1.4 - 40	0.33 - 31
N_{H_2} ($10^{21} \text{ mol cm}^{-2}$)	2.1 - 1.9	2.1 - 1.9
n_{H_2} (mol cm^{-3})	150	150
M_{H_2} ($M_{\odot}$)	280	280
$n_{\text{H}_2}/n_{\text{HI}}$	320 - 10	2.4×10^3 - 12
$n_{\text{HI}}/n_{\text{HI}} + n_{\text{H}_2}$ (%)	0.3 - 9.5	0.08 - 7

In deriving the values from rows fifth to ninth it was assumed that the total hydrogen gas-to-dust ratio remains the same from the intercloud medium to the Chamaeleon dark dust cloud.

It is worth mentioning here that a change of 30% in the spin temperature of IM, introduces variations in the quoted number density and HI mass which are less than 10%.

We are unable to decide with the present data, between the emission case or the absorption case. Therefore if the conditions usually found in other dark clouds (Knapp, 1974; Mahoney *et al.*, 1970) could be applicable to the dark cloud in which the Chamaeleon T-association is embedded, we believe that the limits found in the absorption case, should be the best "first order approximation" for the hydrogen physical parameters in the stellar association under study.

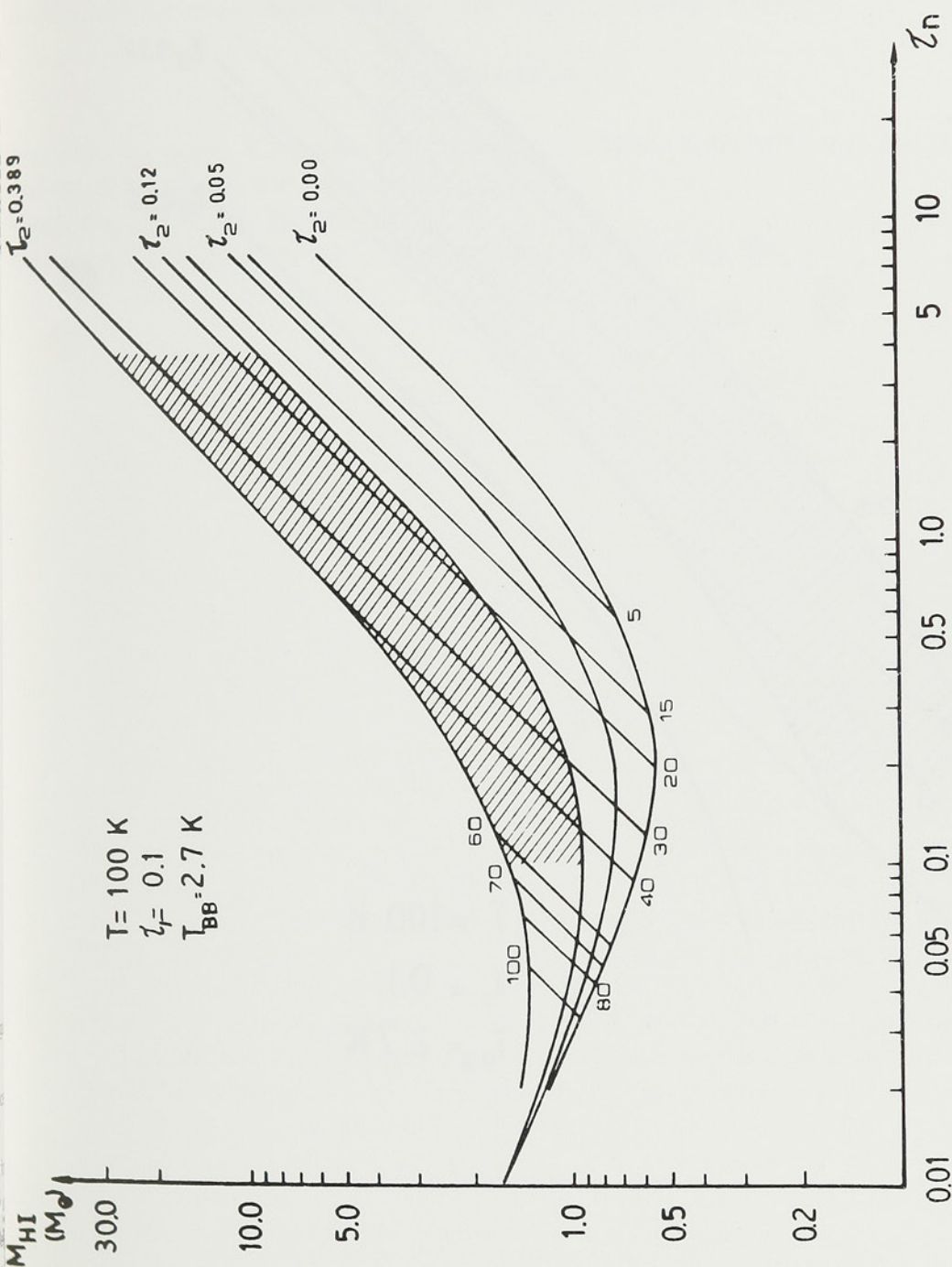


Fig. 2. HI-mass compatible with our negative results as a function of the cloud's optical depth. This is for the case of undetected emission. Solid lines indicate different values of the spin temperature for the undetected HI. Thin lines correspond to different values of the optical depth of the background HI. Hatched areas represent the likely range for the physical conditions of the undetected HI.

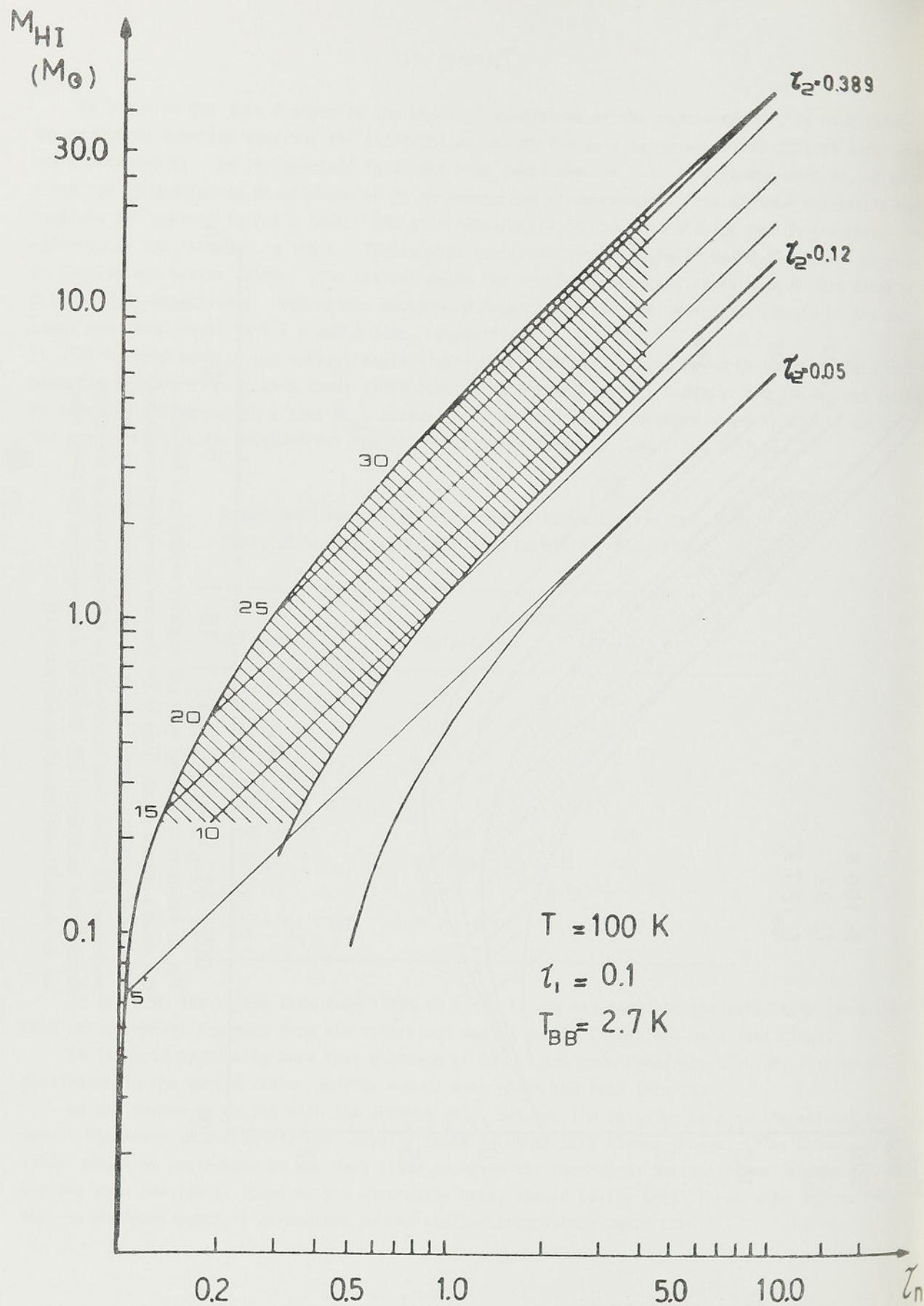


Fig. 3. Same for the case of undetected absorption.

IV. CONCLUSIONS

More than 80 points on the Chamaeleon dark dust cloud and its outskirts, in which a T-association is embedded, were observed in the 21-cm line. Only systematic variations that could be attributed to the general galactic HI were found. Solving the transport equation we were able to derive the range of variation, for the different parameters of the undetected HI, which are compatible with our observational results. The ranges are quoted in Table I.

REFERENCES

- Grasdalen, B., Joyce, R., Knacke, R.F., Strom, S.E., Strom, K.M., 1975, A.J. 80, 117.
Jenkins, F.B., Savage, B.D., 1974, Ap. J. 187, 243.
Knapp, G.R., 1974, A.J. 79, 527.
Mahoney, M.J., Mc Cutcheon, W.H., Shuter, W.L.H., 1976, A.J. 81, 508.

HI IN NINE OPEN CLUSTERS

E.M. Arnal*

Instituto Argentino de Radioastronomía
Observatorio Astronómico de la Universidad de La Plata

I. INTRODUCTION

I have carried out a search for neutral hydrogen associated with the following open clusters: ξ Sculptoris cluster, NGC 2204, NGC 2243, NGC 2345, IC 2391, NGC 2516, NGC 3766, Mel 227 and NGC 6994. They are situated, with exception of NGC 2345 and NGC 3766, at intermediate and high galactic latitudes, $|b| \geq 6^\circ 5$. The main characteristics of them are summarized in Table I. I want to report here the observational results obtained. Previous works in this area have been done by Schwartz (1967), Gordon *et al.* (1968), and Tovmassian (1973).

II. OBSERVATIONS

The observations have been carried out with the radiotelescope of the I.A.R., with an angular and velocity resolution at 1420 MHz of $0^\circ 5$ and 2 km/s, respectively.

In each cluster, the observed points were distributed over a cross with arms orientated in right ascension and declination, and the center of the cross coincident with the optical position of the cluster center. Within a circle with an angular radius equal to three times the optical radius of the cluster, the points were spaced $30'$ apart, and outside that circle 1° apart.

Our filter-bank was centred at the optically observed cluster's radial velocity V_o . When V_o was not known we have adopted the radial velocity derived from the galactic-rotation model of Schmidt (1965).

III. OBSERVATIONAL RESULTS

In none of the clusters, except in NGC 2345 and NGC 2516, evidence of a peculiar behaviour of the HI distribution was found. For the above mentioned clusters dips of absorption were found

* Member of the Carrera del Investigador Científico del Consejo Nacional de Investigaciones Científicas y Técnicas de Argentina.

TABLE I
Principal Characteristics of the Observed Open Clusters

Name	R.A.		Decl.		l	b	ϕ_{c1}	d	Age	V_R	Ref.
	h	m	o	'	(o)	(o)	(')	(pc)	(years)	(km/s)	
ξ Sculp.	00	01.7	-30	13	14.97	-79.26	90	200	5×10^7	-5	(1)
NGC 2204	06	13.5	-18	38	226.03	-16.07	18	4450	3×10^9	60 M	(2)
NGC 2243	06	27.9	-35	15	239.50	-17.97	6	4600	5×10^9	60 M	(3)
NGC 2345	07	06.0	-13	06	226.57	-02.30	11	1750	6×10^7	22 M	(4)
NGC 2516	07	57.5	-60	44	273.94	-15.88	60	400	6×10^7	2	(5)
IC 2391	08	38.8	-52	53	270.36	-06.88	45	150	3×10^7	-2	(6)
NGC 3766	11	33.8	-61	20	293.11	-00.03	12	1530	3×10^7	-17 M	(7)
Me1 227	20	04.5	-79	28	34.54	-30.43	60	120	4×10^8	1 M	(1)
NGC 6994	20	56.3	-12	50	35.73	-33.95	3	3850	?	40 M	(8)

Columns: 1st. - Identification; 2nd. and 3rd. - Equatorial coordinates (1950.0); 4th. and 5th. - Galactic coordinates; 6th. - Angular diameter of the cluster; 7th. - Cluster's distance; 8th. - Cluster's age; 9th. - Radial velocity of the cluster referred to the L.S.R. An M following the number indicates that the previous value was derived from the galactic rotation model of Schmidt (1965); 10th. - References.

References: (1) Epstein, 1968
 (2) Gordon, Howard, Westerhout, 1968
 (3) van den Bergh, 1977
 (4) Moffat, 1974
 (5) Feinstein, Marraco, Mirabel, 1973
 (6) Perry, Hill, 1969
 (7) Winnenburgh, 1973
 (8) Collinder, 1931

(Arnal, 1977).

For the other clusters, assuming that the HI is optically thin and has a spherical distribution coincident with the cluster extension, upper and lower limits for the HI mass and number density can be calculated from:

$$M_{HI} = 5.36 \times 10^{-2} T_b d^2 \phi_{c1}^2 \alpha (M_{\odot}) ,$$

$$n_{HI} = 4.08 T_b d^{-1} \phi_{c1}^{-1} \alpha (\text{at cm}^{-3}) ,$$

being d the distance to the cluster in parsecs, ϕ_{c1} the diameter of the cluster in radians, T_b the minimum detectable temperature and α a factor that takes into account the dilution effects. The results are summarized in Table II. The quoted errors for the mass and number density arise from the uncertainty in cluster distance.

TABLE II
HI Mass and Number Density

Name	M_{HI} ($M_{\odot}$)	n_{HI} (at/cm^3)	
ξ Sculp.	4.4 ± 0.8 (x)	2.3 ± 0.3 (x)	
NGC 2204	240 ± 40 (x)	1.5 ± 0.1 (x)	
NGC 2243	210 ± 55 (x)	26 ± 3 (x)	
NGC 2345	440 ± 90	3 ± 0.5	Derived from absorption measurements
NGC 2516	26 ± 12	13 ± 0.5	
IC 2391	0.5 ± 0.1 (x)	6 ± 0.5 (x)	
NGC 3766	34 ± 7 (x)	3 ± 0.5 (x)	
Me1 227	0.7 ± 0.1 (x)	6 ± 1 (x)	
NGC 6994	180 ± 36 (x)	370 ± 40 (x)	

Columns: 1st. - Name of the cluster; 2nd. and 3rd. - HI mass and number density. When an (x) follows a number it indicates that it is an upper limit.

REFERENCES

- Arnal, E.M., 1977, unpublished Ph. D. Thesis, La Plata University.
 Collinder, P., 1931, *Ann. Obs. Lund.* 2, LK.
 Epstein, I., 1968, *A. J.* 73, 556.
 Feinstein, A., Marraco, H., Mirabel, I., 1973, *Astron. Astrophys. Suppl.* 9, 233.
 Gordon, C.P., Howard III, N.F., Westerhout, G., 1968, *Ap. J.* 154, 103.
 Hawarden, T.G., 1976, *M.N.R.A.S.* 174, 225.
 Moffat, A.F.J., 1974, *Astron. Astrophys. Suppl.* 16, 33.
 Perry, C.L., Hill, G., 1969, *A. J.* 74, 899.
 Schwartz, R., 1967, *Forschungsber des Landes Nordrhein-Westfalen.* N°1844.
 Schmidt, M., 1965, in *Galactic Structure*, ed. A. Blaauw and M. Schmidt, Chicago University Press, p. 526.
 Tovmassian, H.M., 1973, *Austr. J. Phys.* 26, 829.
 Van den Bergh, S., 1977, *Ap. J.* 215, 89.
 Winneburg, W., 1973, *Astron. Astrophys.* 24, 157.

DISCUSSION

WIELEBINSKI.- A technical question: how well do you know your beam and beam stability? Is it not necessary to take out sidelobe effects in your most sensitive measurements? (In Bonn an enormous amount of time went into studying the beam and using the convolution methods to ensure that profiles are real).

ARNAL.- Lamento decir que no conocemos muy bien el diagrama de nuestra antena, pero estamos completamente seguros que el lóbulo principal del diagrama de antena es gaussiano y que los lóbulos secundarios se encuentran por lo menos a -20 dB de éste. Nada puedo decir acerca de la estabilidad.

En cuanto a su última pregunta, cabe decir que en cada sesión de observación se observó una serie de puntos de calibración muy bien conocidos, con una línea de base bien definida, y en

ningún caso hemos notado alguna distorsión en los mismos. Por eso creemos que nuestros perfiles son reales y no están contaminados por posibles efectos de lóbulos secundarios.

BLAAUW.- Are these clusters old enough so that they may have passed several times through the galactic plane?

ARNAL.- Algunos de ellos, como por ejemplo NGC 2204 y NGC 2243, son realmente bastante viejos como para que hayan podido pasar a través del plano galáctico varias veces. Este proceso ha sido mencionado en investigaciones previas como una posibilidad para explicar la ausencia de HI en cúmulos abiertos viejos. Pero el punto es que existen otros objetos en nuestra lista, por ejemplo NGC 3766, que no son lo suficientemente viejos como para que este mecanismo haya podido actuar en forma eficiente, y sin embargo no pudimos encontrar ninguna concentración de HI ligada a los mismos.

WALBORN.- ¿Cuál era la coincidencia entre las velocidades de HI y estelares para los cúmulos detectados?

ARNAL.- El acuerdo es muy bueno. En el caso de NGC 2516 la diferencia es de sólo 0.5 km/seg. En NGC 2345 el dip de absorción se observa a una velocidad de +17 km/seg, y la velocidad radial del cúmulo, derivada del modelo de Schmidt (1965), es del orden de 20 km/seg.

FOTOMETRIA MULTICOLOR DEL CUMULO ABIERTO NGC 2287

Alejandro Feinstein

Observatorio Astronómico, Universidad Nacional de La Plata

Juan J. Clariá

Instituto de Física, Universidade Federal do Rio Grande do Sul
Porto Alegre

Ascensión L. Cabrera

Observatorio Astronómico, Universidad Nacional de La Plata

Se presentan los resultados fotométricos del cúmulo abierto NGC 2287 (M 41) basados en 70 estrellas medidas en UBV, y también algunas en RI y en el sistema DDO.

Mediante los valores observados, V, B-V y U-B, se dedujeron los excesos de color, cuyo promedio para las estrellas miembros resultó $E(B-V) = 0.01 \pm 0.03$. Con el empleo de la secuencia principal de edad cero (ZAMS) de Blaauw, y considerando que las estrellas evolucionadas de la secuencia principal son del tipo B9-A0 (Hartoog, 1976), el punto de giro de la secuencia principal ("turn-off point") se ubica en $B-V = 0.0$. Esto indica que la secuencia principal comienza en $V = 10.7$, con lo que el módulo de distancia verdadero resultó $V_0 - M_V = 9.0$ (figura 1).

El cúmulo presenta siete estrellas gigantes rojas y una gigante amarilla, todas situadas arriba del extremo superior de la secuencia principal. En el diagrama (V-R, V-I), estas ocho estrellas se ubican sobre una línea recta con muy poca dispersión, lo que hace muy probable que todas ellas pertenezcan al cúmulo (figura 2). No resulta evidente la presencia de efectos de enrojecimiento.

La estrella amarilla, HD 49126, se midió en 10 oportunidades, y los valores de la magnitud V parecen sugerir su variabilidad.

La estrella más brillante del cúmulo, HD 49333, es del tipo de helio débil ("He-weak") según Jaschek, Jaschek y Arnal (1969). Ha sido clasificada por Cowley (1972) como B7 III, pero su color: $B-V = -0.16$, $U-B = -0.62$, corresponde a una estrella B4. Las mediciones tanto en RI como en las líneas de hidrógeno, $H\alpha$ y $H\beta$, confirman también un tipo espectral B4 (figura 3). El índice libre de enrojecimiento, $Q = -0.50$, la ubica entre las estrellas B más frías y con características peculiares en las líneas de helio.

La estrella HD 49333 se la clasificaría como "blue straggler", pues aparece en el diagrama color-magnitud en la prolongación de la secuencia principal evolucionada y arriba de las gigantes

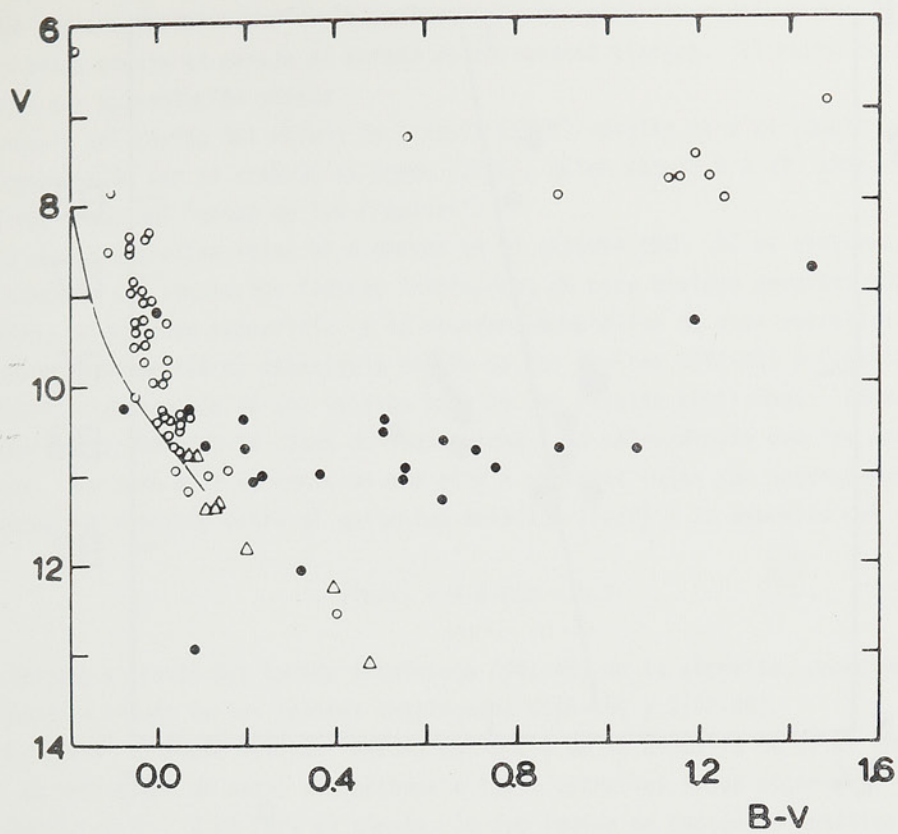


Fig. 1.

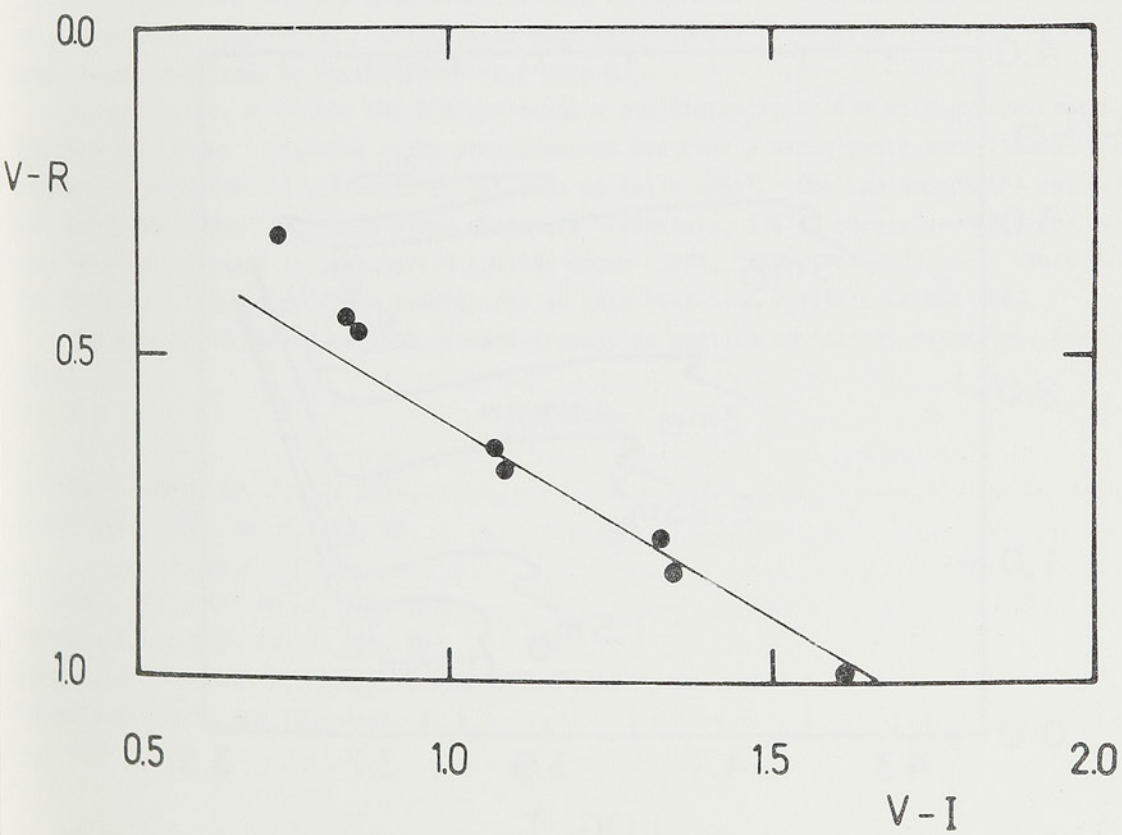


Fig. 2.

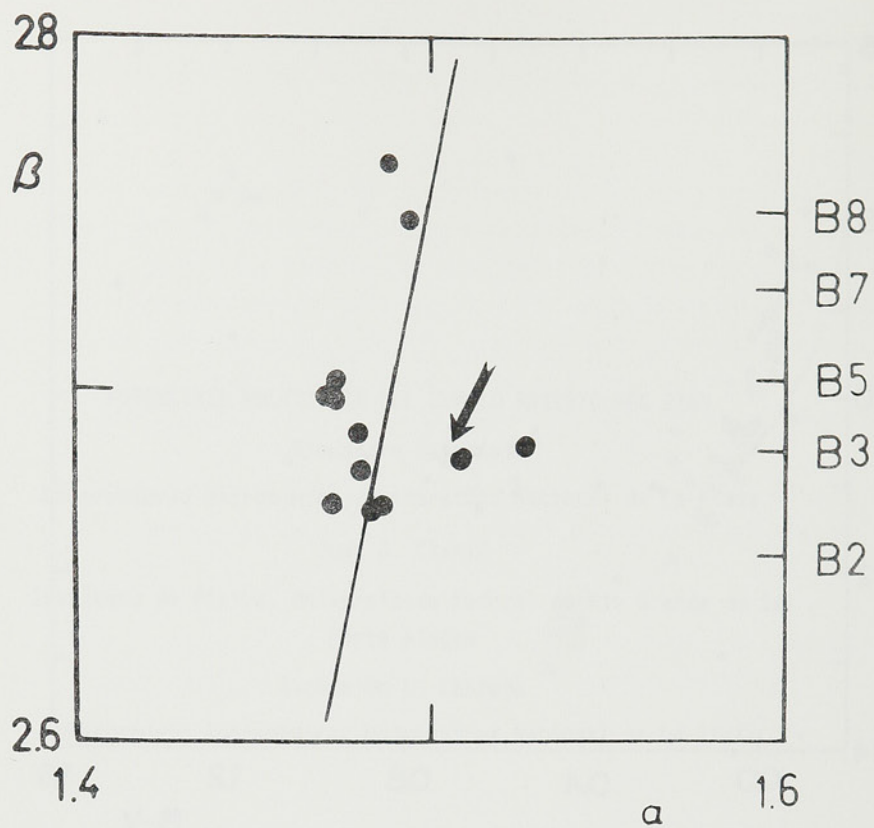


Fig. 3

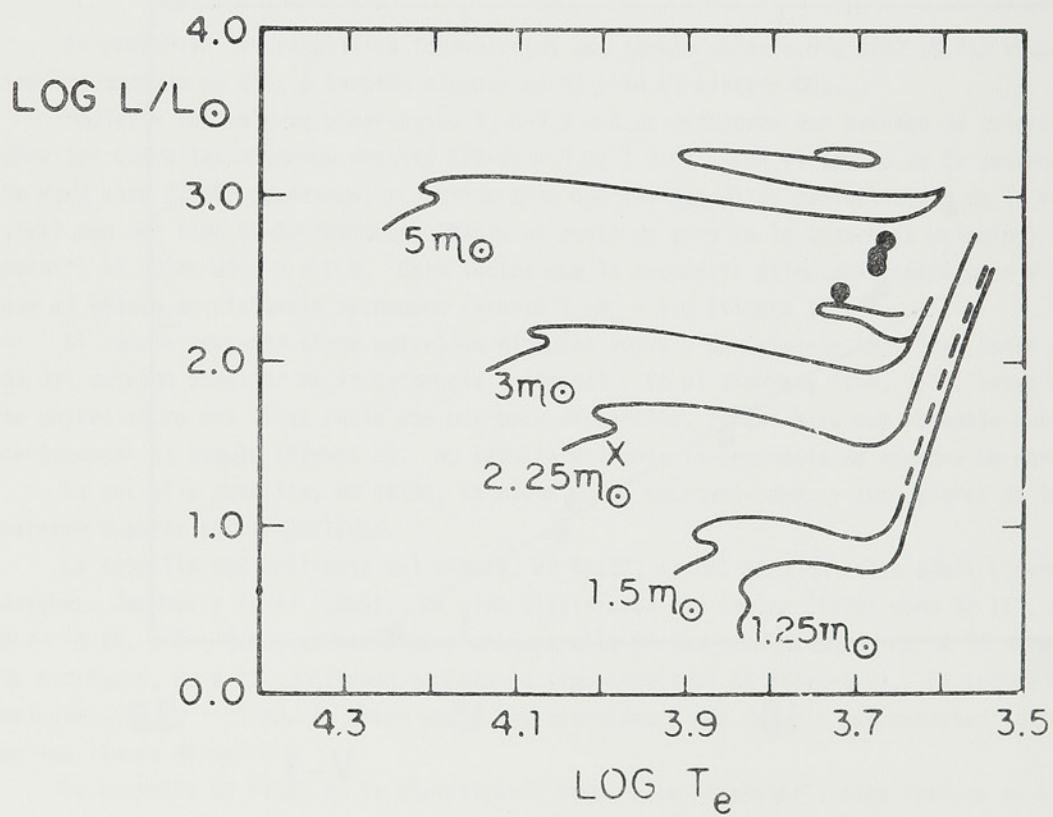


Fig. 4

rojas. Esto sugiere que proviene de la evolución de las gigantes rojas, y su actual posición podría ser la etapa previa al pasaje al estado de las enanas blancas. El hecho de ser de helio débil la vincularía con su evolución pasada.

Mediante la aplicación del método de Lindoff (1968) resulta para el cúmulo una edad de 6×10^7 años. Su comparación con el trabajo de Eggen (1975), quien obtuvo 8×10^7 años, sitúa a este cúmulo como el más viejo del "grupo de las Pléyades".

Cuatro de las estrellas rojas se midieron en el sistema DDO. Si se confirma que las gigantes rojas son miembros del cúmulo, los índices intrínsecos de este sistema permiten obtener la temperatura efectiva, la gravedad superficial y la abundancia metálica de esas estrellas.

El exceso de color $E(B-V)$ obtenido a través de los índices $C(42-45)$ y $C(45-48)$ debe coincidir con el obtenido directamente de los valores UBV , lo que resulta confirmado. Además los índices DDO permiten deducir también la clase de luminosidad. Su coincidencia con los datos espectrales es muy buena. Por todo ello se confirma que esas 4 gigantes rojas son seguramente miembros.

Se conoce una relación entre el contenido metálico $[Fe/H]$ y la anomalía del cianógeno:

$$[Fe/H] = 4.5 \delta CN - 0.2$$

la que se obtiene a través del índice intrínseco $C(41-42)$ de la estrella, comparado con su valor normal obtenido a través de los índices intrínsecos $C(45-48)$ y $C(42-45)$.

Además, $[Fe/H]$ se puede obtener también por medio de la anomalía de color $\delta C(35-42)$ de cada estrella. La aplicación de estos dos métodos a las 4 estrellas rojas observadas permite deducir un valor de $[Fe/H] = -0.02 \pm 0.04$ para el cúmulo, lo que indica un contenido metálico similar al del Sol.

Con los índices DDO para cada estrella roja se puede determinar también la temperatura efectiva y la gravedad superficial. Conocida la magnitud bolométrica resulta inmediato el cálculo de la masa, cuyos resultados se presentan en la figura 4.

En conclusión, el cúmulo NGC 2287, situado a una distancia de 630 pc y con un exceso de color $E(B-V) = 0.0$, tiene 7 gigantes rojas probablemente miembros y una gigante amarilla posiblemente variable. Su estrella más brillante es del tipo de helio débil. Con una separación angular de $5.5''$ del cúmulo Collinder 121 y a la misma distancia (Feinstein, 1967), parece probable una conexión física entre ellos según lo ha sugerido también Eggen (1974, 1975), formando parte ambos del grupo de las Pléyades. Esto se confirma también por el bajo contenido metálico de NGC 2287.

Una descripción más detallada de este trabajo se publicó en *Astron. Astrophys. Suppl.* **34**, 241, 1978.

REFERENCIAS

- Cowley, A., 1972, *Ap. J.* **77**, 750.
 Eggen, O.J., 1974, *Ap. J.* **188**, 59.
 ———, 1975, *P.A.S.P.* **87**, 37.
 Feinstein, A., 1967, *Ap. J.* **149**, 107.
 Hartoog, M.R., 1976, *Ap. J.* **205**, 807.
 Jaschek, C., Jaschek, M., Arnal, E.M., 1969, *P.A.S.P.* **81**, 650.
 Lindoff, U., 1968, *Ark. für Astr.* **5**, 1.

PARAMETROS DE COMPOSICION QUIMICA DEL CUMULO
ABIERTO DE EDAD INTERMEDIA NGC 7789

Juan J. Clariá

Instituto de Física, Universidade Federal do Rio Grande do Sul
Pôrto Alegre

RESUMEN

Utilizando datos fotométricos DDO-UBV se determinan anomalías de CN, gravedades superficiales y temperaturas efectivas de 22 estrellas gigantes del denominado "clump" en NGC 7789. El exceso de color medio $E(B-V)$ obtenido a partir de estas estrellas es 0.22 ± 0.02 , mientras que la razón $[Fe/H]$ del clump resulta -0.35 ± 0.02 . Las propiedades derivadas juntamente con los resultados provenientes de modelos teóricos permiten determinar los parámetros de composición química. Un análisis de todas las variables que directa o indirectamente intervienen en la determinación de la masa media del clump, demuestra que las estrellas rojas del cúmulo pierden parte de su masa en alguna etapa de evolución avanzada.

ABSTRACT

CN strengths, surface gravities, and effective temperatures of 22 giant stars belonging to the clump of NGC 7789 have been determined by using UBV and DDO photometric data. The mean color excess $E(B-V)$ obtained from these stars is 0.22 ± 0.02 , while the $[Fe/H]$ ratio turns out to be -0.35 ± 0.02 . We determine the chemical composition parameters of the cluster by requiring consistency between the just mentioned observational results and some theoretical models. From the analysis of the variables that, directly or indirectly, enter in the determination of the mean mass of the clump, we conclude that there exists some mass loss in the red giants of the cluster.

ESTUDIO DEL CUMULO ABIERTO COLLINDER 140

Juan J. Clariá

Instituto de Física, Universidade Federal do Rio Grande Do Sul
Pôrto Alegre

RESUMEN

Datos fotométricos UBV-H β -DDO, espectroscópicos y cinemáticos, han sido obtenidos en la región de Cr 140. Se confirma la realidad física del cúmulo y se reconoce un número mínimo de 27 miembros. Cr 140 se ubica a (370 ± 30) pc del sol y presenta un enrojecimiento uniforme $E(B-V) = 0.05$. El cúmulo se formó hace 2.1×10^7 años, es dinámicamente estable, y su abundancia metálica es similar a la del sol. Se presentan argumentos en favor de la posibilidad, mencionada por Williams, de que Cr 140 represente una porción remanente de una vieja asociación B que se ha desintegrado parcialmente en una escala de tiempo similar a la edad del cúmulo.

ABSTRACT

Photometric UBV-H β -DDO, as well as spectroscopic and kinematical data in the region of Cr 140 have been obtained. We confirm that Cr 140 is a genuine open cluster with a minimum membership of 27 stars. It is located at (370 ± 30) pc from the sun and it is uniformly reddened by $E(B-V) = 0.05$. The cluster age is 2.1×10^7 years, it is dynamically stable and its metal abundance is similar to that of the sun. We suggest, in agreement with Williams, that Cr 140 might be one of the remainders in a desintegration process which took place in an old B association. We estimate that the time scale for such a process is near to the cluster age.

DISCUSION

ALCAINO.- Los cuatro cúmulos presentados, cuyo rango de latitud galáctica es de $-7^\circ < b < -10^\circ$, tienen un rango de excesos de color muy bajo, de $0.03 \leq E(B-V) \leq 0.05$, todos a una distancia de 400 pc. ¿Es éste el exceso esperado a esta distancia y a esta latitud galáctica, o estamos observando a través de una nube tenue?

CLARIA.- Es lo esperado, está dentro de lo normal.

BLAAUW.- The velocity components perpendicular to the galactic plane seem very large.

CLARIA.- Indeed, the W components perpendicular to the galactic plane appear to be very large. However, I would not assign too much meaning to this result, since it is a consequence of the low accuracy of the proper motions in right ascension. In fact, the W vector depends almost entirely on these proper motion components, and it is well known that the right ascension proper motion system south of declination -25° is not very reliable.

WALBORN.- Es importante tener evidencia independiente para eliminar no-miembros de los diagramas fotométricos; si no, se pueden eliminar miembros peculiares.

CLARIA.- Al efectuar la separación entre miembros y no-miembros del cúmulo, siempre se corre el riesgo de eliminar erróneamente algún miembro físico y viceversa. Para considerar una estrella miembro del cúmulo exigimos que su ubicación en los dos diagramas color-magnitud corresponda al mismo estado de evolución en el cúmulo. Teniendo en cuenta los múltiples factores que contribuyen a la dispersión en estos diagramas, una estrella ubicada dentro de 0.5 magnitudes de la secuencia principal la consideramos parte de ella. Al aplicar este criterio corremos el riesgo de eliminar posibles sub-enanas del agregado. Sin embargo, la frecuencia de tales estrellas en cúmulos abiertos es extremadamente baja, por lo que lo anterior no constituye una restricción seria. Por otra parte, para los miembros más tempranos que A2 exigimos que su posición en el diagrama $\beta/(B-V)_0$ sea consistente con la posición de dichas estrellas en los diagramas color-magnitud, salvo pequeñas diferencias debidas a errores accidentales o enrojecimiento diferencial. En un número apreciable de estrellas pudimos todavía aplicar un tercer criterio basado en los movimientos propios y/o en las velocidades radiales. Sin embargo, al aplicar los criterios mencionados siempre es posible que algún o algunos miembros peculiares del cúmulo hayan sido erróneamente eliminados. No podemos evitar este riesgo y, por lo tanto, cualquier otra evidencia independiente en favor de la vinculación de estas estrellas al cúmulo es importante.

BASIC PARAMETERS OF GALACTIC GLOBULAR CLUSTERS:
HISTOGRAMS, CORRELATIONS, SELECTION EFFECTS*.

G. Alcaíno

Instituto Isaac Newton
Ministerio de Educación de Chile

ABSTRACT

We present the histograms of selected parameters. Mean values are quoted in relevant cases. For those with clearly asymmetric distribution we have cited the median values. Pertinent comments are in place.

We discuss as well the correlations between basic parameters taking into account possible selection effects. The analysis is in the order : position, metallicity, diameter, density, luminosity, frequency of variables. The assessment of correlation is made graphically.

DISCUSION

CLARIA.- En uno de los diagramas que Ud. mostró aprecié que hay unos pocos cúmulos globulares con abundancias metálicas ligeramente mayores que la abundancia metálica solar. ¿Podría Ud. decirnos cuáles son estos cúmulos?

ALCAINO.- De acuerdo a la clasificación de Kukarkin (1974, *The General Catalogue of Globular Clusters of our Galaxy*, Nauka, Moscow) ellos son: NGC 5927, NGC 6304, NGC 6366, NGC 6528, NGC 6539, en general en la dirección del centro de la galaxia, y, con excepción de NGC 6366, todos a latitudes galácticas menores que $\langle b \rangle = 6^\circ$.

* Published in extenso in *Vistas in Astronomy*, Vol 23, 1979.

CURRENT RESEARCH ON GALACTIC STRUCTURE AT
LA PLATA OBSERVATORY

Juan C. Muzzio^{*†}

Observatorio Astronómico, Universidad Nacional de La Plata

I. INTRODUCTION

During the past few years we have done at La Plata Observatory several optical investigations on the spiral structure of our Galaxy, the observations having been obtained from the Cerro Tololo Inter-American Observatory (CTIO) and from the Yale-Columbia station at El Leoncito (EL), San Juan. Our aim is to extend the knowledge about the spiral structure of our Galaxy to large distances from the Sun and to improve this knowledge in regions where heavy interstellar absorption poses a difficulty to optical studies.

Our approach is simple. First, we search for good spiral tracers (OB stars, cepheid variables, Be stars) down to fainter magnitude limits than those currently reached. Then, we study those objects by means of photoelectric photometry to derive their distance to the Sun and the amount of interstellar absorption. A third step will be to obtain radial velocities for the distant spiral tracers in order to investigate the kinematics of spiral structure. Thus far, only one attempt was done by us in this respect (Muzzio and Forte, 1975), using kinematical data obtained by other authors, and I will not deal with this subject in what follows since, for the time being, it is just a future project.

II. SEARCHES FOR FAINT OB STARS

The techniques used to discover OB stars fainter than about 12 mag, and the results we obtained with them in the past were discussed by Muzzio (1976).

* Member of the Carrera del Investigador Científico del Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina.

† Visiting Astronomer Cerro Tololo Inter-American Observatory, supported by the National Science Foundation under contract No. AST 74-04128.

Our current searches for faint OB stars are being done using Kodak IIIa-J plates (baked in N₂) obtained with the Curtis Schmidt-telescope at CTIO and the thin prism (Blanco, 1974) which gives a dispersion of 1360 Å/mm at H γ . The spectra are widened 0.2 mm and, using 30-min and 80-min exposure times, we can cover the magnitude interval 12 mag < B < 15 mag.

The results of our searches in the Coalsack and the Vela regions were published by Muzzio and Orsatti (1977a and b). The search for OB stars in the Circinus-Norma region ($320^\circ < l < 330^\circ$) has been completed by Orsatti and we are now classifying the OB stars found. The results for this region will be soon presented in the same way as those for the other two ones were, i.e., accurate positions, finding charts and BV photographic photometry are provided together with the spectral types.

III. SEARCHES FOR CEPHEID VARIABLES

Hoping to find long period cepheids belonging to the Norma-Scutum arm (Kerr, 1969) a search for variable stars in Norma ($l=328^\circ$) was made by Cabrera, Muzzio and Sánchez (1977). A $2^\circ \times 2^\circ$ region was searched for variable stars, down to about 16.5 mag at maximum, on plates obtained with the double astrograph at EL and with the Curtis Schmidt-telescope at CTIO. Eight new variables were found and BV photographic photometry of them is now being obtained in order to decide what kind of variables they are and, if any one of them turns out to be a cepheid, to derive its distance to the Sun. Some eclipsing and long period variables can tentatively be recognized from our preliminary results, but it has not been possible to recognize any cepheid yet.

Plates for a similar search in Vela ($l=268^\circ$) are being obtained at EL.

IV. OBJECTS SHOWING H α LINE EMISSION

Objects showing H α line emission (OSHLE) are easy to discover down to very faint magnitudes, and Be stars are good spiral tracers but, unfortunately, as Allen (1976) noted, few of the lists of OSHLE provide enough data to decide which of the objects listed are Be stars.

Since the thin objective prism plates can be used to give an approximate spectral classification (Blanco, 1974) they offer a nice opportunity to improve the above mentioned situation. Accordingly, we began searches for OSHLE in the same regions where we had searched for OB stars. We also added a region in Ara ($l=336.7^\circ$, $b=-0.6^\circ$) where we had obtained, as an experiment, plates with the thin prism and an UG5 filter; these plates do not allow us to get such a good classification as that gotten with plates obtained without the filter, but in crowded regions the filter is needed to avoid excessive overlapping of the spectra.

The search for OSHLE is performed on Kodak 127-04 plates (baked in N₂) obtained with the Curtis Schmidt-telescope, the 4° prism and the RG2 filter. Exposure times range from 3-min to 90-min and the spectra were widened 0.1 mm. Be stars can be found down to about 1 mag fainter than the limiting magnitude of the thin prism plates for the discovery of OB stars. Our surveys are complemented with UBV photographic photometry of the OSHLE, which allows us to derive distances to the Be stars and also provides some information about objects too faint to be classified on our thin prism plates. The results thus far obtained are as follows.

The Coalsack region is being studied by R.E. Martínez, S. Waldhausen and myself. We undertook only a limited search for OSHLE using short exposure plates because the region has been already thoroughly investigated in this respect by Hidajat (1962), The (1962), Weaver (1974) and Gómez and Mendoza (1976) who found about 300 objects. Nevertheless, our search yielded a dozen new objects,

a proof of the variable character of many of them. For about two thirds of the objects we were able either to find some previous classification in the literature (for the brighter ones) or to classify them from our plates; more than half of them are Be stars, about one fourth are Ae stars and most of the others belong to the G, K and M classes, plus a few F stars and planetary nebulae.

About 200 OSHLE were found by A.M. Orsatti, H.G. Marraco and myself in the Circinus-Norma region. We do not have additional information on these objects yet, but it is interesting to note that most of them were found on the short exposure rather than on the long exposure plates, suggesting either a lack of distant objects or that heavy absorption sets in at some distance from the Sun.

The Ara region had already been searched for OSHLE by Velghe, Denoyelle and De Kersgieter (1970), but our plates reach fainter magnitudes and M. Rabolli, I.E. Vega and myself have been able to find about six times more objects than they did.

V. PHOTOELECTRIC PHOTOMETRY OF FAINT OB STARS

Our earlier results on UBV and H β photometry of faint OB stars were published by Muzzio and Forte (1975) for the Norma region, and by Muzzio, Feinstein and Orsatti (1976) for the Crux-Centaurus region.

In April 1977 I obtained from CTIO UBV photometry of about 100 OB stars and H β photometry for about two thirds of them. These stars lie in the Vela, Coalsack and Circinus regions investigated by us and they were selected from the catalogue of Stephenson and Sanduleak (1971) and from our own lists. The heavy absorption present in those regions has posed some difficulties to our analyses, but some preliminary results are as follows.

Most of the OB stars in Vela are relatively nearby and might belong to the Vela OB1 association, but there are also quite a few OB stars (some of them Be stars) farther away. This result is not at variance with the idea of an arm seen edge on in this region (Herbst, 1975; Denoyelle, 1977).

OB stars in the Coalsack region are scattered between about 1 kpc and 4 kpc from the Sun, a result which supports the idea that either a spiral arm (Kerr, 1969) or a spur (Humphreys, 1976) is seen tangentially in this region.

Most of the OB stars in the Circinus region seem to belong to the Centaurus link.

REFERENCES

- Allen, D.A., 1976, *IAU Symp.* No. 70, 229.
Blanco, V.M., 1974, *P.A.S.P.* 86, 841.
Cabrera, A.L. Muzzio, J.C., Sánchez, G., 1977, *IAU Information Bull. on Variable Stars*. No. 1299.
Denoyelle, J., 1977, *Astron. Astrophys. Suppl.* 27, 343.
Gómez, T., Mendoza, E.E., 1976, *Rev. Mexicana Astron. Astrof.* 1, 381.
Herbst, W., 1975, *A. J.* 80, 503.
Hidajat, B., 1962, *Contrib. Bosscha Obs.* No. 16.
Humphreys, R.M., 1976, *P.A.S.P.* 88, 647.
Kerr, F.J., 1969, *Ann. Rev. Astron. Astrophys.* 7, 39.
Muzzio, J.C., 1976, *Símpoio de Estrutura Galáctica*, Brasília, in press.
Muzzio, J.C., Feinstein, A., Orsatti, A.M., 1976, *P.A.S.P.* 88, 526.
Muzzio, J.C., Forte, J.C., 1975, *A. J.* 80, 1037.

Muzzio, J.C., Orsatti, A.M. 1977a, A. J. 82, 345.

_____ 1977b, A. J. 82, 474.

Stephenson, C.B., Sanduleak, N., 1971, *Publ. Warner and Swasey Obs.* 1, No. 1.

The, P.-S., 1962, *Contrib. Bosscha Obs.* No. 17.

Velghe, A.G., Denoyelle, J., De Kersgieter, A., 1970, *Astron. Astrophys.* 8, 123.

Weaver, W.B., 1974, *Ap. J.* 189, 263.

DISCUSION

WALBORN.- Las estrellas Ae encontradas ¿están en asociaciones o asociadas con nubes de polvo?

MUZZIO.- El término "Ae" fue usado en mi charla en una forma un tanto imprecisa, sin querer implicar que fueran las así llamadas por Herbig. Estrictamente, son estrellas que presentan H α en emisión y cuyos espectros son de clase A. Sin embargo, para estar asociadas con las nubes de polvo del Saco de Carbón deberían ser subluminosas con respecto a las estrellas A normales, con magnitudes absolutas más débiles que $M_V \sim 4^m$ o 5^m , aproximadamente. Es posible que luego que hayamos obtenido datos UBV de estas estrellas, podamos decidir si se hallan asociadas con el Saco de Carbón o si son más distantes.

RESULTS OF AN $H\alpha$ SURVEY IN THE SOUTHERN MILKY WAY

D.J. MacConnell

Centro de Investigación de Astronomía "Francisco J. Duarte"
Mérida

During several visits to the Cerro Tololo Inter-American Observatory in the years 1967-1974, the Curtis Schmidt telescope was used to photograph the southern Milky Way using a 10° objective prism and yellow/red-sensitive plates. The purpose was to find new planetary nebulae, Be stars and others with $H\alpha$ in emission, carbon and S stars, and Wolf-Rayet stars. The observations were made in the spectral range 5900-6800 Å with a dispersion of 420 Å/mm at $H\alpha$. The exposure time was 30 minutes and the spectra were widened to 0.3 mm which gives an approximate visual limiting magnitude of 12.0 for the continuum of an A star. The survey covered 4250 square degrees and reaches to approximately ± 15 degrees in galactic latitude. The plates were scanned with a binocular microscope and estimates of the continuum intensity and of the emission lines were made. The coordinates of the objects selected were obtained in an approximate manner using millimetre paper and six reference stars from the SAO catalog. The accuracy obtained in this way is about ± 0.5 which is usually sufficient to establish whether the object has been catalogued. The coordinates of two groups, the suspected planetaries and two novae, were determined with higher precision using a measuring machine and an average of nine reference stars.

A planetary should have emission of [OIII] at 5007 Å but this line falls out of the range of the plates used. A total of seventeen suspected planetaries was discovered. To consider these objects as planetaries, the criterion of the presence of $H\alpha$ emission and absence of a continuum was used. Furthermore, some objects show a diffuse $H\alpha$ line which would suggest that they are disks. Those objects which do not have diffuse $H\alpha$ could be confused with emission stars having continuum below the plate limit, and the diffuse objects could be HII regions. Dr. N. Sanduleak checked the plate collection of the Warner and Swasey Observatory and confirmed the observations presented here in 15 of the 17 cases. Dr. Sanduleak also searched blue plates of low dispersion and found the 5007 Å line in one of the 15 objects. The absence of this line in the remaining 14 objects could be attributed to reddening. The results on the suspected planetaries has appeared in *Astronomy and Astrophysics Supplements Series*, 33, p. 219, 1978.

The largest group of objects discovered is that of the stars with $H\alpha$ in emission. This group is a mixture of various spectral types, but the majority are probable of type B. The number of

objects in this group is about 800 which comprises approximately 11% of the stars of this type previously catalogued.

The smallest group is that of two novae discovered accidentally in two pairs of plates. Nova Oph 1968 and Nova Sgr 1969 were published in the *Information Bulletin on Variable Stars* No. 1340.

The fourth group corresponds to the late carbon stars. With the dispersion and spectral range of the plates, the C_2 bands which define the type are not seen, but these stars have intense bands of CN in the range 6000-6800 Å which were used as classification criterion. This group contains 34 stars which represents approximately 1% of the C stars catalogued already. The fifth group is that of the S-type stars which are defined by the presence of the ZrO band with head at 6474 Å. The number of S stars discovered is 204 which represents about 25% of this type previously published. It is conceivable that some are of a mixed M-S type.

The stars in the groups H α -emission, C, and S have been sent for publication in the *Astronomy and Astrophysics Supplements*.

DISCUSSION

MENDOZA.- ¿Encontró alguna estrella T Tauri en su búsqueda?

MACCONNELL.- No, no he encontrado ninguna estrella de este tipo.

RADIAL VELOCITIES FROM OBJECTIVE PRISM PLATES

Jurgen Stock

Centro de Investigación de Astronomía "Francisco J. Duarte"
Mérida

ABSTRACT: The CIDA program for the determination of radial velocities from objective prism plates has so far produced data for 5870 stars. This material permits statistical conclusions concerning some kinematical characteristics of the galaxy.

I. INTRODUCTION

A program of radial velocity determinations from objective prism plates has been underway for a number of years. The method used has been described by Stock and Osborn (1972, 1973, 1974). So far, six consecutive fields have been analyzed covering an area of about 150 square degrees. The area consists of a strip five degrees wide in declination, centered on $-32^{\circ}5'$, and extends in right ascension from $12^{\text{h}}27^{\text{m}}$ to $14^{\text{h}}30^{\text{m}}$. The catalogue includes 5870 stars between the 6th and 13th photographic magnitude. The material is already sufficient to derive a number of results.

II. THEORETICAL CONSIDERATIONS

In a simplified model of our galaxy we may suppose that there exists a local escape velocity V_e , and that its value is independent of the direction. This means that, in a given direction, radial velocities are permitted only between $-V_e$ and $+V_e$, if observed from a point which does not move with respect to the galaxy. If observed from a moving point, the total range of radial velocities remains the same, but they will be displaced by the component of the observer's motion in the direction under consideration. The range of radial velocities can readily be observed when, in a given area of the sky, a large number of radial velocity data are available. Naturally, stars with velocities near the escape velocity do not necessarily exist. Hence, such observation permit only the determination of a minimum value for V_e . However, one may expect to find such stars among the stellar population which shows a spherical distribution around the galaxy.

From radial velocities, one can also derive the displacement of the velocity range with respect to the local standard of rest. Such observations, if carried out in different parts of the sky, permit the derivation of the local circular velocity V_c and thus serve to check whether the relation $V_e = \sqrt{2} V_c$ holds.

III. COMPARISON WITH SPECTROGROGRAPH VELOCITIES

The most extensive compilation of radial velocities obtained with slit spectrographs is the *Bibliography of Radial Velocities* by Abt and Biggs (1972). With it we have 14 stars in common. The comparison is shown in Fig. 1. The objective prism velocities were corrected for the solar motion of 20 km/sec towards R.A. 13^h and Dec. $+30^\circ$. Only three of the stars taken from the Abt catalogue are known to have constant radial velocity. These are marked as circled dots in Fig. 1. For seven additional stars only one slit observation is available. These are marked as simple dots. The remaining four stars are known variables and are marked as crosses.

IV. RESULTS

Fig. 2 shows the distribution of the radial velocities as a function of the right ascension. Only velocities with absolute values over 100 km/sec have been plotted. The velocities cover a strip about 600 km/sec wide, thus indicating:

$$V_e \geq 300 \text{ km/sec}$$

Also one notices that the strip defined by the highest positive and negative velocities is displaced towards positive velocities with a possible variation of this displacement with the right ascension. Both properties of the figure are in agreement with the known direction towards the galactic centre and with previous determinations of the circular velocity of the stars in the solar neighbourhood.

For two separate areas, one near 13^h and the other near 14^h , we give the distribution of all radial velocities in our catalogue (Figs. 3 and 4, respectively). The corresponding dispersion is indicated in each of the figures. Correcting these for the average error of our catalogue velocity, we derived a natural velocity dispersion of approximately 30 km/sec for the stars in our catalogue.

Finally, we give in Table I the distribution of the average velocity and its dispersion for different types of stars and for different magnitude ranges. The highest velocity dispersion is found for the G pec stars; these are metal deficient objects. Also, their average velocity is positive and very high. The same characteristics, although to a lesser degree, are shared by the faintest stars of type B and A in the catalogue, and of those of type A w. The latter are A type stars with weak hydrogen lines. The M - stars also show a high velocity dispersion, but their average velocity is negative.

The data presented already indicate a number of the kinematical characteristics of our galaxy. Definitive conclusions, however, have to wait until similar data have been obtained for other parts of the sky.

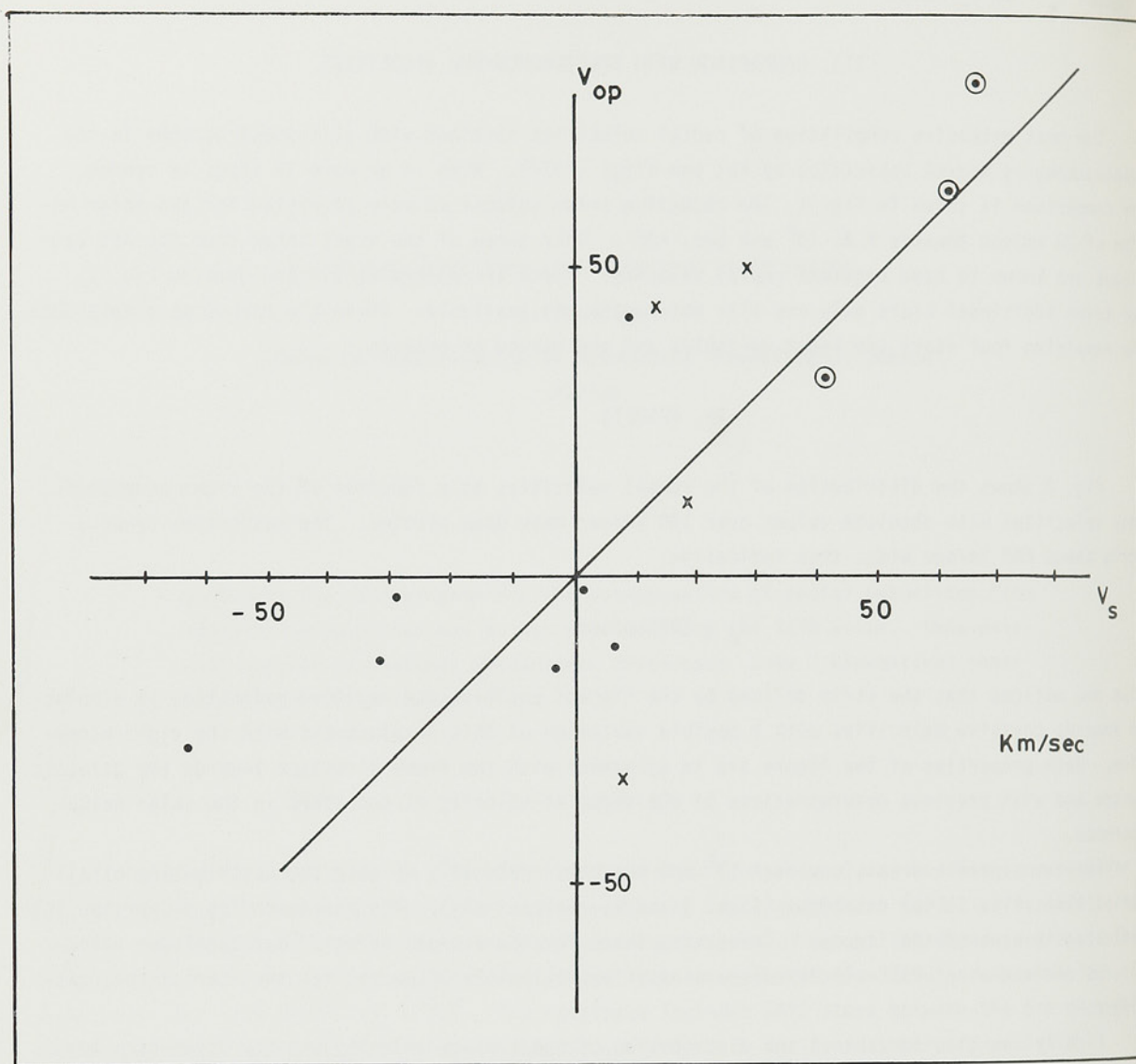


Fig. 1. Comparison of the objective prism radial velocities with velocities determined with slit spectrographs. Circled points indicate non-variable stars, points indicate stars for which only one slit spectrum is available, and crosses variable stars.

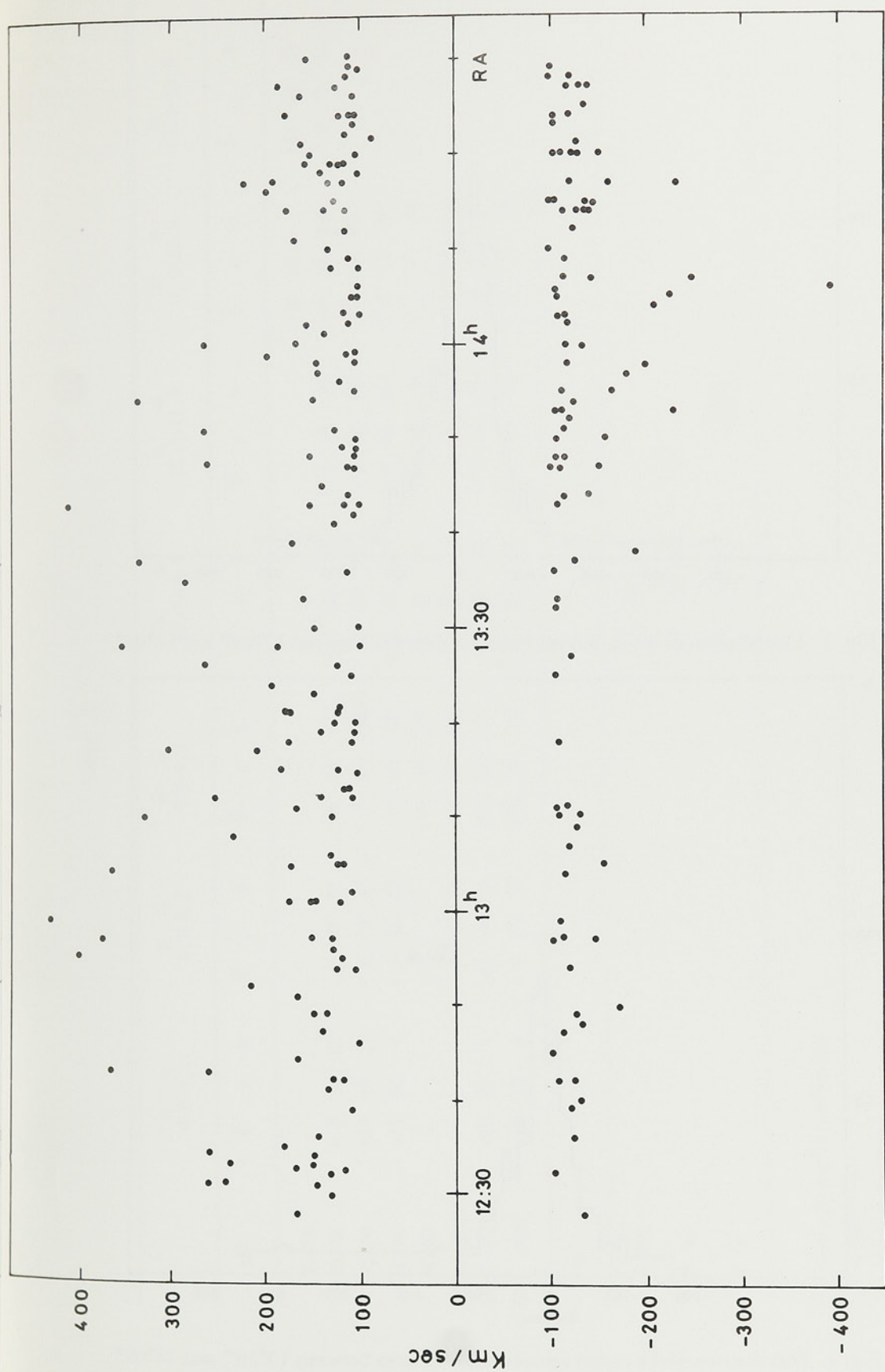


Fig. 2. Distribution of the radial velocities as function of the right ascension.

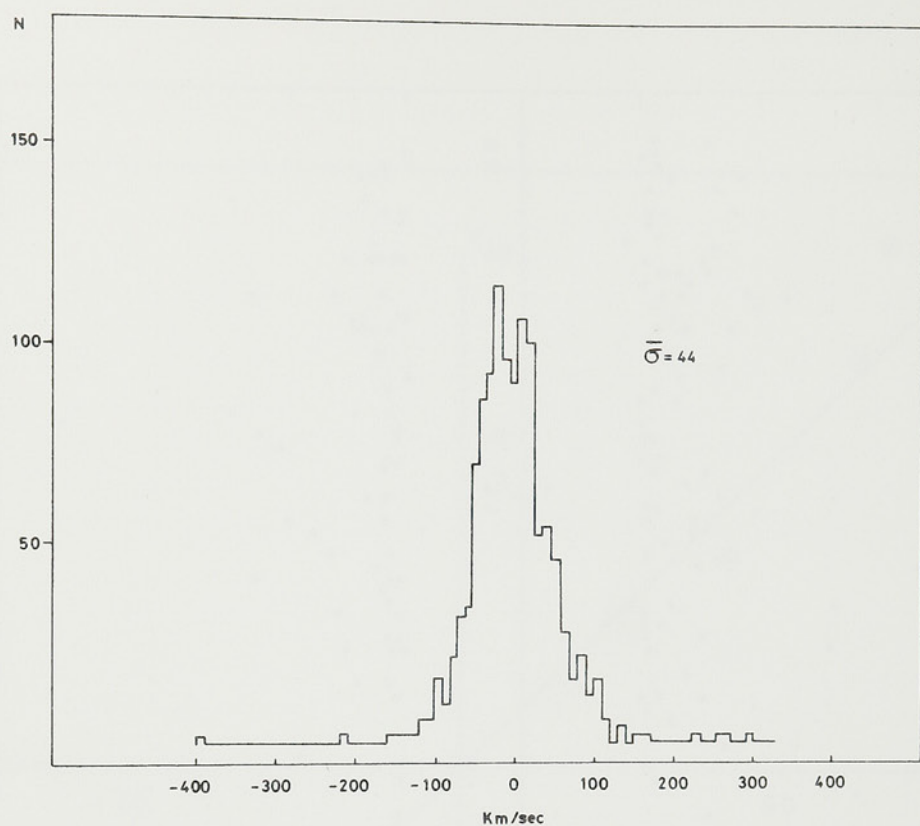


Fig. 3. Distribution of the radial velocities for the area between 12^h55^m and 13^h05^m .

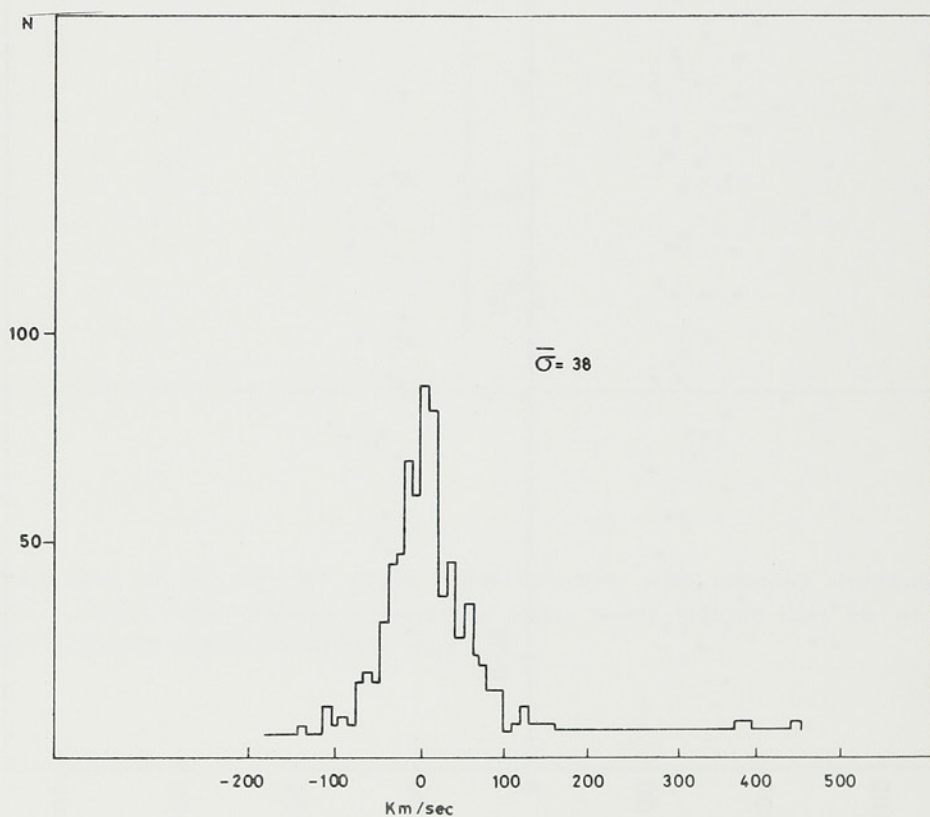


Fig. 4. Distribution of the radial velocities for the area between 13^h55^m and 14^h05^m .

TABLE I

SP	6.0-7.9			8.0-8.9			9.0-9.9			10.0-10.9			11.0-11.9			12.0-12.9			13.0-13.9		
	$\bar{V}$	μ	N	$\bar{V}$	μ	N	$\bar{V}$	μ	N	$\bar{V}$	μ	N	$\bar{V}$	μ	N	$\bar{V}$	μ	N	$\bar{V}$	μ	N
B5-B9																					
A0-A9	+ 8	14	12	- 7	25	31	-14	24	43	- 9	32	59	- 9	45	64	+39	41	7	+51	93	34
F0-F9	+24	49	13	+ 8	24	42	- 6	30	139	- 2	27	396	- 2	32	712	- 0	44	513	- 2	35	13
G0-K9	-11	20	9	+ 8	26	19	- 7	32	85	+ 6	42	320	+ 6	45	921	+ 5	51	704	+ 5	51	704
M0-M3							-29	37	28	-10	30	26	-14	52	42	-16	83	45			
G0III-K9III				- 3	18	15	- 6	31	59	+ 2	40	177	- 1	38	252	+ 1	47	74			
G0IV -K0IV	+20	27	4	-23	44	11	-16	58	21	+ 5	52	91	+ 2	48	275	+ 5	43	77			
G0V -K9V	+28	29	4	- 3	58	12	+10	31	35	0	35	65	+ 1	46	109	- 5	60	34			
SP	$\bar{V}$			μ			N			$\bar{V}$			μ			N			$\bar{V}$		
G Pec	+67			134			37														
F W	0			54			18														
A W	+41			74			22														

$\bar{V}$ = Average radial velocity
 μ = Dispersion
N = Number of stars

REFERENCES

- Abt, H., Biggs, E., 1972, *Bibliography of Stellar Radial Velocities*, Tucson, Arizona: Kitt Peak National Observatory.
- Stock, J., Osborn, W.H., 1972, *The Role of Schmidt Telescopes in Astronomy*, ed. U. Haug. Hamburg, European Southern Observatory, p. 63.
- _____, 1973, in *Spectral Classification and Multicolour Photometry*, I.A.U. Symposium N°50, ed. Ch. Fehrenbach y B.E. Westerlund. Dordrecht, D. Reidel Publ. Co., p. 290.
- Stock, J., Osborn, W.H., Upgren, A.R., 1974, *Bull. Am. Astron. Soc.* 6, 317.

DISCUSION

MENDOZA.- ¿Cuáles son los tipos espectrales de las estrellas con las velocidades radiales más altas?

STOCK.- Son las del tipo G pec, o sea, de baja metalicidad.

LAS ESTRELLAS CENTRALES DE NGC 2346, He 2-36 y NGC 3132

Roberto H. Méndez

Instituto de Astronomía y Física del Espacio
Buenos Aires

RESUMEN

Se analizan espectrogramas, fotometría uvby, espectrofotometría fotoeléctrica y mediciones en ultravioleta desde el satélite ANS (Pottasch *et al.*, 1977 a, b), con el propósito de determinar los parámetros atmosféricos de estos objetos y deducir propiedades de las fuentes de energía que excitan a las respectivas nebulosas.

La estrella central de NGC 2346 da la impresión de pertenecer a la rama horizontal y su extinción interestelar es mucho menor que la correspondiente a la nebulosa, por lo cual debe tratarse de un objeto más cercano, accidentalmente superpuesto a NGC 2346. La estrella central de He 2-36 se ubica por encima de la rama horizontal, presumiblemente en una etapa de rápida evolución. Ambas estrellas parecen ser variables.

HD 87892 (la estrella central de NGC 3132) pertenece a la secuencia principal. Su compañera visual (hallada recientemente por Kohoutek y Laustsen, 1977) debe ionizar a la nebulosa y aparentemente no irradia como un cuerpo negro. Esta estrella debe haber sufrido una apreciable pérdida de masa, y con HD 87892 probablemente están en camino de transformarse en un sistema similar a Sirio.

ABSTRACT

Spectrograms, uvby photometry, photoelectric spectrophotometry and ultraviolet measurements from the ANS satellite (Pottasch *et al.*, 1977 a, b), are analyzed to determine the atmospheric parameters of the A-type stars and derive properties of the energy sources responsible for the excitation of the respective nebulae.

The central star of NGC 2346 appears to belong to the horizontal branch, and its interstellar extinction is much smaller than that of the nebula, suggesting that it is a foreground object accidentally superposed on NGC 2346. The central star of He 2-36 lies above the horizontal branch, presumably in a rapid evolutionary phase. Both stars are probably variable.

HD 87892, the central star of NGC 3132, belongs to the main sequence. Its visual companion (recently found by Kohoutek and Laustsen, 1977) seems to ionize the nebula and apparently does not

radiate as a black body. It must have experienced an important loss of mass. These two stars are probably in the way to become a system similar to Sirius.

REFERENCIAS

- Kohoutek, L., Laustsen, S., 1977, *Astron. Astrophys.* 61, 761.
Pottasch, S.R., Wesselius, P.R., Wu, C.-C., van Duinen, R.J., 1977 a, *Astron. Astrophys.* 54, 435.
Pottasch, S.R., Wesselius, P.R., Wu, C.-C., Fieten, H., van Duinen, R.J., 1977 b, *Astron. Astrophys.* in press.

DISCUSION

NIEMELA.- ¿Cuál es la probabilidad de que una estrella de la rama horizontal aparezca superpuesta a una nebulosa planetaria?

MENDEZ.- Extremadamente pequeña. Esto convierte a NGC 2346 en un caso muy curioso, porque la diferencia entre las extinciones interestelares de la nebulosa y la estrella hace pensar que no pueden estar a la misma distancia, y al mismo tiempo, la estrella es del tipo que uno esperaba encontrar asociada con una nebulosa planetaria.

BUSQUEDA DE BINARIAS ESPECTROSCOPICAS ENTRE ESTRELLAS
CENTRALES DE NEBULOSAS PLANETARIAS

Roberto H. Méndez

Instituto de Astronomía y Física del Espacio
Buenos Aires

Virpi S. Niemela
Villa Elisa, Buenos Aires

RESUMEN

Se presentan resultados de un programa de búsqueda de variaciones espectrales y de velocidad radial entre las estrellas centrales más brillantes de nebulosas planetarias australes. Se describen las siguientes estrellas:

- a) HD 141969 (320-9° 1). Presenta un espectro BCO Ib según el sistema de clasificación de Walborn (1971).
- b) NGC 1360. Binaria espectroscópica (Méndez y Niemela, 1977).
- c) NGC 2346. Probable binaria espectroscópica; aún no se conoce el período (Méndez *et al.*, 1978).
- d) NGC 3132. El límite superior para las variaciones de velocidad radial es de 20 km s^{-1} (Méndez *et al.*, 1978).
- e) NGC 246. Un espectro de la estrella central obtenido en Agosto de 1977 muestra la aparición de una intensa emisión en HeII $\lambda 4685$.
- f) HD 138403 (315-13° 1). Se describe la estrella central como de tipo O8fp, con perfiles P Cygni en líneas de SiIV, NIII y CII. Las emisiones de dichos perfiles P Cygni desaparecieron en 1970, quedando solamente los perfiles de absorción en las líneas respectivas.

ABSTRACT

We present results of a search for spectral and radial velocity variations among the brightest southern central stars of planetary nebulae. The following stars are described:

- a) HD 141969 (320-9° 1). The spectral type is BCO Ib according to the Walborn (1971) classification scheme.

- b) NGC 1360. Spectroscopic binary (Méndez and Niemela, 1977).
- c) NGC 2346. Probable spectroscopic binary; period still unknown (Méndez *et al.*, 1978).
- d) NGC 3132. The upper limit for radial velocity variations is 20 km s^{-1} (Méndez *et al.*, 1978).
- e) NGC 246. A spectrogram of the central star obtained in 1977 August shows the appearance of a strong emission at HeII $\lambda 4685$.
- f) HD 138403 ($315-13^\circ 1$). The spectral type of the central star is O8fp, with P Cygni profiles of SiIV, NIII and CII lines. These P Cygni emissions disappeared in 1970, leaving only the absorptions of the respective lines.

REFERENCIAS

- Méndez, R.H., Niemela, V.S., 1977, *M.N.R.A.S.* 178, 409.
 Méndez, R.H., Lee, P., Niemela, V.S., 1978, *M.N.R.A.S.* in press.
 Walborn, N.R., 1971, *Ap. J. Lett.* 164, L67.

DISCUSION

WALBORN.- Se conocen varios objetos que son representantes luminosos de la Población I rodeados de "shells" semejantes a primera vista a nebulosas planetarias (por ejemplo AG Car, HD 148937). ¿Hay alguna información externa al espectro sobre la luminosidad de HD 141969? ¿Cuál es su latitud galáctica?

MENDEZ.- No hay mucha información sobre la luminosidad. Por supuesto, sería demasiado arriesgado usar la paralaje espectroscópica. Una estimación de la extinción interestelar ayudaría a acotar la distancia. La velocidad radial de la línea interestelar del CaII K es 38 km s^{-1} , lo cual, a esas longitudes, indica una distancia mínima de 2 kpc para la estrella. Esto no ayuda mucho, sin embargo, porque si se tratara de una estrella supergigante de Población I debería encontrarse a 7 u 8 kpc del sol. Con respecto a su segunda pregunta, la latitud galáctica es 9° .

THE ELEMENTAL ABUNDANCES IN HALO PLANETARY NEBULAE

S.M.V. Aldrovandi

Instituto Astronômico e Geofísico USP

São Paulo

I. INTRODUCTION

The study of the chemical abundance in halo planetaries provides a good opportunity for testing theories of the chemical evolution of the Galaxy. Recently, Hawley and Miller (1977) have obtained new spectrophotographic data of three halo planetary nebulae: K648, $49 + 88^\circ 1$ and $108-76^\circ 1$. These objects have been previously observed, respectively, by O'Dell *et al.* (1964) and Peimbert (1973), Miller (1969), Boeshaar and Bond (1977). From the observed line intensities these authors have determined the abundances of He, N, O, Ne and S using the method described by Peimbert and Torres-Peimbert (1971).

In this paper an attempt is made to obtain the elemental abundances by constructing a thick photoionization model as described by Aldrovandi and Stasinska (1978). This type of model has been used by Péquignot *et al.* (1978) to study the planetary nebula NGC 7027 and by Stasinska (1977) to construct a series of models for HII regions.

II. PHOTOIONIZATION MODELS

The input parameters are the ionizing source spectrum, the distribution of the gas density and its chemical composition. The optical depth and the radiation field are computed at each step and the equations of ionization and thermal balance are solved, assuming spherical symmetry. So, the physical conditions of the gas are obtained and the line intensities relative to H β are calculated.

The charge exchange reactions between ions and H 0 are considered. Unless otherwise is stated, the charge exchange rates are supposed to have the same values as proposed by Péquignot *et al.* (1978). The gas density is assumed to have a value near the electronic density suggested by the observed line ratios [OII]3726/3729 and/or [SII]6716/6730. Indications about the ionizing spectrum are obtained from the line intensity ratio HeII 4686/H β . In the first approach, the chemical abundances are taken from the authors cited above who observed these nebulae, except for C and Mg

for which no abundance determination is available.

For K648 two types of models have been constructed:

- Model A: using a central star with effective temperature $T_{\text{eff}} = 36000^\circ\text{K}$ and spectrum given by Mihalas (1972), suggested by the line intensity ratio $[\text{OII}]\lambda 3727/[\text{OIII}]\lambda 5007$ given by Peimbert (1973). The hydrogen number density is taken to be $n_{\text{H}} = 3 \times 10^3 \text{ cm}^{-3}$ and the charge exchange rate for $\text{O}^{++} + \text{H}^0 \rightarrow \text{O}^+ + \text{H}^+$ is $k(\text{O}^{++}) = 1 \times 10^{-9} \text{ cm}^3 \text{ s}^{-1}$ (Péquignot *et al.*, 1978).
- Model B: with $T_{\text{eff}} = 90000^\circ\text{K}$, spectrum interpolated from Hummer and Mihalas (1970), $n_{\text{H}} = 2 \times 10^3 \text{ cm}^{-3}$ and $k(\text{O}^{++}) = 5 \times 10^{-11} \text{ cm}^3 \text{ s}^{-1}$. Model B1 takes into account the charge exchange reactions and B2 does not.

For both types of model the chemical composition which better reproduces the observed line intensities relative to H (Table I) is H, He, C, N, O, Ne, Mg and S respectively equal to 1., 0.08, 8×10^{-5} , 1.8×10^{-6} , 2.0×10^{-5} , 2.5×10^{-6} , 8.0×10^{-7} and 4.0×10^{-7} . Model A fits Peimbert's observations and Model B1 Hawley and Miller results. Both models are compatible with the HeII 4686 observed limit.

In table I, R_{f} is the calculated final radius of the nebula.

For the planetary nebula 49 + 88°1 a central star with $T_{\text{eff}} = 95000^\circ\text{K}$ and a black body spectrum are taken. The assumed hydrogen density is $n_{\text{H}} = 500 \text{ cm}^{-3}$, as suggested by the $[\text{SII}]$ ratio, and $k(\text{O}^{++}) = 1 \times 10^{-10} \text{ cm}^3 \text{ s}^{-1}$. In Table I two models are presented as well as the observational data. Model C1 takes into account charge exchange reactions and C2 does not, and the elemental abundances are H, He, C, N, O, Ne, Mg, S : 1., 0.09, 4.0×10^{-4} , 2.15×10^{-5} , 1.35×10^{-4} , 4.4×10^{-6} , 4.0×10^{-6} , 4.0×10^{-7} .

In Table I are also given the observed and calculated results for the halo planetary 108-76°1. The central star is assumed to have $T_{\text{eff}} = 125000^\circ\text{K}$ and a black body spectrum. For this object a model with homogeneous density (Model D) does not fit very well the observed line intensities. After some trials, the model D with an homogeneous density $n_{\text{H}} = 1.7 \times 10^3 \text{ cm}^{-3}$, $k(\text{O}^{++}) < 10^{-11} \text{ cm}^3 \text{ s}^{-1}$ and chemical composition H, He, C, N, O, Ne, Mg, S : 1., 0.092, 1.0×10^{-4} , 8.0×10^{-6} , 4.0×10^{-5} , 4.2×10^{-5} , 4.0×10^{-6} , 8.0×10^{-6} , gave the best fit. However, an attempt was made taking $n_{\text{H}} = 2.0 \times 10^3 \text{ cm}^{-3}$, a filling factor $f = 0.2$ and the same abundances above, in order to have an emission line region which increases the $[\text{OIII}]\lambda 5007$ line without emitting the $[\text{OII}]\lambda 3727$ line. This dense region must correspond to filaments near the central star. The best fit to Hawley and Miller (1977) observations is given by a composite model (Model E) with 30% of the total emission coming from the dense component and the remaining 70% from the dilute component (model D).

III. CONCLUDING REMARKS

For the halo planetaries K648, 49 + 88°1 and 108 - 76°1 the abundance values obtained from the photoionization models are generally less than those obtained by Hawley and Miller (1977). Comparing both results for each element we see that the abundance ratios are of the order of a factor 2. for oxygen, a factor ~ 1.2 for neon and a factor between 10. and 2. for nitrogen. Only for 49 + 88°1 an estimation for the sulphur abundance is possible and our value is about a factor 10. less than Hawley and Miller's result. For carbon and magnesium no observed line is available. In the photoionization models the carbon abundance is generally high and this element is important to thermal balance of the gas, and so, to the electronic temperature of the emitting region, since the gas cooling is mainly due to carbon lines. The detection of the CII]2326, CIII]1909 and MgII 2798 lines could provide a good test to the assumed abundances.

TABLE I

Ion	$\lambda(\text{\AA})$	K648				49 + 88°1				108 - 76°1			
		Obs.		A	B1	B2	Obs.		C1	C2	Obs.		E
		P	HM				M	HM			BB	HM	
[OII]	3727	.75	.22	.78	.25	.17	2.47	1.72	1.71	.67	.099	.073	.13 .095
[NeIII]	3868 + 3869	.15	.07	.13	.07	.11	.08	.09	.092	.14	3.83	1.32	1.36 1.47
[OIII]	4363	.03	.03	.032	.06	.07	.129	.085	.12	.15	.081	.050	.090 .085
	4959 + 5007	1.9	3.1	1.77	3.0	3.34	8.82	10.1	10.3	12.3	4.06	4.78	4.75 4.51
[NII]	5755	-	-	.003	.003	6.6(-4)	-	.016	.028	.004	-	.006	.013 .014
	6584 + 6584	.09	.11	.097	.11	.022	1.52	1.34	1.25	.207	-	.43	.45 .34
[OI]	6300 + 6363	-	-	.007	.001	5.6(-4)	-	.11	.14	.004	-	.019	.016 .014
[SII]	6717 + 6731	-	-	.021	.019	.021	-	.02	.020	.019	-	-	.38 .27
	4069 + 4076	-	-	.001	.002	.001	-	-	9.2(-4)	9.1(-4)	.06:	-	.02 .02
[HeII]	4686	<.03	-	<.001	.007	.007	.10	.10	.10	.10	.262	.236	.23 .23
HeI	5876	.12	.12	.11	.12	.13	.154	-	.12	.12	-	.12	.11 .12
	4471	-	.05	.041	.047	.047	.056	.050	.049	.049	.037	.034	.04 .04
H α	6563	2.95	2.89	2.81	2.92	2.94	-	2.87	2.83	2.83	-	2.87	3.07 3.06
H γ	4340	-	.428	.493	.487	.485	.54	.47	.494	.494	.544	.398	.479 .479
H δ	4101	-	.173	.284	.279	.277	.28	.25	.286	.286	.361	.191	.272 .272
H β	4861	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1. 1.
[OII]	3726/3729	1.48	-	1.70	1.47	1.45	1.01	-	.92	.90	1.35	-	1.34 1.35
[SII]	6716/6730	-	-	.76	.85	.85	-	1.22	1.19	1.19	-	-	.90 .87
$R_F/10^{17}$ cm		-	-	-	2.81	2.86	-	-	6.51	6.51	-	-	3.55 3.55

The effect of the charge exchange reactions is particularly important to [OII]3727 and [NII] 6584 emissions. If charge reactions are not taken into account the nitrogen abundance must increase by about a factor 5. in order to fit the observed lines, approaching the value obtained by Hawley and Miller. The charge exchange rate corresponding to $O^{++} + H^{\circ} \rightarrow O^{+} + H^{+}$ must be different for each halo planetary studied here. This probably means that the charge exchange rate depends on the gas temperature, since the average temperature of the emitting region is different for each object.

REFERENCES

- Aldrovandi, S.M.V., Stasinska, G., 1978, *Rev. Bras. Fis.* 8, 595.
 Boeshaar, G.O., Bond, H.E., 1977, *Ap. J.* 213, 421.
 Hawley, S.A., Miller, J.S., 1977, (preprint).
 Hummer, D.G., Mihalas, D., 1970, *M.N.R.A.S.* 147, 339.
 Mihalas, D., 1972, *Non-LTE Model Atmospheres for B and O Stars*, NCAR-TN/STR-76.
 Miller, J.S., 1969, *Ap. J.* 157, 1215.
 O'Dell, C.R., Peimbert, M., Kinman, T.D., 1964, *Ap. J.* 140, 119.
 Peimbert, M., 1973, *Mém. Soc. Roy. Sci. Liege 6th Ser.*, 5, 307.
 Peimbert, M., Torres-Peimbert, S., 1971, *Ap. J.* 168, 413.
 Péquignot, D., Aldrovandi, S.M.V., Stasinska, G., 1978, *Astron. Astrophys.* 63, 313.
 Stasinska, G., 1977, *Astron. Astrophys. Suppl.* (in press).

DISCUSSION

MENDOZA.- Me sorprenden sus altas temperaturas y discrepancias en la abundancia del neón con las de M. Peimbert ¿Cuáles son sus comentarios?

ALDROVANDI.- Altas temperaturas são devidas à baixa abundancia dos elementos. Nos modelos apresentados são as raias do carbono que dominam as perdas de energia do gás e, portanto, determinam a temperatura. A discrepancia com o valor de M. Peimbert para abundancia do Neon pode ser devida as reações de troca de carga consideradas.

LASKER.- Do your numbers for line intensities, both the theoretical and the observational ones, pertain to an average over the entire nebula or to some specific part?

ALDROVANDI.- Both the theoretical and the observational values of the line intensities correspond to the whole nebula.

BLAUW.- For the temperature determinations, have you been able to profit from the ANS satellite UV observations between $\lambda = 1550$ and $3300 \text{ \AA}$?

ALDROVANDI.- I do not know any results from the UV satellites for the halo planetaries. It will be interesting to have observational results for the carbon lines in order to test the assumed carbon abundance.

HI ASSOCIATED WITH THE SUPERNOVA REMNANT G.261.9,+5.5

F.R. Colomb and G.M. Dubner

Instituto Argentino de Radioastronomía

I. INTRODUCTION

Theoretical models of the evolution of supernovae remnants predict the formation of massive thin shells of neutral hydrogen behind the shock wave of old remnants.

Neutral hydrogen observations have been made near several supernovae remnants looking for shells surrounding the remnants. In some cases, like the supernovae remnants HB 21, W44 and S147, the observations show evidences of an expanding, fragmentary shell around the sources; while in others, like IC443 or Cygnus Loop, no evidences of expanding HI shells were observed.

Obviously, more observations are required to elucidate the problem of HI shell around SNR's. For this reason we initiate a series of observations of southern SNR in the 21 cm H line. The results for G.261.9,+5.5 are reported here.

This radiosource has been observed in the radio continuum at 2650 MHz by Hill (1967). Its distance has been estimated by several authors using the Σ -d relation. There is a big scatter between the different results; we will assume here an average distance of 3.9 kpc. Such distance gives a linear diameter of 45 pc.

No optical identification exists for this object.

II. OBSERVATIONS

The observations were done with the radiotelescope of the Instituto Argentino de Radioastronomía, with 0'5 of spatial resolution and 2 km/s of velocity resolution.

The observed points covered an extension of 5'5 in right ascension and 3'5 in declination, centered at $\alpha = 135^{\circ}5$, $\delta = -38^{\circ}5$, with a grid spacing of 0'5 between points. Each point was observed at least twice, with an integration time of 6 minutes.

Different types of diagrams were constructed to investigate the HI distribution around G.261.9,+5.5.

Fig. 1 shows a contour map of brightness temperature as function of galactic longitude and

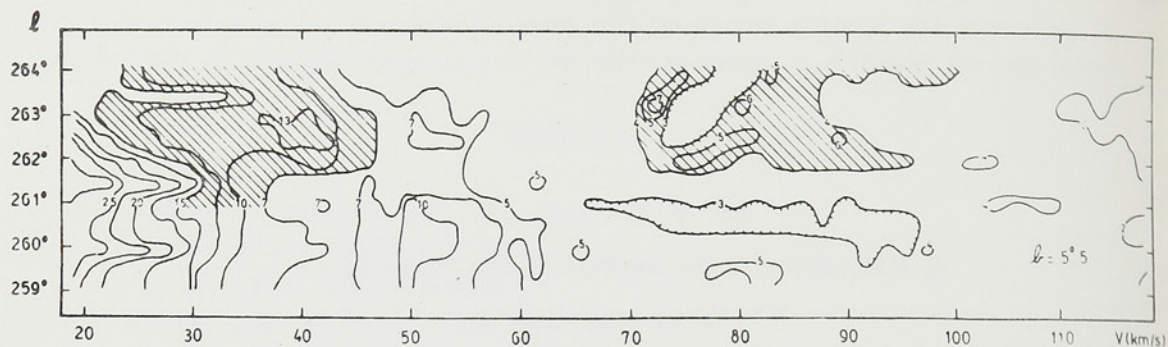


Fig. 1. Brightness temperature contour map in the l - V plane at constant $b = 5.5$. Hatched areas are the HI features related to the remnant.

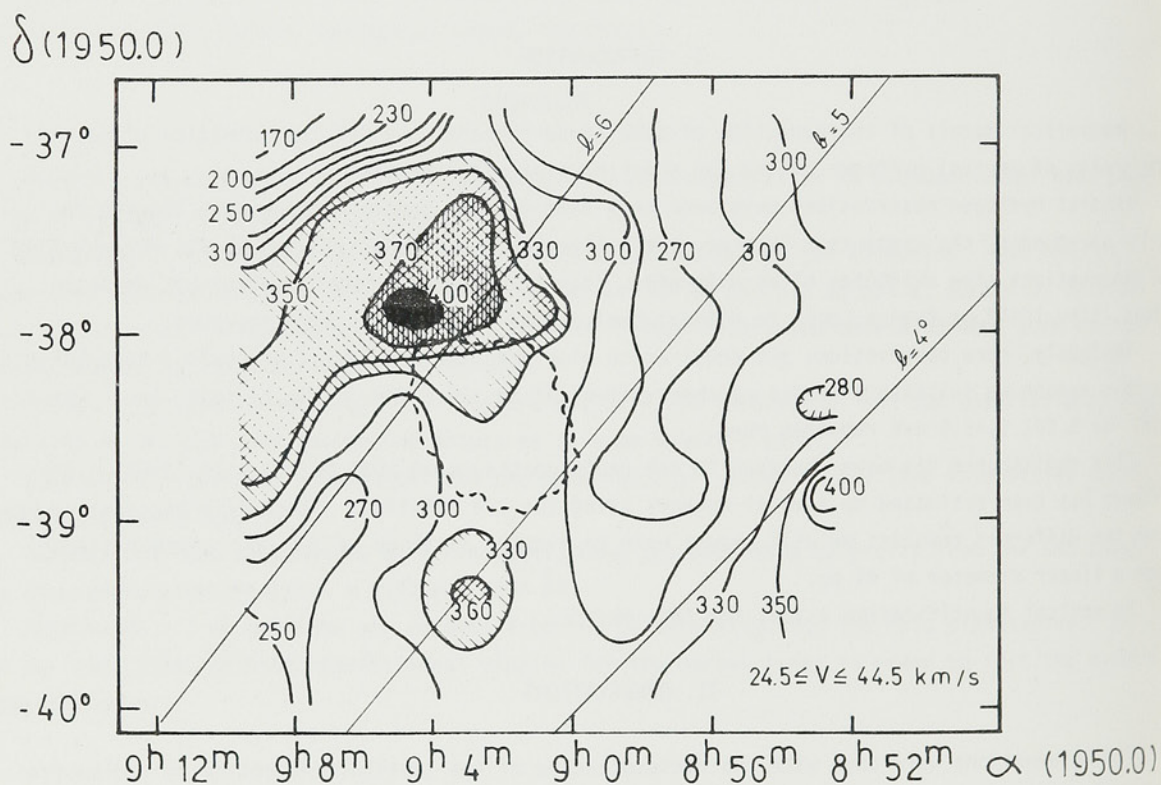


Fig. 2. Integrated brightness contours over the velocity interval (24.5, 44.5). Hatched areas show the clouds related to the remnant. Dashed line is the radiocontinuum contour map.

velocity at $b = 5^\circ 5'$. The prominent HI features are: a) an emission region with velocities between 22 and 46 km/s which resembles an explosive event; and b) a high velocity emission region with velocities between 70 and 100 km/s. There is a region of low density emission between these two features. We shall discuss here the probable connection of these two features with the SNR.

a) The intermediate velocity feature: A map of the contours of brightness temperature of HI, integrated over the interval +24.5 to +44.5 km/s, shows clouds surrounding the supernova remnant (Fig. 2). This positional coincidence suggests a probable association between the HI and the SNR.

Besides, according to the Schmidt's model, this gas is at the same distance as the supernova. Another indication is provided by the flattening of the radio continuum contours in the region of higher HI density.

To study this region in more detail we constructed maps of brightness temperature of HI, integrated every 4 km/s. Fragmentary rings are present, but they do not change enough in size with velocity, and no "caps" are visible, as we would expect in an expanding shell-like structure. However, as has been pointed out by Heiles (1976), we could not expect that shells will retain symmetry during their voyage through the inhomogeneous interstellar medium.

If we assume that the structure observed is part of an expanding shell, we can derive the following characteristic parameters:

Angular radius: $1^\circ 1'$.

Linear radius (at the distance of 3.9 kpc) : 75 pc.

Mass (assuming a background level of 7.3×10^{20} at/cm², corresponding to an isoline of 300°K in Fig. 2) : $10^4 M_\odot$.

Expansion velocity: 12-15 km/s.

Total energy: 2.2×10^{49} erg.

With these numbers and the interpolation formula given by Chevalier (1974) the initial energy of the explosion and its age turn out to be:

$E_0 : 3.5 \times 10^{50}$ erg,

$t : 1.5 \times 10^6$ years,

respectively; our value of E_0 is close to the values obtained for other SNR's (Cygnus Loop, 10^{51} erg; Cas A, 5×10^{50} erg; IC 443, 7×10^{49} D^{5/2} erg, etc). However the age we derive for the "explosion" seems too large to be associated with the supernova.

b) The high velocity feature: Between the velocity interval 46.5 to 75 km/s a huge hole surrounds the SNR as is shown in Fig. 3. Its maximum extension is reached at $v = 60$ km/s. Part of this hole is present at lower and higher velocities too. At about 75 km/s another structure, which could be related to the supernova, appears.

Fig. 4 shows the column density integrated over the interval +76.5 to +104 km/s. Its orientation is very similar to the low velocity feature. However the brightness temperature maps every 4 km/s, do not resemble a shell structure.

Wannier *et al.* (1972) found several high positive velocity complexes ($v \sim 80$ km/s) at high latitudes, perhaps belonging to a distant spiral arm. It may be that the feature we observed belongs to one of these complexes.

The calculated mass for the observed feature is $8 \times 10^3 M_\odot$ at the distance of 3.9 kpc.

$\delta(1950.0)$

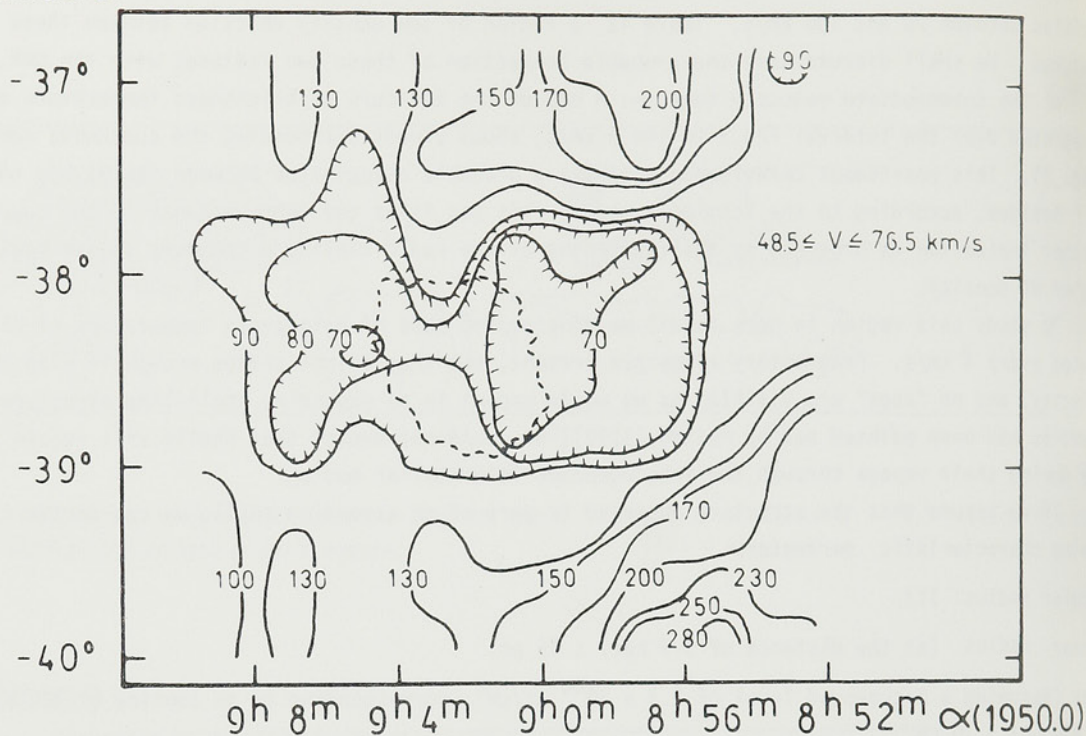


Fig. 3. The same as in figure 2, over the velocity interval (48.5, 76.5).

$\delta(1950.0)$

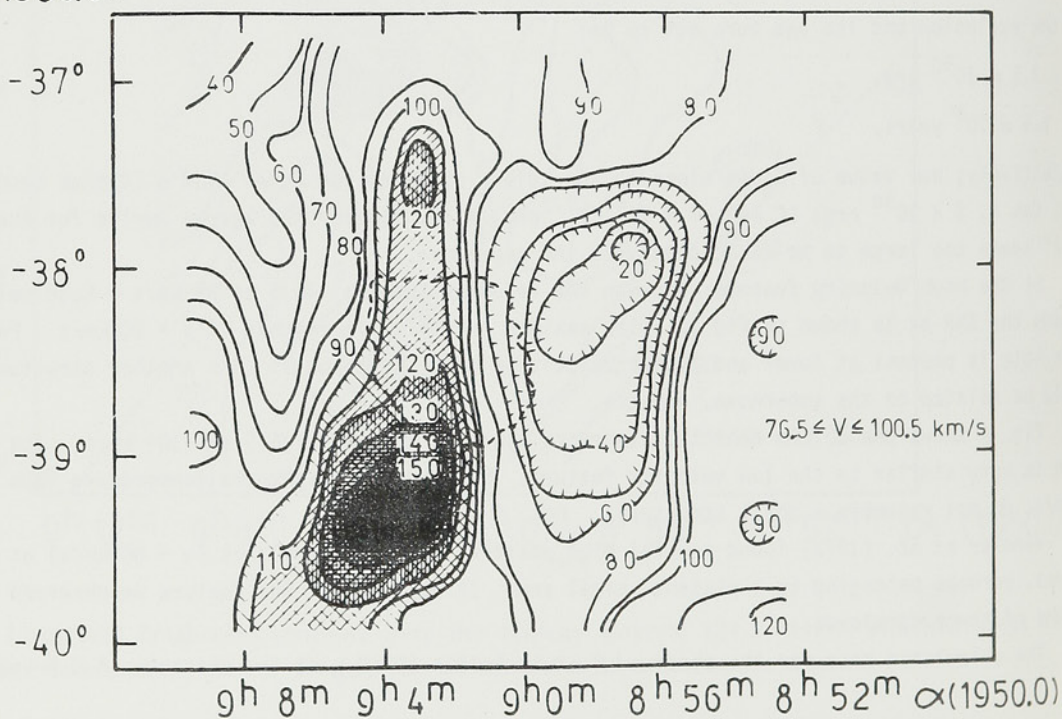


Fig. 4. The same as in figure 2, over the velocity interval (76.5, 100.5).

III. CONCLUSIONS

We have found two clouds probably related to the SNR G.261.9,+5.5. One of these clouds, centered at $v \sim 32$ km/s, shows the contours of brightness temperature remarkably distorted, resembling an explosive event. The gas appears approximately ring shaped around the remnant, suggesting that we are looking at an expanding shell. The calculated parameters are in good agreement with those derived for other SNR's.

The origin of the features centered at $v \sim 80$ km/s is more difficult to ascertain. It could be a product of the explosion, like the high negative velocity jet found by De Noyer (1975) in Cygnus Loop, or perhaps this feature belongs to a distant spiral arm.

REFERENCES

- Chevalier, R., 1974, *Ap. J.* **188**, 501.
De Noyer, L.K., 1975, *Ap. J.* **196**, 479.
Heiles, C., 1976, *Ap. J. Lett.* **208**, L 137.
Hill, E.R., 1967, *Austr. J. Phys.* **20**, 297.
Wannier, P., Wrixon, G.T., Wilson, R.W., 1972, *Astron. Astrophys.* **18**, 224.

DISCUSION

LASKER.- Obviously we must look for $H\alpha$ or [SII] associated with your remnant. However, I would expect the optical shell, if we can find it, to not lie very far from the non-thermal shell. Therefore it is reasonable to expect that your HI may be shown to lie outside the optical and the non-thermal shells.

Your accelerated HI is probably not the HI expected behind a shock wave in the recombination zone (of e.g. Cox, Chevalier or Mansfield and Salpeter), but is more likely to be outlying HI clouds accelerated by parts of the SNR blast that have passed outside what optical astronomers call the "shell".

DUBNER.- Efectivamente, cabe esperar que los filamentos ópticos se distribuyan en la cara interior de la concentración observada, si esta última es material interestelar barrido por la onda de choque.

Nota agregada durante las pruebas: Con posterioridad a esta Reunión, Dr. Lasker hizo una búsqueda de filamentos ópticos con el telescopio Curtis Schmidt de CTIO en la región de G216.9,+5.5. Con una exposición de 3.5 horas en [SII] no se observa nada. En cambio una exposición de 3 horas con filtro de interferencia centrado en $H\alpha$ muestra un pico de $H\alpha$ aproximadamente coincidente con el radiocontinuo, pero no se observa estructura de filamentos.

DETECTION OF NEW STELLAR SiO MASER SOURCES

J.R.D. Lépine, A.M. Le Squeren and E. Scalise Jr.

Centro de Radio Astronomia e Astrofísica
Universidade Mackenzie
São Paulo

ABSTRACT: Eight new SiO maser sources were detected at 43.122 GHz in a search made in 1977 August with the Itapetinga radiotelescope, from a search list of 110 objects which included Mira variables, M supergiants, carbon stars and S type stars. In addition other 18 previously known SiO sources were reobserved, and the H₂O emission at 22.235 GHz of the detected SiO sources was also observed, in order to compare SiO and H₂O maser fluxes. The interesting implications of the results are discussed.

At the end of 1977 July a new 42-48 GHz receiver, with about 1500 K system temperature, was installed at the 13.7 m Itapetinga radiotelescope. Using a 46 channel, 100 kHz resolution filter bank, we made an extensive search for new SiO maser sources during 1977 August, which led to the detection of 8 new sources. The main characteristics of the sources are indicated in table I. One of the new sources, R Aqr, is a symbiotic star, being the first star of this type to show maser emission. Negative results had previously been obtained for this star in the OH and H₂O lines by several authors; the presence of SiO emission reinforces the view expressed by Lépine and Paes de Barros (1977) that the SiO maser, occurring in deeper layers of the envelope than the H₂O maser, is less perturbed by the presence of a companion.

Excepting IRC-30308, which is possibly a supergiant, the remaining new sources are normal Mira variables. We also reobserved 18 SiO sources which were previously detected by Snyder and Buhl (1975) or by Balister *et al.* (1977), and we observed the H₂O emission at 22.235 GHz of the same stars in 1977 September, just after the period of SiO observations. We estimated the absolute SiO and H₂O fluxes of a sample of Mira variables by correcting the observed fluxes for the distance. A preliminary investigation shows that the distribution of the SiO fluxes among the Mira variables,

TABLE I

New Maser Sources of $^{28}\text{SiO } v=1, J=1-0$ Emissions at 43.122 GHz

Name	Spectral type	Period (days)	Phase in optical cycle	SiO integrated flux ($10^{-20} \text{ W m}^{-2}$)	LSR Velocity (km s^{-1})	H_2O integrated flux ($10^{-20} \text{ W m}^{-2}$)	LSR Velocity (km s^{-1})	Distance (parsec)
R Aqr	M7e	387	.53	5	-25.0	< 3	-	181
R Cae	M6e	391	.01	11	+ 1.5	< 3	-	440
R Car	M4e - M8e	309	.51	38	+5.0,+10.0	< 3	9.0	144
T Lep	M6e - M8e	368	.06	13	+28.5	< 3	-	306
RW Sco	M5e	390	.02	17	-70.5	12	-70.5	600
R Tau	M5e - M7e	324	.06	18	9.5	< 3	11.0	594
S Vir	M6e - M7e	378	.51	13	5.0	< 3	14.0	477
IRC-30308	---	-	-	8	1.5	< 3	-14.0	-

expressed in photons per second, is very similar to that obtained by Lépine and Paes de Barros for H_2O , and that most of the Miras present SiO emission, at a rate of about 2×10^{43} photons s^{-1} .

A detailed study including the comparison between the SiO and H_2O fluxes and the interpretation of our results is in preparation.

REFERENCES

- Balister, M., Batchelor, R.A., Haynes, R.F., Knowles, S.H., McCulloch, M.G., Robinson, B.J., Wellington, K.J., Yabsley, D.E., 1977, *CSIRO*, preprint.
Lépine, J.R.D., Paes de Barros, M.H., 1977, *Astron. Astrophys.* 56, 219.
Snyder, L.E., Buhl, D., 1975, *Ap. J.* 197, 329.

DISCUSSION

MENDOZA.- Hace 10 años, en forma independiente, H.L. Johnson y yo sugerimos que el objeto NML Cyg podría ser una supergigante M tardía. ¿Qué indican sus observaciones?

LEPINE.- As observações das raías das moléculas OH, H_2O e SiO em rádio confirmam que este objeto é uma supergigante. Por exemplo nós observamos uma separação de 12 km s^{-1} entre os picos H_2O e SiO , e isto nunca ocorre nas Miras. Existem observações interferométricas na raia OH por Masheder, Booth e Davies (*M.N.R.A.S.* 166, 561, 1974) que também mostram que NML Cyg é uma supergigante.

GALACTIC HI SURVEY AT LOW AND INTERMEDIATE LATITUDES BETWEEN
 $l=220$ AND $l=325^\circ$

E. Bajaja, F.R. Colomb and R. Morras

Instituto Argentino de Radioastronomía

I. THE OBSERVATIONS

The HI survey here described has been done at the IAR as part of the general 21 cm line survey work on the southern hemisphere. It shows the results obtained during the last years by several observers and covers previous partial surveys on this region of the sky made by Bajaja and Colomb (1973) and by Colomb, Gil and Morras (1976).

These surveys were completed with new observations on those parts of the sky necessary to follow interesting features. Only part of these new observations are included here, the rest being still under reduction process.

The IAR radiotelescope has been used for these observations. Its 30 m dish has a HPBW of 0.5° and at the back end 56 channels 10 kHz wide provide a velocity resolution of 2 km/s.

II. RESULTS

Fig. 1 shows the HI column density contour map for velocities between -20 and $+20$ km/s. The most remarkable feature in this map is the long arc shaped structure running from $l = 265^\circ$ to $l = 325^\circ$. It extends probably beyond this last limit and observations are being carried out to follow it in detail.

The curvature of the arc is such that its center can be estimated at about $l = 300^\circ$ and $b = +10^\circ$.

The radial width of the shell-like structure is 8 to 10 degrees and the maximum in the column densities is of the order of $15 \times 10^{20} \text{ cm}^{-2}$. It increases towards the galactic plane because of the galactic background.

The profiles along the HI ridge are in general broader than outside the structure and in many cases they show clearly a double structure.

HI deficiency can be seen around $l = 258^\circ$, $b = -28^\circ$ and $l = 305^\circ$, $b = -22^\circ$. The first one is present in the whole range of observed velocity, implying a real hole in the HI distribution. It was already shown by Colomb *et al.* (1977). The second one coincides in position

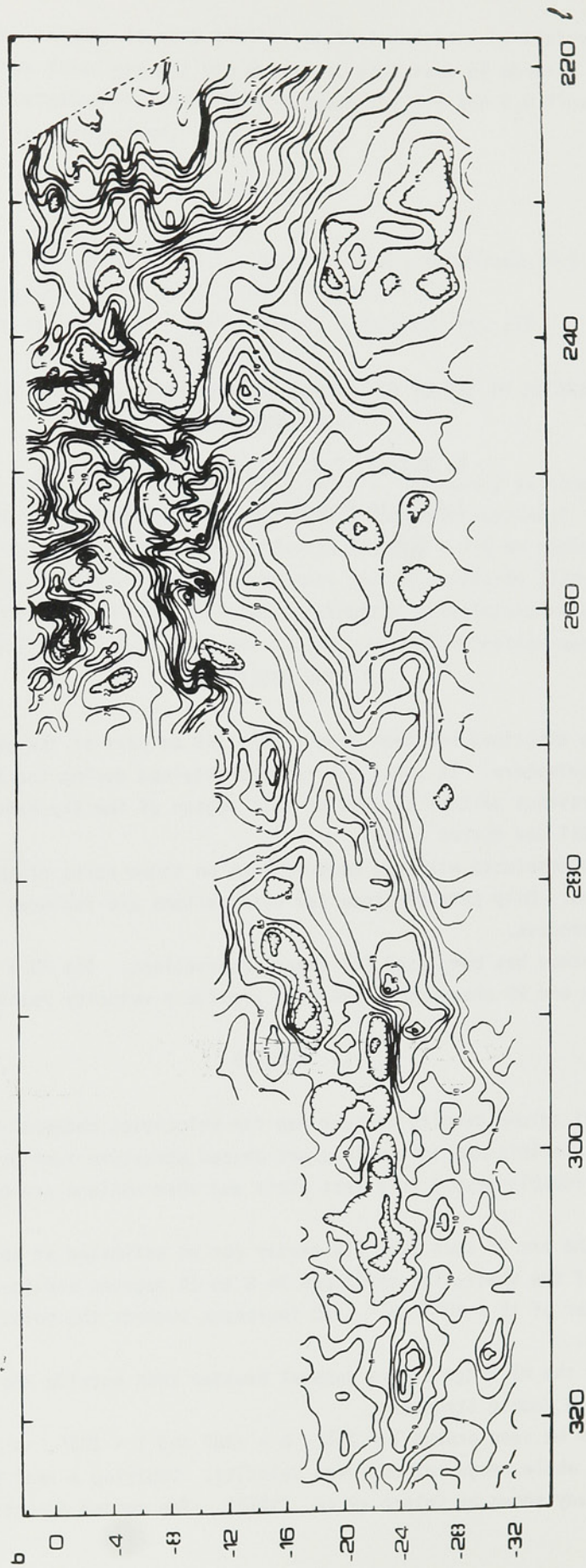


Fig. 1. HI column density contour map for velocities between -20 and $+20$ km/sec. The contours are labeled in terms of $N_H [10^{20} \text{ cm}^{-2}]$

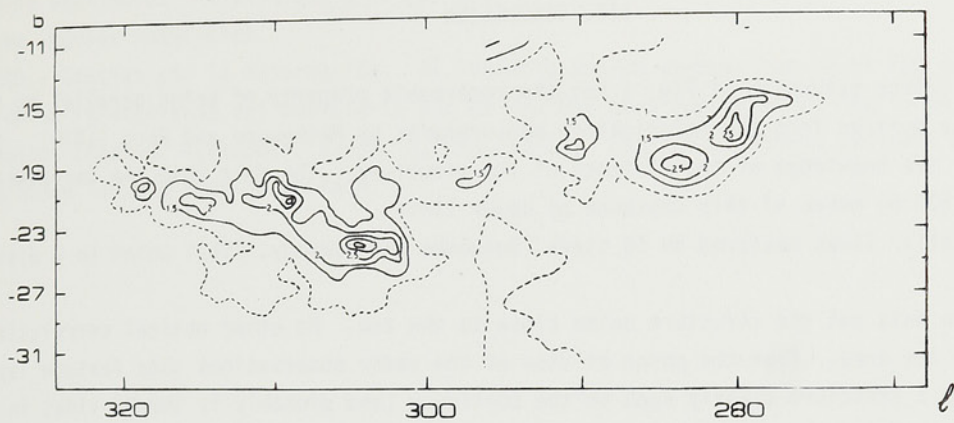


Fig. 2. The same as Fig. 1. for velocities between -40 and -20 km/sec.

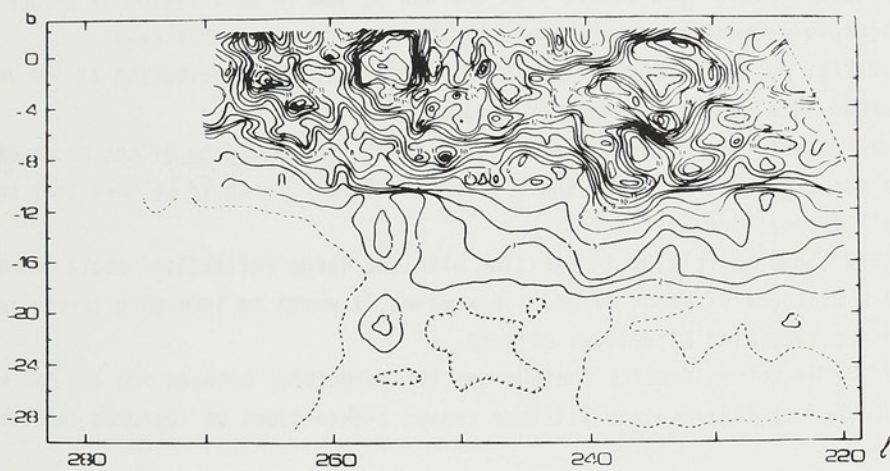


Fig. 3. The same as Fig. 1 for velocities between $+20$ and $+40$ km/sec.

with the feature shown in Fig. 2. This figure represents the HI distribution seen between -40 and -20 km/s and it shows the cloud found by Bajaja *et al.* (1976).

Fig. 3 corresponds to the HI distribution between +20 and +40 km/s. On this velocity range no peculiar features are found but rather extensions from the complex structure on the galactic plane.

III. DISCUSSION

The shell-like structure of Fig. 1 has the remarkable property of being parallel to the magnetic field as derived from the polarization measurements by Mathewson and Ford (1970). This is important for the knowledge of the distance of the structure. The fact that the correlation disappears beyond 500 pc makes of this distance an upper limit.

Interstellar lines measured on 10 stars (Buscombe and Kennedy, 1962) point to a distance of 100 to 300 pc.

All these data put the structure quite close to the sun. No other optical correlation has been found in the area. From the point of view of the radio observations this feature lays just below the loop I structure clearly seen in the continuum (and probably in the HI line) in the northern hemisphere. This makes it possible that what we see is the extension of that feature in the southern hemisphere. No continuum, however, has been observed associated with this southern part.

The estimated curvature center of the arc is close to the position of the SNR G.296.3 + 10. Its distance, 1.3 kpc, is however too large to make of it the origin of the shell.

Another possibility for the interpretation of this feature is provided by the theory of stellar winds, originated in early type stars, blowing on interstellar matter (Castor *et al.*, 1975).

The swept material would form shells like the one we see in this region if enough energy is provided. The Scorpio-Centaurus association could be the source in this case.

The cloud of Fig. 2, being coincident with a hole in the HI distribution at low velocities looks like perturbed local hydrogen expelled towards us.

Its distance, as determined through an interstellar line, would be of the order of 160 pc, which puts it in the same region as the shell-like structure. It could be then that the cloud is part of this shell approaching us.

Optically this cloud correlates in position with the large reflection nebula found by Danziger *et al.* (1974) at a distance of about 77 pc. This makes it worth to look more carefully at the edge of the shell for the same kind of optical objects.

Fig. 3 shows the HI column density contour map for velocities between +20 and +40 km/s. Nothing remarkable can be seen at intermediate latitude except z-extensions of features connected with the galactic structure.

REFERENCES

- Bajaja, E., Colomb, F.R., 1973, *Carnegie Institution of Washington Publication* N° 632.
Bajaja, E., Colomb, F.R., Gil, M., 1976, *Astron. Astrophys.* 49, 259.
Buscombe, W., Kennedy, P.M., 1962, *M.N.R.A.S.* 124, 195.
Castor, J., Mc Cray, R., Weaver, R., 1975, *Ap. J.* 200, L 107.
Colomb, F.R., Gil, M., Morras, R., 1976, *Astron. Astrophys. Suppl.* 26, 195.
Colomb, F.R., Pöppel, W.G.L., Heiles, C., 1977, *Astron. Astrophys. Suppl.* 29, 89.
Danziger, I.J., Dennefeld, M., Kunth, D., Shuster, H.E., 1974, *Astron. Astrophys.* 37, 416.

DISCUSION

WIELEBINSKI.- A 408 MHz survey made at Parkes by G. Haslam of Max Planck Institute, Bonn, is now becoming available. This should give you possibilities of comparing HI with radio continuum at the same angular resolution.

MORRAS.- Gracias por la información. Al respecto quiero agregar que en el IAR se va a realizar también un relevamiento del hemisferio sur en 820 MHz para completar el realizado en el norte por Berkhuisen (*Astron. Astrophys. Suppl.* 5, 263, 1972). Este relevamiento proveerá también información sobre la zona aquí presentada.

A LOW-LATITUDE SOUTHERN ATLAS OF GALACTIC HYDROGEN

W.G.L. Pöppel

Instituto Argentino de Radioastronomía

E.R. Vieira

Instituto de Física, Universidade Federal do Rio Grande do Sul

Porto Alegre

C.A. Olano and M.L. Franco

Instituto Argentino de Radioastronomía

An Atlas of 21 cm line profiles for a set of points on the sky with spacings of 1° in galactic longitude l and latitude b were obtained by the authors. The regions covered by the Atlas are sketched on Fig. 1.

The observations were made with the 30 m radiotelescope at Parque Pereyra Iraola ($\lambda=3^h52^m33^s$ W of Gr., $\phi=-34^\circ52'11''$). Its angular resolution is 0.5° . The receiver is of the Dicke type and is equipped with 56 channels of 10 kHz (~ 2 km/s) width separated by 18.95 kHz ($=4.0$ km/s). All the observations were obtained at two different local oscillator settings, separated by ~ 47.5 kHz (10 km/s), with an integration time of 3 minutes each. Therefore, a hydrogen line profile for a given point on the sky consists of 112 values for the antenna temperature, spaced at 2 km/s. Every point of the survey was observed at least twice, at different dates. The results were averaged. The preliminary reductions were done on the IBM 1620 of the National University of La Plata, Argentina. The averaging of the profiles and the contour maps were done with the Burroughs 6700 of the Federal University of Rio Grande do Sul, Brazil.

In order to calibrate the brightness temperature scale (T_b), a set of five accurately calibrated reference points was used (Pöppel and Vieira, 1973). Our scale was normalized by fixing the peak intensity of the point $l = 356^\circ00'$, $b = -04^\circ00'$ at 80.0 K. This point is just the standard region S9 observed by Williams (1973). For S9, Jackson (1976) estimated the ratio of our brightness temperature scale to that of Williams as being 0.991 ± 0.029 . A common temperature scale has been proposed by Harten *et al.* (1975). Since, according to these authors, the ratio between this scale and William's is estimated to be 1.02 ± 0.02 , this would mean that the scale adopted by us agrees with the common scale to an accuracy that is within the experimental uncertainty.

The observational work of a given day was always started by observing one of the five reference points, and this was repeated at intervals not longer than 2 hours and also at the end of the work period. As a result, the mean gain uncertainties are estimated to be $\sim 3\%$ of T_b .

The Atlas is divided into three parts. A description of them is given in Table I (Δt = net observing time, ΔT = mean total noise for a 3 minutes integration time). A small fraction of the

TABLE I

Part	Authors	Extension	Nr. of points	Nr. of observed profiles	Δt	ΔT	Observation periods
					(hours)	(K)	
I	W.P. and E.V.	$\left\{ \begin{array}{l} 240^\circ \leq l \leq 372^\circ (=12^\circ) \\ +3^\circ \leq b \leq +17^\circ \end{array} \right.$	1995	4266	~ 427	1.5	Jul.68-Jan.70 Sept.70-Oct.70 March 71 Jul.71-Jan.72 Jan.73-Jan.74
II	M.F., W.P. and E.V.	$\left\{ \begin{array}{l} 0^\circ \leq l \leq 12^\circ \\ -3^\circ \geq b \geq -17^\circ \end{array} \right.$	195	~ 442	~ 44	1	Dec.74-Febr.75 Sept.75-Dec.75 Aug.76-Sep.76
III	C.O., W.P. and E.V.	$\left\{ \begin{array}{l} 320^\circ \leq l \leq 345^\circ \\ +18^\circ \leq b \leq +26^\circ \\ 345^\circ \leq l \leq 350^\circ \\ +18^\circ \leq b \leq +20^\circ \end{array} \right.$	249	~ 588	~ 59	1	Nov.74-Febr.75 Sep.75-Mar.76

first part was already published (Pöppel and Vieira, 1974). The whole Atlas is now ready for publication. The results are presented in two sets of diagrams: a) average profiles for each point on the sky; a sample is given in Fig. 2; b) contour maps in the planes $l - v$, for constant values of b , and $b - v$, for constant values of l , both for $T_b = 5$ K, 10 K, 15 K, ... (v is the radial velocity reduced to the LSR). A sample is given on Fig. 3. All the results are also on magnetic tape.

The purpose of the Atlas is to study the properties of the low latitude HI gas, excluding the complexity of the galactic plane. Such a study would be particularly interesting at the Southern Hemisphere, where observations are lacking more than at the Northern. A previous research had been done by Vieira (1968, 1971) in the region $302^\circ \leq l \leq 310^\circ$, $+2^\circ \leq b \leq +12^\circ$.

In the following we will briefly mention some results obtained by several authors by analyzing partial data of the Atlas.

An anomalous velocity cloud near $l = 349^\circ$, $b = +3^\circ$, was investigated by Cugnon (1968). Mirabel et al. (1975) used the Atlas, complemented with observations at $b = +2^\circ$ and $+1^\circ$ in order to obtain a more complete picture of the feature, including the region originally out of Cugnon's limits of observation. A comparison with optical and radio observations was made and several possibil-

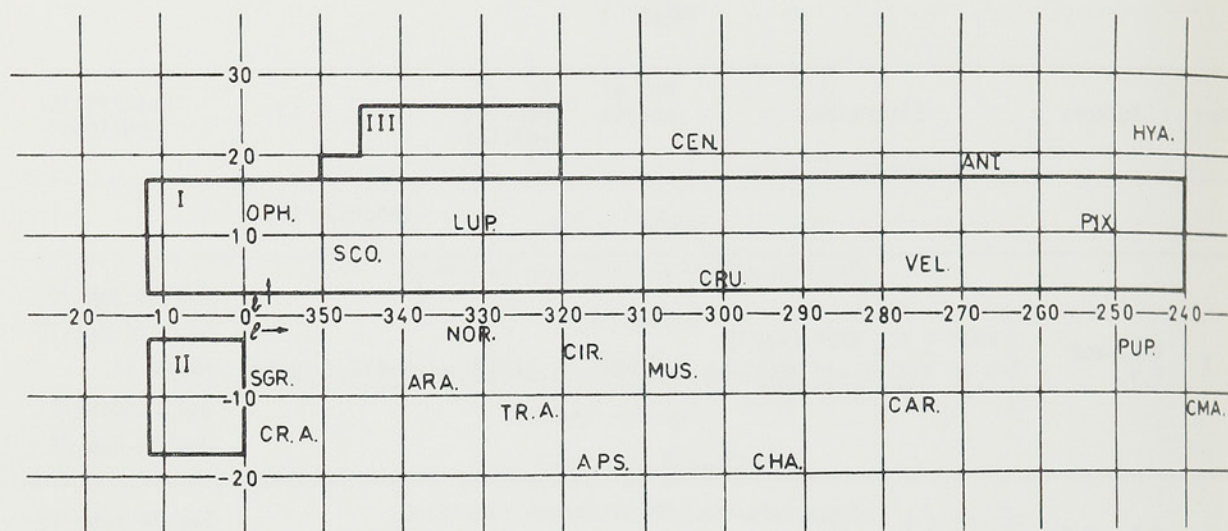


Fig. 1.

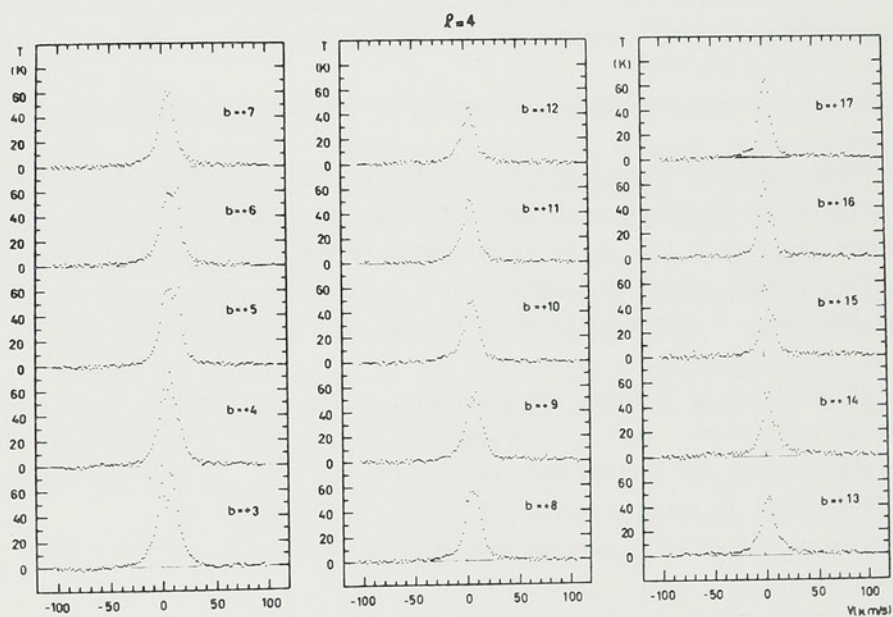


Fig. 2. From Pöppel and Vieira, 1974.

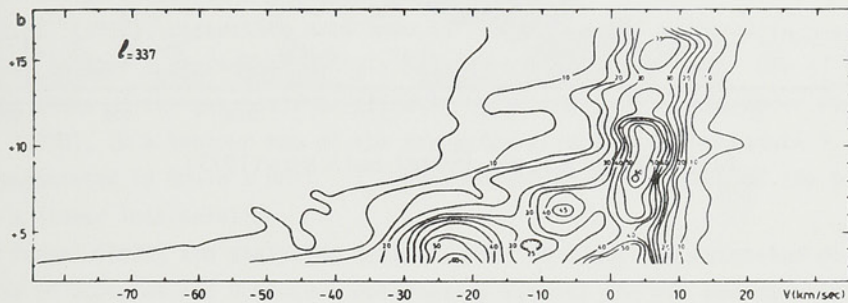


Fig. 3.

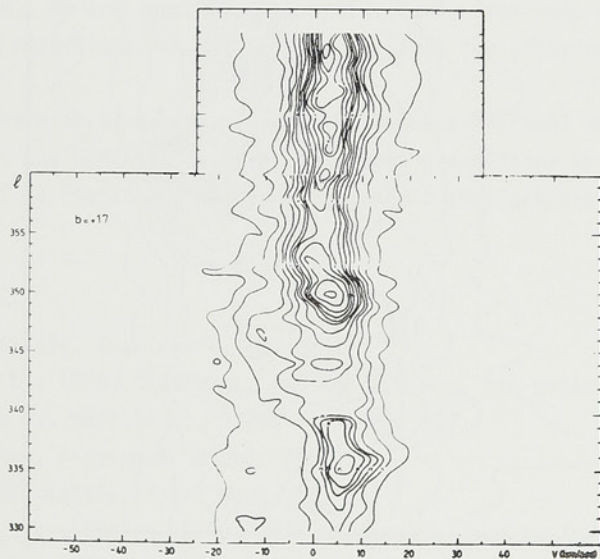


Fig. 4.

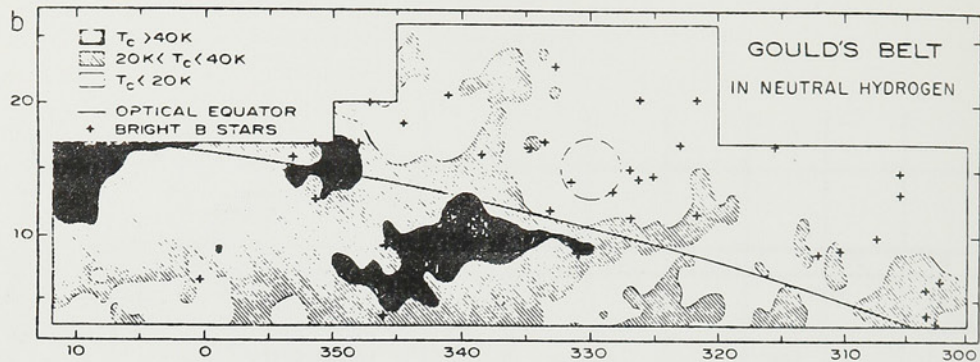


Fig. 5. From Strauss, Pöppel and Vieira (1977).

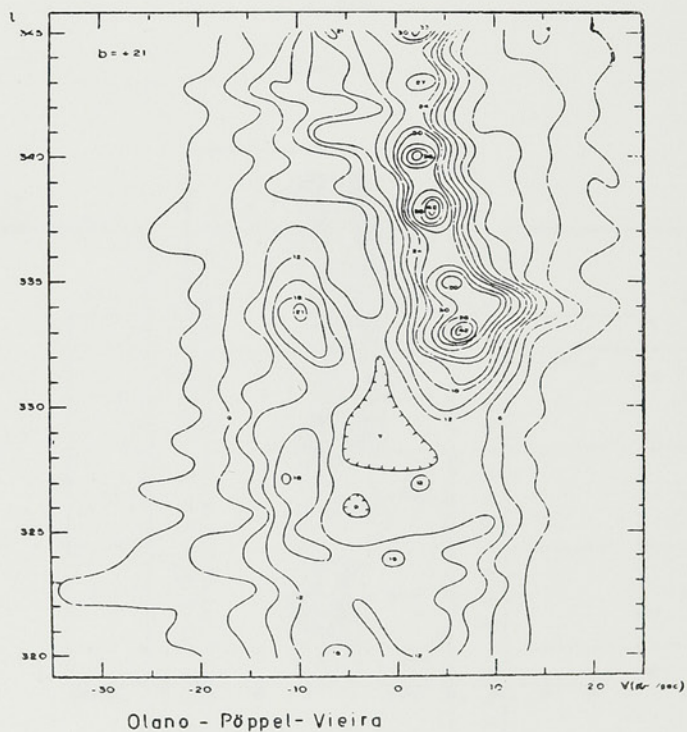


Fig. 6.

ities of interpretation as to the nature of the object were analyzed.

Franco and Pöppel (1978) analyzed the region $348^\circ \leq l \leq 12^\circ$, $+3^\circ \leq b \leq +17^\circ$. The study reveals strong kinematic asymmetries of the interstellar gas, with a notorious predominance of positive radial velocities, referred to the LSR. The principal cause of this is a very intense source, a ridge-like object ("Ridge", see Fig. 4), which presents very special characteristics and seems to be identical with Lindblad's feature A (Lindblad, 1967). It should, therefore, be related to Gould's Belt. The object can be easily followed into high northern latitudes and also into low southern latitudes, as well as into values of l remarkably lower and higher than those considered in the study. It seems also highly probable that feature A presents both the cold as well as the hot component of the interstellar medium.

Strauss *et al.* (1978), discussing data from our Atlas, made a comparative study of optical and radioastronomical data of a section of Gould's Belt from $l = 300^\circ$ to 12° . One of their conclusions is that the mean plane of the gas could be slightly below the optical equator. Fig. 5, taken from Strauss *et al.* (1978), is a contour map of the corrected brightness temperature T_c of the gas, which is presumably associated to Gould's Belt. T_c was computed by elimination of the background contribution with a linear interpolation.

Olano and Pöppel (1978) are analyzing data in order to study the extension of an elongated HI emission feature in Scorpius and Ophiucus, observed by Sancisi and van Woerden (1970). Besides, there seems to be a similar feature at lower longitudes, which could perhaps be a fragment of the former. Fig. 6 is a contour where this similar feature having a radial velocity of -12 km/s with respect to the LSR can be clearly distinguished.

ACKNOWLEDGEMENTS: Special thanks are due to engineers E. Filloy, J.C. Olalde, R. Dugatkin, R. Gerra and J. Sández, and to all the technical staff of the IAR for their efficient work. They made the observations possible. We are indebted to Dr. K.C. Turner for many helpful discussions during the observations and the reductions, and to Dr. F.M. Strauss for allowing to show results prior to publication.

The IAR functions under an agreement between the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), the Comisión de Investigaciones Científicas de la Provincia de Buenos Aires and the University of La Plata, and with the support of the Carnegie Institution of Washington.

REFERENCES

- Cugnon, P., 1968, *Bull. Astron. Inst. Neth.* 19, 363.
Franco, M.L., Pöppel, W.G.L., 1978, *Astrophys. and Sp. Science.* (in press).
Harten, R.H., Westerhout, G., Kerr, F.J., 1976, *A. J.* 80, 307.
Jackson, P.D., 1976, *Astron. Astrophys. Suppl.* 25, 433.
Lindblad, P.O., 1967, *Bull. Astron. Inst. Neth.* 19, 34.
Mirabel, I.F., Pöppel, W.G.L., Vieira, E.R., 1975, *Astrophys. and Sp. Science.* 33, 23.
Olano, C.A., Pöppel, W.G.L., 1978 (in preparation).
Pöppel, W.G.L., Vieira, E.R., 1973, *Astron. Astrophys. Suppl.* 9, 289.
Pöppel, W.G.L., Vieira, E.R., 1974, *An Atlas of Galactic Hydrogen*, Carnegie Inst. of Washington Publ. N°633.
Sancisi, R., van Woerden, H., 1970, *Astron. Astrophys.* 5, 135.
Strauss, F.M., Pöppel, W.G.L., Vieira, E.R., 1978, submitted for publication.
Vieira, E.R., 1968, Doctoral Thesis, University of Buenos Aires.

Vieira, E.R., 1971, *Ap. J. Suppl.* 22, 369.

Williams, D.R.W., 1973, *Astron. Astrophys. Suppl.* 8, 505.

DISCUSSION

BLAAUW.- Is it possible to give an estimate of the HI mass of the feature associated with the Sco-Cen association?

PÖPPEL.- No. Aún no tenemos esos datos. Hasta ahora sólo hemos delimitado la zona cubierta por la nube en $V \approx -12$ y valores menores de velocidad y estamos haciendo una aproximación gaussiana de perfiles.

LOW VELOCITY GALACTIC HI AT $|b| \geq 10^\circ$

F.R. Colomb and W.G.L. Pöppel

Instituto Argentino de Radioastronomía

C. Heiles

University of California

U.S.A.

HI in the northern sky has been surveyed with almost complete sampling (see Heiles and Jenkins, 1976). In view of the limited 21 cm line data presently available in the southern sky at intermediate and high galactic latitudes, another large survey was started. It covers the whole sky at the south of $\delta = -25^\circ$ and with $|b| \geq 10^\circ$. This southern survey will eventually be combined with the northern one, which was performed at Hat Creek.

The southern observations were started in October 1973 and finished in July 1977, using the 30 m radiotelescope of the Instituto Argentino de Radioastronomía, originally provided by the Carnegie Institution of Washington, constructed in Argentina by members of both institutions and operated by the personnel of the IAR. This telescope has a HPBW of $30'$ in the 21 cm line. We used a parametric amplifier donated by Dr. S. Colgate, which provided a total system temperature of about 200 K. The 56 channel filterbank was modified for the survey work by splitting the bank into two halves and interlacing the channels. This provided 56 filters which were 2 km/s wide, separated by 2 km/s. The total effective velocity range covered by the survey is about 80 km/s centered at zero km/s.

The data were obtained by keeping the telescope at a fixed hour angle and letting the sky drift through the beam at fixed δ . This was performed for values of δ within the interval -25° to -60° . For the interval -61° to -89° the telescope was swept in α with a velocity right opposite to the Earth's rotation. The spacing in δ was 1° . The total net observing time is of the order of 1100 hours, plus about 15% of overlapping observations.

The calibration of the temperature scale was performed by using the HI profile at the southern pole as a standard, and using a gas discharge tube as a secondary standard. A calibration of the channel and receiver gain was performed each time the frequency of the local oscillator was changed, or otherwise at intervals of time not longer than approximately two hours. Unfortunately, the receiver gain and the intensity of the noise tube fluctuated somewhat with time. Therefore, the intensity scale of our data fluctuates from one region to another by as much as $\pm 25\%$. However we hope to improve this substantially when the comparison of all the set of observations of

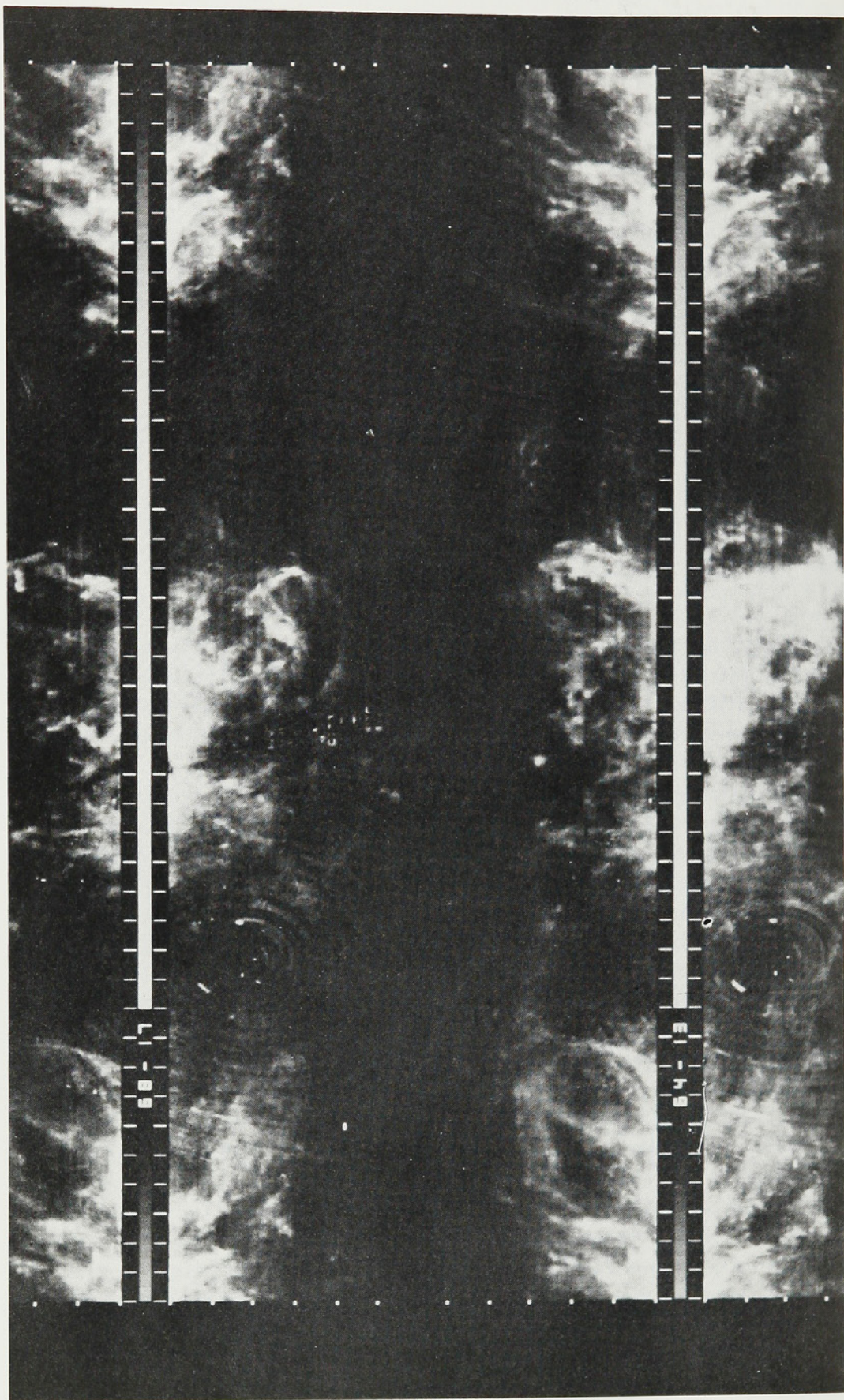


Fig. 1. (Top) Photographic presentation of HI column density within a velocity width of 2 km/s centered at $v = +17$ km/s. Galactic latitude extends from -65° at the bottom to $+65^\circ$ at the top; marks on the edges indicate 10° increments in latitude. The mark for $b = 0^\circ$ is excluded and there are no data for $|b| < 10^\circ$. Galactic longitude $l = 0^\circ$ at the right hand edge and increases through 360° to 60° at the left hand edge; thin marks appear every 10° , and thick marks every 30° in l .
(Bottom) Same as above, but for $v = +13$ km/s.

the South Pole and the noise tube level will be finished.

At present, all the observations belonging to the survey have been completed. They were first reduced and transferred from punched cards to magnetic tape on the IBM/360 computer of the Universidad Nacional de La Plata. Now they are being further corrected and organized into a grid at Berkeley. Photographic presentations of HI column density are expected to be made using the PDS microdensitometer of the Berkeley Astronomy Department.

A portion of the survey, using less than 45% of the observations was presented in a preliminary photographic format (Colomb *et al.*, 1977). The main conclusion is that the HI seems to lie predominantly in long arcs instead of in self-contained, roughly spherical interstellar clouds. Two HI structures were discussed by examining their kinematical behaviour and their associations with radiocontinuum emission, diffuse x-ray emission, and interstellar optical polarization. These structures probably are parts of expanding shells produced by energetic events. We refer to Colomb *et al.* (1977) for further details.

ACKNOWLEDGEMENTS: We would like to thank all the personnel of the IAR who collaborated in one way or another with this work, especially engineers E. Filloy, J.C. Olalde and J. S  niz. S. Acero assisted in the observations and L. Dimier in the data handling. We are indebted to Dr. S. Colgate for donating the parametric amplifier.

The IAR functions under an agreement between the Consejo Nacional de Investigaciones Cient  ficas y T  cnicas (CONICET), the Comisi  n de Investigaciones Cient  ficas de la Provincia de Buenos Aires and the University of La Plata, and with support of the Carnegie Institution of Washington.

REFERENCES

- Colomb, F.R., P  ppel, W.G.L., Heiles, C., 1977, *Astron. Astrophys. Suppl.* 29, 89.
Heiles, C., Jenkins, E.B., 1976, *Astron. Astrophys.* 46, 333.

DISCUSSION

WALBORN.-   En qu   coordenadas est  n hechas las representaciones?

P  PPEL.- En coordenadas α , δ , que evitan distorsiones de las zonas de latitudes gal  cticas altas. La representaci  n final se har   en coordenadas gal  cticas.

Nota agregada durante las pruebas: Con posterioridad a esta reuni  n las observaciones del Hemisferio Sur se combinaron con las del Hemisferio Norte, obteni  ndose 20 mapas de toda la Galaxia a diferentes velocidades. Como ejemplo, en la Fig. 1 se muestran los mapas correspondientes a las velocidades +17 km/s y +13 km/s (arriba y abajo respectivamente). La estructura filamentosa es claramente visible en esta fotograf  a.

A 45 MHz RADIOTELESCOPE FOR GALACTIC
AND
EXTRAGALACTIC RESEARCH

Jorge May, Francisco Reyes and Juan Aparici

Observatorio Radioastronómico, Maipú
Departamento de Astronomía
Universidad de Chile

Due to the lack of information or accuracy in the spectra of Southern radio sources, at the low frequency region, a 45-MHz large array has been built at the Maipú Radio Astronomy Observatory. The antenna is a rectangular filled array of 528 full-wavelength dipoles distributed in 48 rows of 11 dipoles each one with a total effective aperture of $13\,000\text{ m}^2$ and a resolution of $2:1$ (N-S) $\times$ $4:6$ (E-W). The dipoles are made of 2 mm diameter copper wires, supported by wooden poles, and located $\lambda/4$ above a reflecting screen made of galvanized wire. The dipoles are linearly polarized in the E-W direction. The antenna is a transit instrument that can be electrically steered only in the N-S direction within $\pm 45^\circ$ from the zenith. A Butler matrix of hybrid rings provides 8 simultaneous beams contained in the meridian plane.

Six low-noise, high-gain preamplifiers are located at the array. Since the noise temperature of the preamplifiers is 200°K the system noise is completely dominated by the sky background temperature (5000°K for the galactic poles). The receiver has a variable I.F. bandwidth from 10 kHz (specially useful for detection of pulsars) to 3 MHz (maximum sensitivity). A high-precision and very stable D.C. amplifier with offset provides the analog outputs for recorders. Relatively fast analog-to-digital converters are used to feed a HP 2114B digital computer. Two 5722 saturated noise diodes are used as a standard calibrator.

From measurements already done and improvements made in the gain stability of the preamplifiers and D.C. amplifiers, a sensitivity of 8°K or 2 Jy for the galactic poles and 80°K or 20 Jy for the galactic center can be anticipated. A general survey of radio sources and observations of pulsars, using long term integration techniques, will be soon started.

DISCUSSION

WIELEBINSKI.- This instrument is a welcome new addition in radio astronomy. You must be congratulated on the present state and encouraged to extend the instrument's resolution. There is at present a great need of, say, 1 arc min resolution maps at low frequencies of galactic and extragalactic sources.

MAY.- Thank you for your comments. We also believe this project is very important and we have been encouraged by Prof. Woltjer to go on and build an interferometer. The Chilean Communication Committee has approved a free band of near 3 MHz around 45 MHz to be used only for radioastronomical purposes.

TERCERA PARTE

ASTRONOMIA ESTELAR: ASTROFISICA

OBSERVATIONAL ASPECTS OF BLACK HOLES*

Invited Lecture

J.A. de Freitas Pacheco

Instituto Astronômico e Geofísico U.S.P.

São Paulo

I. INTRODUCTION

In the actual astrophysical context, we can consider three classes of black holes: a) cosmological, which are black holes with masses of the order of 10^{14} g or less and which would be formed at the earlier phases of the Universe; b) stellar holes, which would be formed as a consequence of the evolution of massive stars; c) massive black holes, which are those that would be formed through the collapse of the central dense regions of globular clusters or nuclei of galaxies and that are frequently invoked to explain the activity of quasars and Seyfert nuclei.

In the following sections we review the main astrophysical aspects of such objects.

II. COSMOLOGICAL BLACK HOLES

The formation of black holes in the first evolutionary phases of the Universe was examined by Hawking (1971). On the other hand, Hawking (1974, 1975) has also shown that the intense gravitational field near the horizon can be the source for particle creation. This effect can be interpreted as a quantum tunnel effect, through which one of the particles from pairs created spontaneously escape to infinity and the other remains inside the horizon in a negative energy state. The theoretical rate of particle emission of a given electrical charge e , axial quantum number n and within the energy interval E to $E + dE$ is:

$$\frac{dN}{dt} = \frac{r dE}{2\pi\hbar} \left[\exp\left(\frac{E - nh\Omega - e\psi}{\hbar\chi/2\pi C}\right) + 1 \right]^{-1}, \quad (1)$$

* Part of this work was elaborated at the Nice Observatory - France, as a part of a scientific program between CNRS (France) and CNPq (Brasil).

where Ω , ψ and χ are respectively the angular velocity, the electrostatic potential and the surface gravity of the hole, and Γ is the probability for the hole to absorb an incident particle with the same quantum numbers. The plus and minus signs apply respectively to fermions and bosons.

If $\Omega = \psi = 0$, equation (1) has a "Planckian" form with an equivalent black body temperature given by:

$$T = \frac{\hbar c^3}{8\pi G M k} \sim \frac{10^{26}}{M} \text{ } ^\circ\text{K} \quad , \quad (2)$$

where M is the hole mass (in grams).

Equation (2) shows that the emission is important for small black holes, which are those that could be formed in the beginning of our Universe, when the density was extremely high. Considering an equation of state of the form $p = \gamma \epsilon$ (p is the pressure and ϵ the total energy density), for $\gamma = 1/3$ and 1 respectively, black holes of mass of the order of 10^{14} g would have to be formed in the first 10^{-24} to 10^{-25} seconds, in the pre-hadronic era, where the physics is completely unknown. On the other hand, within the composite particle picture of Hagedorn, if we consider a non-symmetric Universe ($N > \bar{N}$) and particles with large baryonic number, we have an equation of state of the form $p \approx \rho_\star c^2$ ($\rho_\star \approx 10^{14}$ g cm $^{-3}$). In this case mini-holes of mass of about 10^{14} g would have to be formed at $t \sim 10^{-10}$ s (hadronic era). Anyway, the physics at the epoch of formation of such objects is completely uncertain.

Why have we considered in the above examples holes with a mass of about 10^{14} g?

As the black holes emit particles, they loose mass and evaporate in a time scale (Page, 1976):

$$\tau \sim 10^{-26} M^3 \text{ s} \quad . \quad (3)$$

Therefore, holes with a time scale less than the Hubble time ($T_H \approx 3.6 \times 10^{17}$ s) have already evaporated and this corresponds to a mass of about 3.3×10^{14} g.

In a first approximation, the energy of the emitted particles is:

$$E \sim kT \sim \frac{10^{22}}{M} \text{ eV} \quad . \quad (4)$$

This means that the typical energy of a particle emitted by a hole of mass of 3.3×10^{14} g is 30 MeV. The question now is to know what kind of particles are emitted and in what proportion. Table I shows the results of the calculations by Page (1976). We can observe that for mini-holes of mass of the order of 3×10^{14} g, 10% of the total emission is under the form of photons.

In this case, we can compare the photon emission of these hypothetical mini-holes with the observed energy density of the background radiation above 30 MeV and establish an upper limit for the density of these objects in the Universe.

The total energy rate emitted by a black hole of mass M is (Carr, 1976):

$$\frac{dW}{dt} \sim \frac{6.3 \times 10^{46}}{M} \text{ erg s}^{-1} \quad . \quad (5)$$

If $N_\star$ is the density of the considered holes and f is the fraction of the total energy emitted under the form of photons, the photon energy density will be:

TABLE I

Interval of mass	Gravitons	Photons	Neutrinos	Muons and Pions	Baryons	Electrons
$M > 10^{17} \text{ g}$	0.02	0.17	0.81	-	-	-
$10^{15} \text{ g} < M < 10^{17} \text{ g}$	0.01	0.09	0.45	-	-	0.45 (e^+, e^-)
$10^{14.5} \text{ g} < M < 10^{15} \text{ g}$	0.01	0.07	0.51	0.41 (μ^+, μ^-)	-	-
$10^{14} \text{ g} < M < 10^{14.5} \text{ g}$	< 0.01	0.10	0.55	0.35 (π^+, π^-, π^0)	-	-
$10^{13.5} \text{ g} < M < 10^{14} \text{ g}$	< 0.01	0.11	0.40	-	$0.12 \left \begin{array}{c} K^+, K^-, K_L^0, K_S^0 \\ N, \bar{N} \end{array} \right $	0.25 (e^+, e^-)

$$u(30 \text{ MeV}) \approx N_* f \frac{dW}{dt} T_H \quad (6)$$

Since the observed energy density is $u(>30 \text{ MeV}) \approx 3 \times 10^{-17} \text{ erg cm}^{-3}$, from eq. (6) one obtains:

$$N_* \lesssim 3.9 \times 10^4 \text{ pc}^{-3} \quad (7)$$

which is equivalent to a matter density in the Universe of:

$$\rho_* \leq 4.8 \times 10^{-37} \text{ g cm}^{-3} \quad (8)$$

This value is about six orders of magnitude less than the luminous matter found in galaxies. Therefore the mechanism to form such holes was not efficient, and they should not contribute to the dynamical evolution of the Universe as a whole.

III. STELLAR BLACK HOLES

Since black holes with typical stellar masses can be detected essentially through their gravitational effects, the chances to detect such an object are greater if we look into binary systems. Indeed, several systems have been proposed as possible candidates: ϵ Aur (Cameron, 1971), β Lyr (Devinney, 1971), BM Ori (Wilson, 1972), and in spite of all these suggestions, only Cygnus X-1, which is associated with an X-ray source, remains as the strongest example.

In the systems which are not associated with X-ray sources, the main line of reasoning is to argue that, in single spectroscopic binaries, the "unseen" secondary star is highly underluminous for its mass. The mass of the secondary star is generally evaluated through the gravitational effects produced in the primary, mainly through the ellipsoidal effect. Evidently, the secondary mass must exceed the acceptable upper limit for the compact equilibrium configurations such as white dwarfs and neutron stars. The analysis of the ellipsoidal effect is very difficult, since the extraction of the amplitude of such an effect from the observed light curve presents serious difficulties, specially when, in addition to the underlying ellipsoidal variations, some other sources of light and/or obscuration may be present. Another assumption usually made in such an analysis is that one of the stars (generally the primary) fills the Roche lobe, what implies that the orbit is circular, that the spin of the primary is synchronized with the orbital motion and that the radiative forces do not considerably distort the equipotentials. Therefore, we should be careful when using masses estimated by such a procedure.

In the case of Cygnus X-1, the mass of the compact object may be four times greater than the maximum mass of a stable neutronic configuration (Pacheco, 1975; Sodr , 1976). This led us to the idea that the compact object may be a black hole. Besides this point, the following arguments can be done: the X-ray emission originates probably in a gaseous disk around the hole. Following the model proposed by Pacheco and Steiner (1976), the distance r from the hole, in the disk, where the temperature is T , is approximately given by:

$$r \approx 25 \frac{(\mathcal{M} / \mathcal{M}_\odot)^{3/2}}{L_{37}^{1/2} T_9^{1/4}} \text{ km} \quad (9)$$

where $\mathcal{M}$ is the mass of the hole, L_{37} is the total disk luminosity in units of $10^{37} \text{ erg s}^{-1}$ and T_9 is the temperature in units of $10^9 \text{ }^\circ\text{K}$. If the detected photons of greatest energy (500 keV) are

emitted at the inner part of the disk, then the temperature is about 5×10^9 °K and since the luminosity between 2 - 10 keV, where almost all the energy is emitted, is 1.4×10^{37} erg s⁻¹, from eq. (9) one obtains:

$$r_{in} \sim 580 \text{ km} \quad .$$

On the other hand, the inner radius of the disk cannot be less than the "last stable orbit", which in the case of a Schwarzschild hole (zero angular momentum) is about three times the horizon radius, i.e.:

$$r_* = \frac{6GM}{c^2} \quad , \quad (10)$$

which, for a $12 M_\odot$ object, corresponds to a distance of 106 km. Such a result is compatible with that obtained from eq. (9). Instabilities near the "last stable orbit" allow us to predict fluctuations in the X-ray emissivity with time scales of the order of:

$$t \sim 92 \frac{GM}{c^3} \quad . \quad (11)$$

These, in the case of Cyg X-1, correspond to time scales of about 5 m, in agreement with the observations of Rothschild *et al.* (1974).

Could Cyg X-1 be a triple system? In this case, the secondary star would be an $11 M_\odot$ star (B type ?) and around it, we would have a $1 M_\odot$ neutron star. However, the photometric variability, the radial velocity curve (including the fact that the HeII $\lambda 4686$ line varies in antiphase with the absorption lines) and the soft X-ray dips, which are always observed near superior conjunction, favour the simple binary model.

Recent new optical polarization data by Kemp (IAUC 3149) would imply an orbital inclination angle of about 70°. In this case, the mass of the compact object would be only $3.3 M_\odot$, compatible with the upper limit of mass for stable neutron stars. On the other hand, the primary would be highly overluminous since its mass would be about $8.2 M_\odot$. Although from some theoretical calculations we can obtain an $8.5 M_\odot$ He star (from a $25 M_\odot$ star in a binary system which has suffered a strong mass exchange) with supergiant characteristics but with lower luminosity, this possibility remains open to discussions.

IV. SUPERMASSIVE BLACK HOLES

After the association of some X-ray sources with globular clusters (for instance, NGC 1851, NGC 6441, NGC 6624, M15, NGC 6440, NGC 6712), Bahcall and Ostriker (1975) suggested that the emission could be produced by $100 M_\odot$ - $1000 M_\odot$ black holes in the cluster center.

As we will see, one of the possibilities to form such massive holes would be through the accretion of the debris of stars in the hole tidal radius. However, the growth time scale for this process in globular clusters is greater than the Hubble time.

A massive object in the cluster center produces a density cusp (Shapiro and Lightman, 1976). Bahcall, Bahcall and Weistrop (1975) have studied the stars distribution profile in M15, concluding that the mass of the central massive object cannot be greater than:

$$M_{BH} \lesssim 10^4 \left(\frac{M}{L} \right)_A M_{\odot} ,$$

where $(M/L)_A$ is the mass-luminosity ratio for the cluster. If such a limit does not exclude massive holes to explain the X-ray emission, the difficulty remains to form them in a time shorter than the Hubble time.

About a decade ago, Lynden-Bell (1969) suggested that the activity of quasars and Seyfert nuclei may be associated with supermassive black holes in a state of accretion. Hills (1975) suggested that the tidal disruption of stars inside the Roche limit of the hole could be the adequate source of gas. The process of accretion increases the mass of the hole until the Roche radius be engulfed by the horizon of the hole. This occurs when the mass of the hole attains the critical value of about $3 \times 10^8 M_{\odot}$.

Let us analyze with some more detail the Seyfert nucleus of NGC 1068.

The infra-red emission from the nucleus of NGC 1068 is $3.3 \times 10^{44} \text{ erg s}^{-1}$, and it is likely that this radiation be due to thermal emission from dust grains (Jones and Stein, 1975). If we assume that the UV emission responsible for the heating of the grains and the gas ionization is due to OB stars, we are faced with two problems: the rate of star formation in the central region must be about $37 M_{\odot}/\text{year}$ and the effective temperature of the stars required to explain the observed line ratio (HeII $\lambda 4686/H$) is of the order of $1.5 \times 10^5 \text{ }^\circ\text{K}$.

Let us consider the possibility that the UV emission originates in a gaseous disk around a supermassive black hole.

Let us suppose, as a consequence of the evolution of a massive star, that a $10 M_{\odot}$ black hole was formed in the nucleus, where the stellar density is very high. The tidal growth time (Young, 1977) until density cusp effects around the hole produce a considerable increase in the accretion rate is:

$$\tau \approx 10^{10} M_6^{-1/3} \rho_6^{-1} \sigma_{200} \text{ years} , \quad (12)$$

where M_6 is the initial black hole mass in units of $10^6 M_{\odot}$, ρ_6 is the central stellar density in units of $10^6 M_{\odot} \text{ pc}^{-3}$ and σ_{200} is the stellar dispersion velocity in units of 200 km s^{-1} . The central stellar density of NGC 1068 is about $4 \times 10^7 M_{\odot} \text{ pc}^{-3}$ (Pacheco and Souza, 1977) and the dispersion velocity is 150 km s^{-1} (Richstone and Morton, 1975). Therefore from eq. (12) one obtains a growth time of the order of 6.9×10^9 years, less than the presumed age of the galaxy.

The maximum peak luminosity is attained when the hole mass reaches the critical value:

$$M_{\text{crit}} \approx 1.7 \times 10^7 \rho_6^{-1/2} \sigma_{200}^3 M_{\odot} = 1.1 \times 10^6 M_{\odot} , \quad (13)$$

since then, the high velocity disruptive stellar collisions provide an accretion rate of the order of:

$$\dot{M} = 10^{-2} \rho_6^{1/2} \sigma_{200}^2 = 0.036 M_{\odot}/\text{year} , \quad (14)$$

corresponding to a luminosity $L = \eta \dot{M} c^2 = 2.1 \times 10^{44} \text{ erg s}^{-1}$ (we have assumed $\eta = 0.1$, since for a Schwarzschild hole $\eta = 0.06$, while for an extreme Kerr hole $\eta = 0.3$).

In this regime, the growth time scale is (Young, 1977):

$$\tau_* \approx 2 \times 10^{11} M_6^{-2} \rho_6^{-2} \sigma_{200}^7 \text{ years} \quad , \quad (15)$$

and taking into account the uncertainties in the dispersion velocity due to the strong dependence on it, the time scale is in the range $10^7 - 10^8$ years.

On the other hand, since the debris have angular momentum, a gaseous disk is formed around the hole. For an opaque disk, as in the present case, the temperature distribution is:

$$T(r) = \left[\frac{3G M \dot{M}}{8\pi\sigma_B r^3} \left(1 - \frac{r_0^{1/2}}{r^{1/2}} \right) \right]^{1/4} \quad , \quad (16)$$

and taking $M = 1.1 \times 10^6 M_\odot$ and $\dot{M} = 0.036 M_\odot/\text{y}$, the maximum temperature reached on the disk surface is 4.6×10^5 °K, corresponding to a photon energy of about 40 eV.

Summarizing the above results, we have:

- a) the calculated tidal growth time scale is less than the galaxian age and therefore a stellar hole has time enough to grow;
- b) the peak luminosity satisfies the energy requirements;
- c) the time scale of the maximum luminosity is within the range usually admitted for the Seyfert phenomenon;
- d) most of the energy is emitted in the UV region, where its efficiency to ionize the gas and heat the dust grains is high and also not conflicting with the upper limit in the X-ray region, which is about $5 \times 10^{41} \text{ erg s}^{-1}$ in the 2-6 keV range;
- e) the peak luminosity is very near the Eddington limit and therefore some gas may be blown out of the nucleus. This could have been the source of motions responsible for the broadening of the emission lines.

Therefore although this is not the only explanation for the observed activity, it is not in contradiction with known facts, favouring the Lynden-Bell's idea about the presence of a massive black hole in the galactic nuclei responsible for all such an activity.

REFERENCES

- Bahcall, J., Bahcall, N., Weistrop, D., 1975, preprint.
 Bahcall, J., Ostriker, J., 1975, *Nature*, 256, 23.
 Cameron, A., 1971, *Nature*, 229, 178.
 Carr, B., 1976, *Ap. J.* 206, 8.
 Devinney, E., 1971, *Nature*, 223, 110.
 Hawking, S., 1971, *M.N.R.A.S.* 152, 75.
 ——— 1974, *Nature* 248, 30.
 ——— 1975, *Commun. Math. Phys.* 43, 199.
 Hills, J., 1975, *Nature* 254, 295.
 Jones, T., Stein, W., 1975, *Ap. J.* 197, 297.
 Lynden-Bell, D., 1969, *Nature* 223, 690.
 Pacheco, J.A. de Freitas, 1975, *Astrophys. and Sp. Science* 32, 205.
 ——— 1977, in press.

- Pacheco, J.A. de Freitas, Steiner, J., 1976, *Astrophys. and Sp. Science* 39, 487.
 Pacheco, J.A. de Freitas, Souza, R.E., 1977, to be published.
 Page, D., 1976, *Phys. Rev. D.* 13, 198.
 Richstone, D., Morton, D., 1975, *Ap. J.* 201, 289.
 Rothschild, R., Boldt, E., Holt, S., Seleritsos, P., 1974, *Ap. J.* 189, L13.
 Shapiro, S., Lightman, A., 1976, *Nature* 262, 743.
 Sodr , L., 1976, Thesis, University of S o Paulo.
 Young, P., 1977, *Ap. J.* 215, 36.
 Wilson, R., 1972, *Astrophys. and Sp. Science* 19, 165.

DISCUSSION

STEINER.- Qual a precis o na determina  o do  ngulo de inclina  o de Cygnus X-1 pela polariza  o observada?

PACHECO.- N o sei, porque os resultados de Kemp n o foram ainda publicados.

STRAUSS.- En Porto Alegre, usando una t cnica similar a "area scanning" observamos 14 c mulos globulares; 4 de ellos mostraron un efecto marginal de exceso de densidad en el centro respecto de los modelos te ricos de King (*Astron. Astrophys. Suppl.*, in press).

WALBORN.- Creo que la posible existencia de un hoyo negro en Cygnus X-1 no pelagra tanto como implic .

1) La derivaci n de $i \approx 70^\circ$ de la polarizaci n variable es indirecta y depende del modelo.

2) Se ha estudiado la distancia en bastante detalle y todo indica alrededor de 2.5 kpc.

3) No se ha establecido la existencia de pulsaciones regulares y permanentes como en los sistemas con estrellas de neutrones comprobados.

4) Una masa grande elimina una estrella de neutrones, pero una masa peque a no elimina un hoyo negro. Dado que las caracter sticas en rayos X de Cyg X-1 (y de Circinus X-1) son distintas a los sistemas con estrellas de neutrones conocidos, persiste la posibilidad que estos dos contengan hoyos negros.

QUINTANA.- Hay cierta evidencia que la actividad del n cleo de una galaxia, manifestada por ejemplo en emisi n en rayos X o como radiofuente, depende de la capacidad de la galaxia de conservar el gas interestelar producido por el conjunto de sus estrellas (siendo masiva, o no movi ndose muy r pido con respecto al gas intergal ctico para el caso de galaxias activas en c mulos).  C mo se relacionar a esta evidencia con la idea de que los n cleos activos son alimentados por estrellas que una a una son capturadas por el hoyo negro?

PACHECO.- N o necessariamente a atividade observada deve ser explicada pela presen a de um buraco negro. O modelo apresentado somente se aplica a nucleos densos, de tal forma que haga tempo suficiente para o buraco crescer em massa, atrav s da captura de estrelas.

QUINTANA.- Entre otras muchas teor as que se propusieron para explicar los " -ray bursts" hubo la proposici n que ellos eran el resultado de la evaporaci n de mini-black holes en el halo de la galaxia.  Qu  comentarios le merece esta teor a?

PACHECO.- Resultados obtidos por Hawking e Carr indicam que uma poss vel associa  o   improv vel, j  que tais mini-buracos emitiriam essencialmente raios-X (n o gamma). Outra dificuldade na compara  o reside no calculo do espectro de massa inicial de tais mini-buracos negros.

MODELS OF EQUIPOTENTIAL SURFACES FOR LUMINOUS BINARY SYSTEMS

Virpi S. Niemela

Villa Elisa, Buenos Aires

and

Juan Zorec*

Instituto de Astronomía y Física del Espacio, Buenos Aires

ABSTRACT

Models of equipotential surfaces were calculated for 4 binary systems with luminous components, taking into account the radiation pressure of both stars in the potential function. Electron scattering was assumed to be the main opacity source. In all cases the models deviate considerably from the classical "Roche" equipotentials. The usual contact surfaces do not exist in these systems.

We present models of equipotential surfaces for the following binary systems: V729 Cyg (Of+Of), V453 Sco (B0I+Of), V444 Cyg (WN5+O6) and CV Ser (WC8+O9). These systems contain a luminous star apparently exceeding the Eddington limit if normal main sequence composition is assumed. But if we assume they have a high abundance of He, these stars have the radiation pressure parameter less than unity, i.e. they fall within the Eddington limit.

DISCUSSION

MENDOZA.- ¿Existe alguna evidencia observacional que apoye un bajo contenido de hidrógeno en alguna de sus estrellas?

NIEMELA.- En las estrellas Wolf-Rayet no hay evidencia de hidrógeno, pero la Of y la supergigante B tienen líneas de Balmer en su espectro. La suposición de $X = 0$ es obviamente un caso límite.

* Present address: Institut d'Astrophysique, Paris, France.

RELATIVISTIC ELASTICITY THEORY AND THE
STRUCTURE EQUATIONS OF SOLID NEUTRON STARS

H. Quintana

National Radio Astronomy Observatory,* Green Bank
West Virginia

Neutron stars are the only known stable bodies where we can learn about the behavior of matter in very strong gravitational fields. Although not many details of their structure are accessible, there are some observable dynamical effects strongly dependent on their detailed inner structure. Masses, moments of inertia and other global parameters are sensitive to the form of the equation of state at densities $5\text{--}15 \times 10^{14} \text{ g cm}^{-3}$. Other higher order effects depend on details of the inner structure, like characteristics of the superfluid, magnetic field strengths or the rigidity value in crystalline layers.

In the ten years or so of pulsar observations a number of sudden speed-ups have been detected. By far the largest and better studied are five glitches that have occurred in the Crab and Vela pulsars. Various mechanisms have been suggested as possible causes; the arguments have been reviewed by Ruderman (1972). One of the most attractive interpretations of the sudden speed-ups is in terms of changes ΔI in the moment of inertia I due to crackings in a solid star layer, triggered by internal stresses induced by the pulsar slowing down (Ruderman, 1969; Baym and Pines, 1971). See Figure 1. The observed jumps imply $\Delta I/I \sim 10^{-8}$, and $\Delta I/I \sim 10^{-6}$ for the Crab and Vela glitches, respectively. In the first the breaking of a crystalline crust (with a typical rigidity $\mu \sim 10^{29} \text{ dyne cm}^{-3}$) is sufficient to account for the effect, but the much larger jumps in Vela require the consideration of a solid core (with $\mu \sim 10^{35} \text{ dyne cm}^{-3}$). Several calculations of the equation of state have been inconclusive to decide whether nuclear matter will crystallize at densities $\geq 5 \times 10^{14} \text{ g cm}^{-3}$ (for a review: Canuto, 1975). This is partly due to the limited knowledge of the forces present at supranuclear densities but mostly because of the lack of the adequate many-body theory of strongly interacting particles.

Independently of the fact whether solid cores exist or not, it is interesting to theoretically study the properties of elastic solids in strong gravitational fields. Contrary to the classical tests of General Relativity that mostly involve weak fields (where corrections are small),

* Operated by Associated Universities, Inc., under contract with the National Science Foundation.

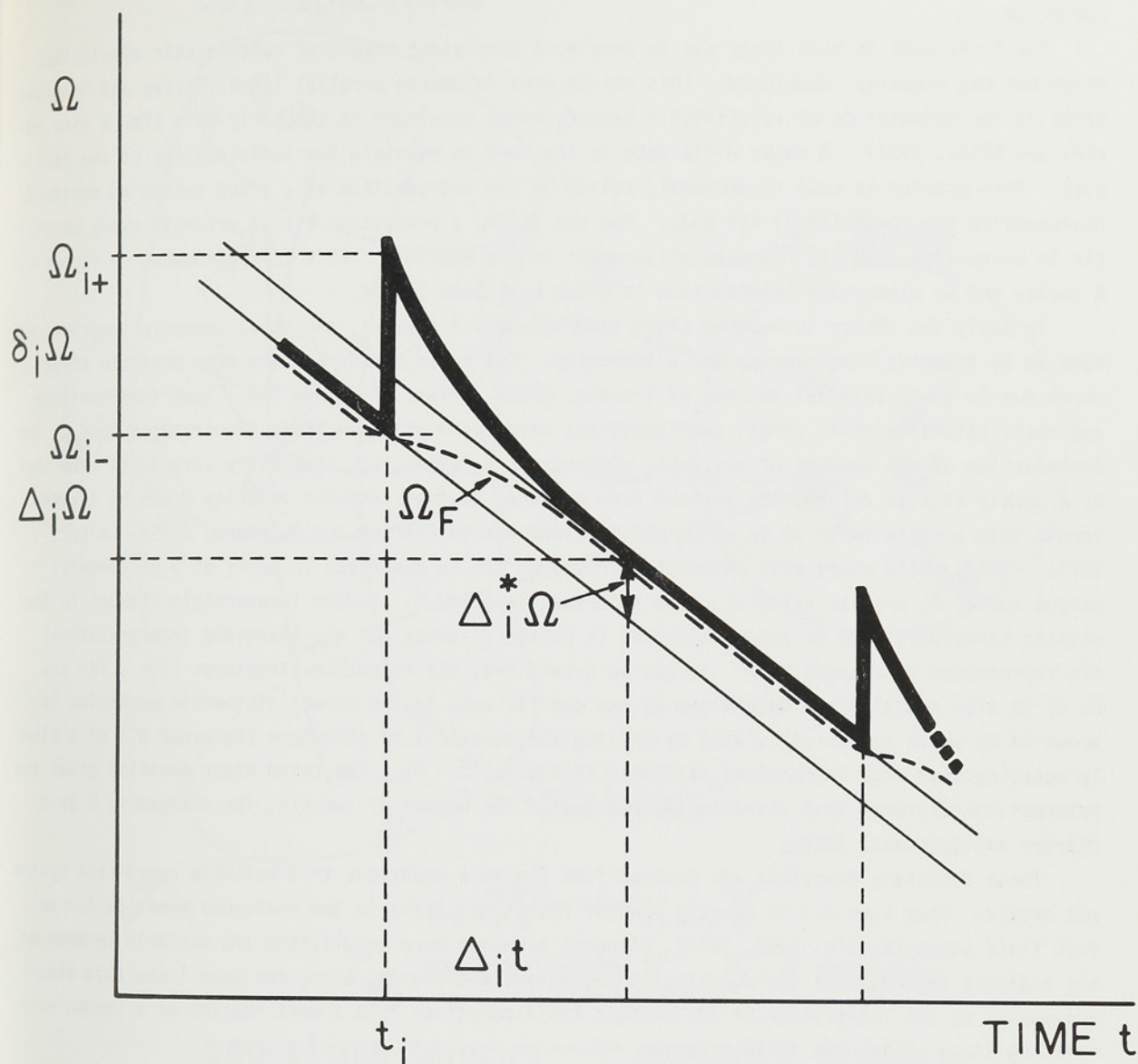


Fig. 1. Schematic representation of the time behaviour of the observed angular velocity —heavy line— of a pulsar during a glitch. The pulsar is originally slowing down at a constant rate under the combined action of electromagnetic, gravitational radiation induced and other smaller torques. At time t_i the angular velocity is observed to suffer a sudden jump $\delta\Omega_i = \Omega_{i+} - \Omega_{i-}$. This is followed by a relaxation period $\Delta_i t$ during which the *slope* of $\Omega(t)$ tends to recover its original value. In the two-component theory of neutron stars (Ruderman, 1969), this relaxation process is interpreted as the effect of a weak coupling between the solid, corotating part of the star (which suffered the sudden jump in Ω : crust + charged components + solid core, if any) and the superfluid component (the neutron fluid below the crust). This superfluid accelerates slowly (with an Ω represented by Ω_F) until the whole star is rotating as a solid body. The final effect of the glitch —of total duration $\Delta_i t$ — is a change $\Delta_i^* \Omega$ in the angular velocity as compared with the value the pulsar would have had no speed-up and relaxation occurred. In different models, the values of $\delta_i \Omega$, $\Delta_i^* \Omega$ and $\Delta_i t$ can be related to details of the pulsar inner structure.

matter in neutron stars provides unique opportunities to test Einstein theory in extremely curved spacetime.

The first step in such study was to develop a consistent theory of relativistic elasticity, which was not properly developed. This can be done following parallel lines (Carter and Quintana, 1972) to the formulation of relativistic hydrodynamics developed in the early 60's (for a nice review see Ellis, 1971). A major difference is the need to maintain the individuality of the particles. This problem is most conveniently solved by the introduction of a fixed separated manifold representing the particles of the body. One can define a projection P that projects every particle in space-time into its representative point in the manifold. This is represented in Figure 2. A review and an elementary introduction is given by Ehlers (1973).

To apply the theory to neutron stars in a solvable framework, the usual symmetry restrictions have to be assumed; stationarity and axisymmetry. But solid stars can have many possible structures due to their internal degrees of freedom, which perfect fluids do not. Some idealizations, and restrictions on their stress configurations have to be placed. These requirements lead to the introduction of the concept of relaxable structures: axisymmetric, stationary structures such that by a purely elastic deformation derived from a change in their angular velocity Ω can be transformed into a state (with $\bar{\Omega}$) in which all stresses vanish (Carter and Quintana, 1975a; Carter, 1975). Cold, solid stars with relaxable structures can be described in terms of 3 parameters: baryon number B , angular velocity Ω and reference velocity $\bar{\Omega}$. Sudden irreversible changes in the elastic structure, such as those occurring in pulsar glitches (on the starquake interpretation) are represented by changes in $\bar{\Omega}$. It can be proved that all relaxable structures (i.e., for any $\bar{\Omega}$, Ω) in slow rotation are determined by two coefficients in the moment of inertia expansion in terms of Ω , which can be calculated by solving the equations of structure (to order Ω^3) of a slowly rotating star with a spherical relaxable structure ($\bar{\Omega} = 0$). The third order equation gives the relevant coefficients that characterize changes in the moment of inertia, for changes in $\bar{\Omega}$ or Ω (Carter and Quintana, 1975b).

These structure equations are derived from Einstein equations in a suitable coordinate system and metric. They turn out to be very similar (Quintana, 1976) to the analogous equation for perfect fluid stars (Hartle, 1968, 1973), although somewhat more complicated and unstable because of the rigidity dependence. The numerical integrations can proceed along the same lines (and simultaneously) as the integration of the perfect fluid equations from a perturbation of a common non-rotating star. This work is in progress.

It is possible that free precession had been observed in neutron stars. The Crab wobble (a three-month modulation) was originally suggested as due to free precession, later to be shown to be the effect of frequency noise. Various periodicities in compact x-ray sources have been suggested as produced by free precession. Although these suggestions wait to be confirmed, possible observation of free precession is exciting because such phenomena reflects the internal stellar structure (Pines and Shaham, 1974) and is highly dependent on the detailed structure of the solid components of the star. The relativistic solid structure equations (Quintana, 1976) permit the accurate calculation of the important moment of inertia coefficients and the strain and stress fields throughout the star.

Another astrophysically interesting application of relativistic elasticity theory is to the description of the interaction (and oscillations) of a solid body with incoming gravitational waves. To describe a test body the weak limit of Einstein equations are sufficient (Dyson, 1969), but for a body in a strong gravitational field (its own or external) the full relativistic theory is needed. This work is described in a recent paper by Carter and Quintana (1977). More general-

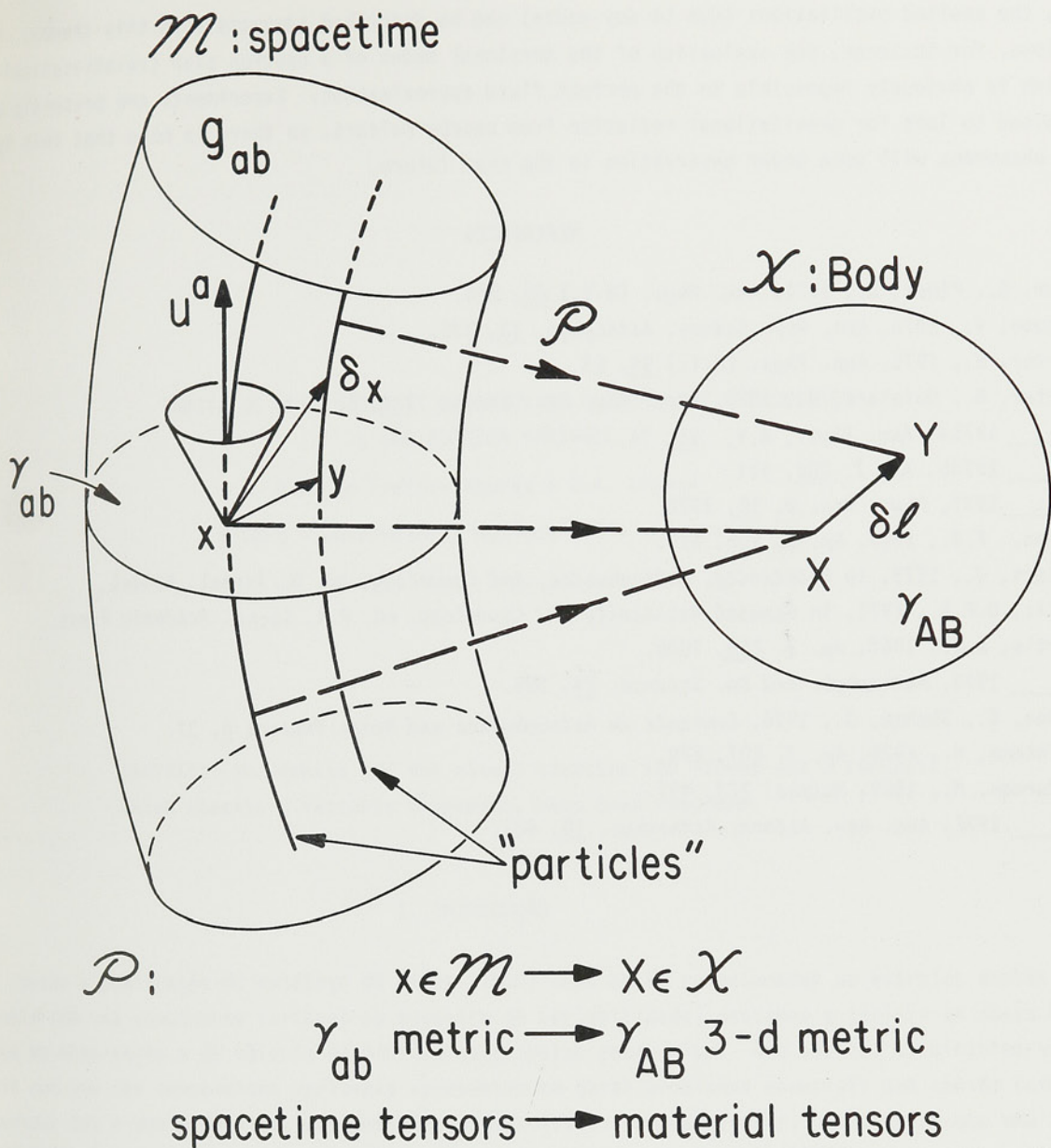


Fig. 2. M represents that section of spacetime —with metric g_{ab} — that contains the solid medium. A particle at x moves with 4-velocity u^a . The tensor

$$\gamma_{ab} = g_{ab} + u_a u_b$$

is the metric on the 3-d subspace (locally) orthogonal to u^a . δx^a is a connecting vector between the particle through x and a nearby particle at y . Its projection on the subspace defined by γ_{ab} : $\delta x_{\perp} = \gamma_{ab} \delta x^b$ is the orthogonal distance separating the two particles. Each particle of the medium (i.e. each worldline) is represented by a point on a separate manifold X (the body). The projection P maps M on X . Differentiability conditions allows the projection to be extended to the orthogonal tangent space at $x \in M$ and the one at its corresponding point $X \in X$ (P has an inverse P^{-1}), so that a one-to-one correspondence can be established between 3-d tensors at X and 4-d orthogonal tensors at $x \in M$. At different proper times τ along the worldline of x , the projected tensors on X will be functions of τ . In particular, the projected metric γ_{ab} induces a 3-d metric γ_{AB} in X : $\gamma_{AB} = P(\gamma_{ab})$, which then represents the distances between particles of the body: γ_{AB} is essentially the state of strain of the body.

ly, the excited oscillations (due to any cause) can be described adequately in this theory. This allows, for instance, the evaluation of the torsional modes of a neutron star (relativistically), which is obviously impossible in the perfect fluid approximation. Experiments are presently being planned to look for gravitational radiation from nearby pulsars, so there is hope that this type of phenomena will come under observation in the near future.

REFERENCES

- Baym, G., Pines, D., 1971, *Ann. Phys. (N.Y.)* 66, 816.
 Canuto, V., 1975, *Ann. Rev. Astron. Astrophys.* 13, 335.
 Carter, B., 1975, *Ann. Phys. (N.Y.)* 95, 53.
 Carter, B., Quintana, H., 1972, *Proc. Roy. Soc. London.* 331, 57.
 _____ 1975a, *Ann. Phys., N.Y.* 95, 74.
 _____ 1975b, *Ap. J.* 202, 511.
 _____ 1977, *Phys. Rev. D.* 16, 2928.
 Dyson, F.J., 1969, *Ap. J.* 156, 529.
 Ehlers, J., 1973, in *Relativity, Astrophysics, and Cosmology*, ed. W. Israel. Reidel.
 Ellis, G.F.R., 1971, in *General Relativity and Cosmology*, ed. R.K. Sachs. Academic Press.
 Hartle, J.B., 1968, *Ap. J.* 150, 1005.
 _____ 1973, *Astrophys. and Sp. Science.* 24, 385.
 Pines, D., Shaham, J., 1974, *Comments in Astrophysics and Space Physics* 6, 37.
 Quintana, H., 1976, *Ap. J.* 207, 279.
 Ruderman, M., 1969, *Nature.* 223, 497.
 _____ 1972, *Ann. Rev. Astron. Astrophys.* 10, 427.

ÓRBITA DE DOIS SISTEMAS BINARIOS EM QUE UMA DAS COMPONENTES É UMA ESTRELA VARIÁVEL

R.R. de Freitas Mourão e O.L. Chaves

CNPq - Observatório Nacional, Rio de Janeiro

ABSTRACT: The orbits for the visual binaries LDS 720-BC and α Fornacis, which contain a variable component, have been computed.

I. INTRODUÇÃO

Desde a publicação do catálogo de Baize (1962) onde estão relacionados as estrelas duplas visuais com uma componente variável ou suspeita de variabilidade, passamos a incluir em nosso programa de observação e de cálculo de órbitas as estrelas deste tipo. Com efeito, as binárias visuais com uma das componentes variáveis apresentam em geral problemas especiais que convém serem estudados sob o ponto de vista astrométrico e astrofísico, em particular, os casos em que uma das componentes é uma estrela flare tendo em vista os trabalhos de Kunkel (1975).

Neste trabalho relatamos os resultados obtidos com dois sistemas; num deles a estrela companheira é suspeita de ser variável, caso da α Fornacis e no outro, a companheira é um flare no sistema LDS 720-BC.

II. α FORNACIS

2.1 - O sistema binário α For = h 3555 = ADS 2402 = DM - 29° 1177 ($\alpha = 3^h 07^m.8$ e $\delta = -29^\circ 23'$; 1900) possui uma componente com suspeita de variabilidade, sendo tal aspecto levantado por Dawson, Van den Bos e Finsen. Em 1925.849 e 1925.941 (separação de 1") Van den Bos com um refrator de 26 polegadas observou-a como uma simples estrela durante 5 noites, embora mais tarde, 1925.953 a 1927.046, declarou que era fácil a observação da segunda componente. Por outro lado, Voûte (1932) com o refrator de 24 polegadas escreveu que após várias tentativas em 1929 não pode ver a companheira embora a sua separação fosse de 1", logo depois ela se transformou num objeto de fácil observação. Com efeito, a diferença de magnitude, Δm , entre as componentes parece variar de 2.8

a 4.7 com períodos de invisibilidade inexplicáveis por uma diminuição de distância.

TABELA I

DATA	Δm	ρ	OBSERVADOR
1925.99	3.2	0".8	Van den Bos
1926.92	3.9	0.8	Van den Bos
1926.98	3.0	0.9	Finsen
1928.97	4.2	0.9	Van den Bos
1929.05	3.1	0.9	Finsen
1930.98	4.7	1.0	Van den Bos
1931.79	3.2	1.1	Van den Bos
1931.97	3.4	1.1	Finsen
1933.96	3.1	1.2	Van den Bos
1934.51	3.0	1.2	Finsen
1935.02	4.7	1.3	Finsen
1935.87	3.0	1.3	Finsen
1936.83	3.4	1.3	Simonov
1940.27	3.5	1.3	Van den Bos
1944.98	3.7	1.0	Van den Bos
1946.98	3.9	0.8	Van den Bos
1949.02	3.1	0.5	Van den Bos
1956.04	3.2	0.5	Van den Bos
1956.04	3.2	0.8	Van den Bos
1958.04	3.0	1.2	Van den Bos
1959.04	2.9	1.3	Van den Bos
1959.81	2.6	1.5	Mourão
1959.87	2.8	1.5	Van den Bos
1960.90	3.0	1.7	Van den Bos
1968.74	2.8	2.7	Mourão
1974.76	3.0	2.3	Mourão
1975.14	2.5	2.4	Holden
1976.86	2.2	3.6	Holden

2.2 - Elementos orbitais.

Utilizando-se 59 observações micrométricas efetuadas no período de 1835 a 1975, foi possível, através do método de Thiele-Innes modificado por Arend e Freitas-Mourão (1968), obter os seguintes elementos orbitais:

P = 194.911 anos	e = 0.637
n = 1°847	i = 78°111 (1900)
T = 1946.852	Ω = 118°600 (1900)
a = 2".858	ω = 41°414 (1900)

Os resíduos apresentam uma irregularidade sistemática, em particular em ângulo de posição que faz supor a existência de um companheiro invisível. Woolley (1948) supôs que o período do companheiro invisível fosse de 20 anos.

2.3 - Paralaxe dinâmica e características físicas.

Partindo da magnitude aparente global (3.95), de diferença de magnitude ($\Delta m = 2.62$) e do tipo espectral determinado (F8 IV), obtemos uma paralaxe dinâmica de 0".060, muito afastada da trigonométrica fornecida no catálogo de Jenkins (1952). Entretanto, supondo que a estrela pertença ao ramo das gigantes, obtemos, usando as fórmulas de Russell e Moore (1940), os seguintes valores:

TABELA II

Paralaxe dinâmica	0".072	
Componentes	A	B
Magnitude visual absoluta	3.27	5.89
Massa (unidade solar)	1.70	0.82
Raio (unidade solar)	1.41	0.93
Densidade (unidade solar)	0.47	0.50
Temperatura efetiva	6940°K	4482°K
Tipo espectral	F5	G3

O valor da paralaxe dinâmica é equivalente ao valor fornecido no General Catalogue de Jenkins (1952) que é de $0".072 \pm 0.005$, que é a média dos valores $0".084 \pm 0.009$ do Mc Cormick Observatory; $0".072 \pm 0.009$ do Yale Observatory e $0".057 \pm 0.010$ do Cape Observatory.

III. LDS 720-BC

3.1 - A componente da estrela binária LDS 720-BC = DM -32° 16135 ($\alpha = 20^h 35^m 6$, $\delta = -32^\circ 47'$; 1900) é uma estrela flare. Dois flares já foram observados por Luyten e Joy (1957). Foi relacionada entre as variáveis que formam sistema duplo por Kunkel (1975).

3.2 - Elementos orbitais.

Partindo de 16 observações fotográficas e micrométricas efetuadas entre 1913 a 1969 foi possível determinar uma órbita I por Freitas-Mourão (1976).

Órbita I:	P = 239.57 anos	e = 0.827
	n = 1°503	i = 107°21 (1900)
	T = 1920.69	$\Omega = 73^\circ 70$ (1900)
	a = 6".952	$\omega = 95^\circ 06$ (1900)

O sistema 720-BC, entretanto, aceita outras soluções dentre elas a seguinte:

Órbita II:	P = 604.827 anos	e = 0.508
	n = 0°5952	i = 131°361 (1900)
	T = 1894.921	$\Omega = 129^\circ 670$ (1900)
	a = 5".611	$\omega = 71^\circ 964$ (1900)

Esta órbita II foi obtida pelo mesmo processo da anterior, sem a inversão de quadrante para a observação de 1913.74, e mais uma última observação efetuada em 1976.

3.3 - Paralaxe dinâmica e características físicas.

Empregando os valores da magnitude aparente global 10.1, a diferença de magnitude 0.2 e o tipo espectral dM4,5e, determinamos para a órbita I e II os seguintes elementos:

TABELA III

ORBITA	I		II	
Paralaxe dinâmica	0".197		0".071	
Magnitude visual absoluta	11.59	12.56	9.39	10.36
Massa (unidade solar)	0.39	0.30	0.71	0.55
Raio (unidade solar)	0.53	0.44	0.82	0.68
Densidade (unidade solar)	2.58	3.46	0.76	0.17
Temperatura efetiva	2855°	2430°	4123°	3507°
Tipo espectral	M4	M8	K3	K9

Se bem que a órbita II forneça uma paralaxe dinâmica mais próxima da trigonométrica 0".1131 ± 0.008 que se encontra no catálogo de Jenkins (1952), os elementos físicos da órbita I parecem mais próximos das determinações astrofísicas.

IV. CONCLUSÕES

Em consequência do estudo destes dois sistemas binários visuais do qual uma componente é uma estrela variável, aconselhamos que os observadores dediquem maiores atenções a este tipo de binária, em especial, ao estudo das características físicas das companheiras e não só da principal. A diferença entre as paralaxes dinâmicas e as trigonométricas evidenciam, em geral, que estas estrelas não satisfazem as relações massa-luminosidade, estando as vezes situadas fora da sequência principal.

REFERENCIAS

- Arend, S., Freitas-Mourão, R.R., 1968, *Commun. Obs. Roy. Belgique, Serie A*, N°5.
 Baize, P., 1962, *J.O.* 45, 6-7, p. 149.
 Freitas-Mourão, R.R., 1976, *Astrophys. Lett.* 18, 37.
 Jenkins, L.F., 1952, *General Catalogue of Trigonometric Stellar Parallaxes*. Yale Univ. Obs.
 Joy, A.N., 1957, in *Non-Stable Stars*, ed. G.H. Herbig. Cambridge Univ. Press, p. 31.
 Kunkel, W.E., 1975, in *Variables Stars and Stellar Evolution*, ed. V.E. Sherwood and L. Plaut. Symposium N°67 UAI, p. 15.
 Luyten, W.S., 1941, *Publ. Astr. Obs. Univ. Minnesota*, 3, 33.
 Russell, H.N., Moore, C.E., 1940, *The Masses of the Stars*, The Univ. of Chicago Press, p. 112 e 117.
 Van den Bos, W., 1928, *Ann. Leyde*, 14, 19.
 Voûte, J., 1932, *Ann. Bosscha*, 5, 1.
 Woolley, R., 1948, *Mem. Commonwealth Observatory*, 2, 4, p. 39.

SOBRE LA INVESTIGACION DE VARIABLES CATACLISMICAS
EN EL HEMISFERIO SUR

N. Vogt

Observatorio Europeo Austral

RESUMEN: Se exponen, brevemente, nuevos resultados de observaciones fotoeléctricas de dos variables australes de tipo U Gem: VW Hyi muestra dos distintas clases de erupciones, cortas y largas. Durante las largas se observaron "superhumps" periódicos. Al final de una erupción larga el período de los "superhumps" combina con el período orbital formando un período de batido, el cual está presente, por lo menos, durante una semana después de la declinación de la erupción. La variable cataclísmica y eclipsante EX Hya muestra en su etapa de mínima una curva de luz con estructuras alternantes de ciclo a ciclo. Esta relación de ciclos se invierte cada noche. Se enfatiza la importancia de observaciones visuales y fotográficas continuas de las variables cataclísmicas, especialmente durante sus erupciones.

ABSTRACT: New results of photoelectric observations of two southern dwarf novae are shortly presented. VW Hyi shows two distinct types of eruptions, short and long ones. During the latter, periodic "superhumps" were observed. At the end of a long eruption the superhump period combines with the orbital period to a beat period which is present for at least one week after decline from the eruption. The eclipsing dwarf nova EX Hya shows in the minimum stage a light curve shape which alternates from cycle to cycle; this cycle relation, however, is reversed from night to night. The importance of a regular visual and photographic monitoring of cataclysmic variables, especially during their outbursts, is emphasized.

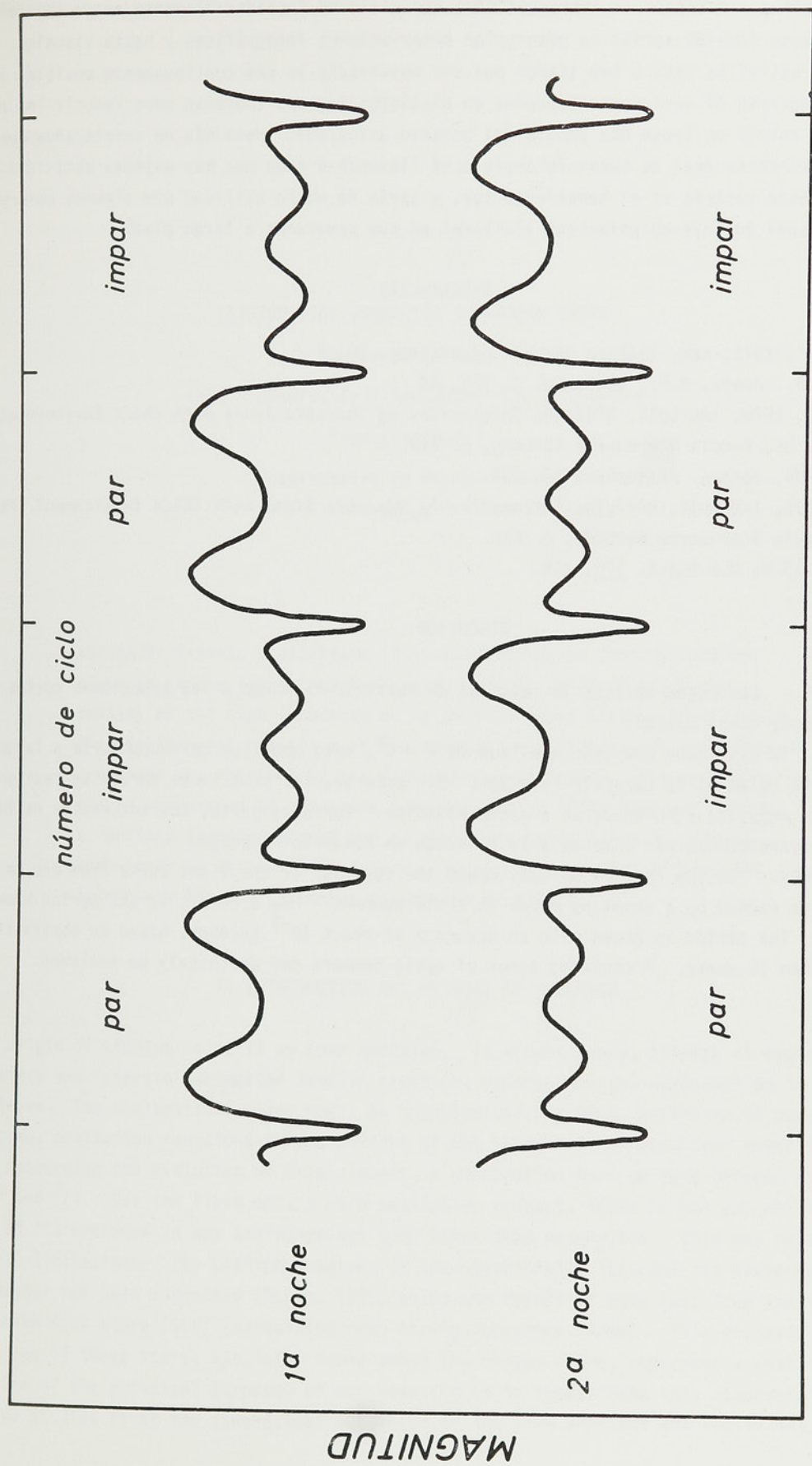
El objetivo principal de esta breve contribución es llamar la atención hacia un tipo de estrellas variables cataclísmicas de las cuales pueden obtenerse valiosas observaciones aun con telescopios e instrumentos de modesto tamaño. Me refiero a las estrellas del tipo U Gem, llamadas "dwarf novae" en la nomenclatura inglesa. Típicamente muestran erupciones de 2 a 5 magnitudes por sobre su luz mínima que duran unos pocos días y se repiten en intervalos irregulares entre 10 días y varios meses. El siguiente modelo binario explica las características principales de estas variables (Crawford y Kraft, 1956) : Una estrella roja extendida que desborda su lóbulo de Roche despidiendo material gaseoso hacia la segunda componente, una enana blanca. El material llega a una velocidad bastante elevada, acelerado por la gravedad de la enana blanca y, normalmente, no cae inmediatamente a la superficie de ésta, sino que forma un disco de acreción de gas caliente que rodea a la enana blanca. Este disco y especialmente su "punto caliente" - es decir, el lugar en que el torrente de gas cae sobre el disco - son las fuentes de luz más prominentes de todo el sistema.

Un ejemplo típico de esta clase de variables y una de las estrellas tipo U Gem más brillantes del hemisferio sur es VW Hyi. En su etapa de inactividad, el punto caliente contribuye en gran parte a la luz total, ocasionando un "hump" cada vez que pasa la línea visual en el transcurso del movimiento orbital del sistema binario, con un período de 108 minutos (Vogt, 1974). Durante una erupción este "hump" desaparece, lo que indica que el lugar de la erupción es el disco en su totalidad y no el punto caliente.

En el caso de VW Hyi se puede distinguir claramente dos tipos de máximos (Bateson, 1977): erupciones cortas que se repiten cada 28 días en promedio y de una duración de alrededor de 4 días, y erupciones largas, llamadas supermáximos, que se repiten cada medio año y duran más de dos semanas. Durante estos supermáximos se ha detectado otro tipo de humps periódicos llamados "super-humps", que no se repiten con el período orbital de 108 minutos, sino con un período 3 por ciento más prolongado, de 111 minutos (Vogt, 1974; Warner, 1975). Este período sobrevive aún a la declinación desde el supermáximo y se combina con el período orbital resultando un período de batido de alrededor de 2.8 días. Las desviaciones O-C de los "humps" normales varía con la fase de este período de batido durante más de una semana después de la declinación de los supermáximos. Hemos elaborado algunas ideas para un modelo que incluye zonas calientes en la superficie de la componente roja del que se deduce una rotación diferencial (Schoembs, 1977 ; Vogt, 1977).

Recientemente hemos obtenido observaciones de otra estrella austral tipo U Gem, EX Hya. Se trata de un sistema binario eclipsante con un período de 99 minutos. Nuestras extensas observaciones fotoeléctricas muestran (Fig. 1) la existencia de una estructura alternante en la curva de luz: ciclos con dos cumbres alrededor de las fases 0.25 y 0.75 se alternan con aquellos que presentan un déficit de luz en esas fases. La explicación más sencilla sería adoptar un período doble y unir los dos tipos de curvas de luz en un ciclo completo. Esto, sin embargo, es imposible ya que observaciones en noches consecutivas muestran que la situación se invierte de una noche a la siguiente: si en una noche las cumbres aparecen en un número par de ciclos, a la noche siguiente éstas aparecerán en un número impar de ciclos, y los ciclos en números pares muestran déficit de luz. Nunca nos ha sido posible observar la transición de la aparición de cumbres de ciclos pares e impares; sólo una cooperación entre observatorios ubicados en diferentes longitudes podría cubrir la estrella durante 24 horas para resolver este problema.

Todas las observaciones fotoeléctricas que he mencionado aquí fueron obtenidas con telescopios de tamaño modesto - entre 50 y 100 cm de apertura - en el Observatorio Europeo Austral, La Silla. Aún así, telescopios más pequeños serían muy útiles para poder seguir el comportamiento eruptivo impredecible de las estrellas tipo U Gem y establecer un mejor conocimiento de la fre-



CICLOS ORBITALES

Fig. 1. Curva de luz esquemática de EX Hya durante dos noches consecutivas.

cuencia, amplitud y duración de las erupciones que difieren considerablemente entre cada estrella. En este contexto también serían de gran valor observaciones fotográficas y hasta visuales. Sin embargo, las estrellas tipo U Gem tienen que ser observadas lo más continuamente posible, lo cual sólo puede lograrse si varios observadores en distintos lugares cooperan para reducir los riesgos climáticos y cubrir un lapso más amplio del horario universal. Hace más de veinte años que la Sociedad Astronómica Real de Nueva Zelanda está llevando a cabo una muy exitosa actividad relacionada con esta materia en el hemisferio sur, y sería de mucha utilidad que algunos observatorios latinoamericanos incluyeran esfuerzos similares en sus programas a largo plazo.

REFERENCIAS

- Bateson, F.M., 1977, *New Zealand Journal of Science*, 20, 7.
Crawford, J.A., Kraft, R.P., 1956, *Ap. J.* 123, 44.
Schoembs, R., 1978, IAU Coll. N°42, *The Interaction of Variable Stars with their Environment*, Veröff. Dr. Remeis Sternwarte Bamberg, p. 218.
Vogt, N., 1974, *Astron. Astrophys.* 36, 369.
——— 1978, IAU Coll. N°42, *The Interaction of Variable Stars with their Environment*, Veröff. Dr. Remeis Sternwarte Bamberg, p. 227.
Warner, B., 1975, *M.N.R.A.S.* 170, 219.

DISCUSION

STEINER.- ¿Se puede aplicar la relación de Kukarkin-Parenago a las erupciones cortas o a los supermáximos de novae enanas?

VOGT.- VW Hyi tiene una gran amplitud de $4 - 5^m$; esta amplitud correspondería a largos ciclos según la relación de Kukarkin-Parenago. Sin embargo, las erupciones cortas se repiten a intervalos muy seguidos y no obedecen a dicha relación. Por otra parte, los intervalos de los supermáximos corresponden más o menos a la relación de Kukarkin-Parenago.

WAMSTEKER.- In the case of EX Hya, could the turnover of the light curve from odd to even cycles not be caused by a counting error in cycle numbers? How accurate is the period known?

VOGT.- The period is known with an accuracy of about 10^{-5} seconds, based on observations over more than 15 years. A counting error of cycle numbers can definitely be excluded.

LITHIUM LINE FORMATION IN CARBON STARS

Ramiro de la Reza

CNPq - Observatório Nacional, Rio de Janeiro

François Querci

Observatoire de Paris, Meudon

France

ABSTRACT: Kinetic Equilibrium (KE) calculations of neutral Lithium lines in carbon stars have been performed, in order to study the reality of the high abundance of Li in the "Super Lithium Rich" stars. The simultaneous solutions of the transfer and statistical equilibrium equations are obtained by the flux divergence method. The photospheric models correspond to effective temperatures of 3800, 3600 and 3500°K, a surface gravity of $g=10$ and an abundance ratio $C/O=1.3$. Micro-turbulence is set equal to 5 km/s. Appreciable non-LTE effects are found only for the resonance transition at 6708 Å.

I. INTRODUCTION AND METHODS OF RESEARCH

The origin of Lithium is still an open question. In recent years, attempts to explain its presence in stars and interstellar matter involve creation, destruction and distribution in very different places. The explanations cover media as cosmological Big-Bang, explosion of super-massive stars, novae, spallation reactions on the surface of the stars and thermonuclear reactions in red giants. Concerning the evolution of this element, a distinction must be made between the two isotopes ${}^6\text{Li}$ and ${}^7\text{Li}$. For the first one, a pure spallation product, there is not yet any definite evidence of its presence in any astrophysical body other than meteorites. This may be due to observational limitations. The Lithium observed is then essentially ${}^7\text{Li}$, and its presence in interstellar matter has been suggested (Scalo, 1976) to be the result of mass loss from the so-called Super Lithium Rich stars (SLR) (containing very strong resonance lines). This mechanism can be an effective one if these stars, specially found among the carbon stars, represent a real Li abundance effect. One of the principal purposes of our research is to investigate this abundance effect. For this we studied first the theoretical behaviour of the line profiles and equivalent widths of

different Li lines, calculated for a grid of photospheric models of carbon stars.

The kinetic approach we use consists in solving simultaneously the statistical equilibrium and radiative transfer equations by the integral flux divergence method (Athay and Skumanich, 1967). Deviations of the continuum source function from the Planck function have been taken into account. Complete redistribution is assumed. Calculations in the context of a pure LTE theory have been also realized. Our model of the Lithium atom is composed of four bound levels and a continuum. Three neutral lines have been taken into account, namely, the resonance transition at 6708 Å and the transitions at 8126 and 6103 Å. We refer to de la Reza and Querci (1978) for more detailed considerations concerning the radiative and collisional cross sections and damping factors used. The atmospheric models used in this work represent the photosphere of the carbon stars (Querci and Querci, 1975). The molecular line blanketing effect has been taken into account through the opacity probability distribution functions. There is some observational evidence (Gilra, 1976) that shows the probable existence of chromospheres on those stars. We have simulated them by means of different radiation temperatures between 3000 and 5000°K, which produce the photoionization of the Li atoms in the photosphere. The main model parameters used for the KE calculations are $T_{\text{eff}} = 3800, 3600$ and 3500°K , $g=10$ and $C/O=1.3$. For the LTE calculations we have also considered lower temperature models: $T_{\text{eff}} = 3000$ and 2600°K , $g=10$ and $C/O=3.2$.

II. RESULTS

- (1) Lithium is almost completely ionized in the carbon stars models with effective temperatures between 3800 and 3600°K. Ionization is dominated by photoionization processes.
- (2) Almost for all the Li abundances considered (between 10^{-11} to 10^{-8} in number of atoms respect to H) the line source function S is almost constant and greater than the Planck function B in the regions where the line is optically thin. In the region of the $\lambda 6708$ line formation we found, for all cases, $S \leq B$.
- (3) The profiles are very sensitive to the Li abundance and, to a lesser degree, to the chromospheric radiation temperatures. They are not sensitive to deviations of the continuum source function from B . Solid grains, which may act as a filter to the chromospheric radiation, are not important in the formation of the Li lines if they are of the graphite type.
- (4) The equivalent widths and profiles, quite independently from the abundance, can be used to discriminate a hotter chromosphere from a colder one. Because of abundance effects and ionizing radiation, similar equivalent widths are sometimes obtained for the $\lambda 6708$ line in two different physical situations. The ambiguity can be resolved by the $\lambda 6103$ line, because it is not sensitive to the chromospheric radiation field.
- (5) Appreciable non-LTE effects are found only for the resonance line 6708 Å. Ionization in KE is greater than in LTE.
- (6) In LTE, in order to produce extremely strong Li resonance lines (as observed in the SLR stars), we have to invoke lower temperature models, i.e. $T_{\text{eff}} \sim 2600^\circ\text{K}$. But in this case, the lines are formed in the extreme outer layers of the photosphere, where the atmospheric structure is quite uncertain - specially if chromospheres generally exist in these stars - and where microturbulence may become supersonic.

REFERENCES

- Athay, R.G., Skumanich, A., 1967, *Ann. d'Astrophys.* 30, 669.
de la Reza, R., Querci, F., 1978, *Astron. Astrophys.* in press.
Gilra, D.P., 1976, *Mem. Soc. Roy. Sci. Liège*, 6^e série, 9, 77.
Querci, F., Querci, M., 1975, *Astron. Astrophys.* 39, 113.
Scalo, J.M., 1976, *Ap. J.* 206, 795.

DISCUSSION

NIEMELA.- ¿Cuántas líneas de Li se observan en las estrellas "super-ricas en Li"?

DE LA REZA.- Aparte de la línea de resonancia en los 6708 Å se puede observar la línea en 6103 Å.

MENDOZA.- Las estrellas T Tauri son ricas en Li; a través de "vientos estelares" pueden enriquecer el medio interestelar ¿Cómo se compara esto con el enriquecimiento a través de las estrellas de carbono?

DE LA REZA.- Si las estrellas T Tauri son efectivamente ricas en Li pueden contribuir al enriquecimiento de la materia interestelar. Lo que yo no sé es si realmente son ricas. En la etapa T Tauri el ⁷Li se formaría solamente por un mecanismo de superficie. Ahora se ha mostrado tanto teóricamente como observacionalmente (por medio de flares solares), que este mecanismo no es tan efectivo.

PERFILES DE LINEAS DE CaII, CII, SiII OBSERVADAS CON GRAN RESOLUCION EN ESTRELLAS
A Y EL PROBLEMA DE LA EXISTENCIA DE CROMOSFERAS EN DICHAS ESTRELLAS

Rubens Freire

CNPq - Observatório Nacional, Rio de Janeiro

ABSTRACT: There is a gap along the main sequence where the evidence of chromospheric existence is poor, based on classical chromospheric indicators (i.e. emissions in CaII lines, etc.). This work supports partially the idea that early A type stars are rebellious to exhibit chromospheres.

Nevertheless, we show also that a good set of high resolution profiles of CaII, CII and SiII lines for different A type stars (α Lyr, α CMa, γ Gem, α Aql) observed with the Meudon Solar Tower and Satellite Copernicus, combined with a NLTE analysis of lines, provide us several reasons that could be responsible for cashing chromospheric influence on lines profiles (macroscopic velocity fields, rotation, optical depth of center line formation, etc.).

Thus, the observations are compatible with a chromospheric rise that starts at $\log \tau_{c,5000} \leq -3.5$ or -4 , depending on the atmospheric model choosen. The models constructed are on the basis of Frandsen's (1974) NLTE atmospheric model of A0 stars and modified to admit different temperature rises at low optical depth.

I. INTRODUCCION

La existencia de cromosferas estelares se demuestra sea a partir de observaciones de excesos de emisión en regiones del continuo (Ly C, Ba C) o en líneas (con relación al flujo calculado con la teoría clásica de fotosferas), sea por la existencia de líneas provenientes de estados de excitación/ionización con energías muy superiores a la energía térmica media fotosférica, sea por la existencia de flujos de masa no térmicos.

Observacionalmente se constata que los indicadores cromosféricos mencionados existen en un gran rango de tipos espectrales: F0 y tardíos (Wilson, 1956, 1962; Wilson and Bappu, 1957), B5 y más tempranas (Hack, 1969).

Además existen argumentos teóricos basados en la estructura general de las atmósferas estelares y en el rol que jugaría el flujo de masa, que conducen a pensar que las regiones cromosfera y corona tienen un grado de generalidad muy amplio (Pecker *et al.*, 1973; Thomas, 1973; Cram, 1975; Cannon and Thomas, 1977).

Sin embargo, en las estrellas A, dichos indicadores no se manifiestan de una manera precisa. En este trabajo se analizan varias causas que pueden contribuir a ello. Nuestro propósito fue el de buscar emisiones, aunque fueran débiles, en la zona central de líneas intensas: de ahí la necesidad de observar con gran resolución. Nos limitamos a líneas que cumplieran dos criterios: su función fuente es del tipo dominado por colisiones (Thomas, 1957) y además la profundidad óptica media de formación de la línea corresponde a regiones externas de la atmósfera estelar: líneas H y K del CaII, 3968.5 Å y 3933.68 Å; líneas de resonancia de CII a 1334.53 Å, 1335.66 Å y 1335.71 Å; líneas del SiII a 1304.37 Å y 1309.27 Å.

II. LAS OBSERVACIONES

Las observaciones utilizadas fueron obtenidas con el telescopio de la Torre Solar del Observatorio de París, en Meudon (Freire, 1977; Freire *et al.*, 1977, 1978) y a través del Programa para observadores invitados (F. Praderie) en el Satélite Copernicus (Freire, 1977, 1978).

Las observaciones obtenidas en Meudon corresponden a las líneas H y K del CaII de α Lyr (AO V, $V = 0.04$), α CMa (A1 V, $V = -1.47$), γ Gem (AO IV, $V = 1.93$) y α Aql (A7 IV-V, $V = 0.77$). La resolución espectral fue de 35 a 68 mÅ. Salvo γ Gem, que fue observada (tiempo de observación = 2 horas) con una cámara electrónica tipo Lallemand desarrollada por el Grupo Meudon (Baudrand *et al.*, 1972; Felenbok, 1976), el resto de los espectros fue obtenido fotográficamente (tiempo de observación = de 1^h a 1^h30^m).

Las observaciones Copernicus corresponden a α Lyr, y las líneas observadas fueron del CII y SiII; la resolución espectral fue de 50 mÅ (fotomultiplicador U2).

En α CMa y γ Gem, la línea K presenta un perfil asimétrico y además un escalón en la parte violeta de la línea, situado a $\Delta\lambda = 0.12$ Å y $\Delta\lambda = 0.25$ Å respectivamente; en α Aql el perfil de la línea K está muy deformado por efecto de la rotación, siendo simétrica la región central (Freire *et al.*, 1977). En α Lyr las líneas H y K no muestran emisiones, ni asimetrías en sus regiones centrales (Freire *et al.*, 1978). Lo mismo sucede con las líneas UV del CII y SiII (Freire, 1978).

III. PERFILES TEORICOS DE LAS LINEAS

El análisis de los perfiles de las líneas observadas se realizó aplicando la teoría de formación de líneas en NLTE, suponiendo redistribución completa. Utilizamos el programa desarrollado por Dumont (1967) que resuelve simultáneamente las ecuaciones de equilibrio estadístico y de transferencia, introduciendo algunas modificaciones (existencia de dos continuos de ionización, blend de las líneas del CII, opacidades metálicas en el UV).

El cálculo teórico de líneas implica:

- 1) Definir modelos simplificados de los átomos donde tienen lugar las transiciones que dan origen a aquellas líneas: así, consideramos modelos de CaII (3 niveles + 1 continuo), de CII (3 niveles + 2 continuos), de SiII (5 niveles + 2 continuos). Hacemos la hipótesis de que la función fuente es la misma para las líneas del mismo multiplete.
- 2) Conocer un modelo de atmósfera de las estrellas consideradas. Los modelos de partida (Tabla I) se calculan en ETL y en ER (equilibrio radiativo) y se prolongan hasta profundidades ópticas

TABLA I

Modelo	Referencia	T_{ef}	$\log g$	Estrella
LTE, RE, line blanketed	Fowler (1974)	9700°K	4.26	Sirius
LTE, RE	Carbon and Gingerich (1969)	9500 K	4.0	γ Gem
LTE, RE, line blanketed	Carbor and Gingerich (1969)	8000 K	4.0	Altair
LTE, RE	Schild, Peterson and Oke (1971)	9650 K	4.05	Vega
NLTE, RE, sólo H	Frandsen (1974)	10000 K	4.0	de referencia

pequeñas ($\log \tau_{c,3934} \approx -9.$) con un plateau de temperatura. Con estos modelos se reproducen bastante bien los continuos en el UV a partir de 1350 Å. Como comparación se usó un modelo de atmósfera en NLTE y ER para una estrella A0, compuesta sólo de hidrógeno (Frandsen, 1974), que presenta un aumento de temperatura electrónica T_e de 1300 °K para $\log \tau_{c,3934} \approx -4.$ La abundancia de He se ha supuesto de 10% H.

Ahora bien, dichos modelos carecen de cromosfera. Para reproducirla en parte, Freire *et al.* (1977) modificaron el modelo teórico de Frandsen, agregándole aumentos arbitrarios de T_e , hacia el exterior (hasta 10 000, 15 000 y 20 000 °K); la densidad ρ se calculó aplicando el equilibrio hidrostático. Los modelos obtenidos no están en ER. Procediendo de una manera semi-empírica, determinaron en qué $\tau_{c,5000}$ debía comenzar ese aumento de T_e para poder reproducir los perfiles de líneas observadas, así como también el flujo continuo.

3) Fijar un valor del parámetro de microturbulencia ξ . Freire *et al.* (1977, 1978) tomaron $\xi = 3$ km/s para α CMa, γ Gem, α Aql y $\xi = 1$ km/s para α Lyr (el valor corrientemente admitido para α Lyr es de 3 km/s, Hunger, 1960).

4) Conocer el parámetro de rotación $v \sin i$ de la estrella: 10 km/s para α CMa y γ Gem, 18 km/s para α Lyr y 200 km/s para α Aql.

IV. RESULTADOS Y CONCLUSIONES OBTENIDAS

Las observaciones con gran resolución, combinadas con una interpretación NLTE de los perfiles de líneas, nos han permitido obtener los resultados siguientes:

1) Las abundancias NLTE, Ca/H, C/H, Si/H en las estrellas A estudiadas no muestran grandes diferencias con las solares (Goldberg, Muller and Aller, 1960; Withbroe, 1971) y con otras determinaciones en estrellas A (Snijders, 1976, 1977; Kamp, 1976).

2) Las abundancias LTE calculadas a partir de los perfiles pueden conducir a graves errores de interpretación: en nuestro caso, Ca/H LTE puede estar entre 1/5 a 1/10 del valor NLTE correspondiente (Freire, 1977, 1978; Freire *et al.*, 1977, 1978).

3) En α CMa y γ Gem, la asimetría de las líneas K es fácilmente atribuible a la existencia de campos de velocidad macroscópicos en las capas externas de la atmósfera estelar (Magnan y Pecker, 1974; Simonneau, 1973).

4) Se pueden obtener escalones en la zona central de un perfil de absorción con un modelo de atmósfera estelar sin aumento de temperatura y en ETL (ej.: γ Gem, Freire *et al.*, 1977).

5) Aun una velocidad de rotación moderada (10 a 20 km/s) puede alisar lo suficiente el perfil de la línea de tal manera que si hubiera emisiones cromosféricas débiles, éstas no serían observadas, o bien, sólo lo serían como posibles escalones en el perfil.

- 6) Las observaciones de perfiles en las estrellas A estudiadas, son compatibles con la existencia de cromósferas en ellas, cuyo aumento de temperatura aparezca en $\log \tau_{c,5000} \approx -3.5$ a -4 .
- 7) Las líneas H y K de CaII no son buenos indicadores cromosféricos en las estrellas A tempranas.

REFERENCIAS

- Baudrand, J., Combes, M., Felenbok, P., Fort, B., Picat, J.P., 1972, in *Adv. EEP.* 33, A 7.
- Cannon, C.J., Thomas, R.N., 1977, *Ap. J.* 211, 910.
- Carbon, D.F., Gingerich, O., 1969, in *Theory and Observation of Normal Stellar Atmospheres*, ed. O. Gingerich, The MIT Press, p. 337.
- Cram, L.E., 1975, in *First European Solar Meeting, Obs. e Mem. Oss. Arcetri, Firenze*, N°105, p. 5.
- Dumont, S., 1967, *Ann. d'Astrophys.* 30, 421.
- Felenbok, P., 1976, IAU Coll. N°40, eds. M. Duchesne, G. Lefèvre, Part I, Chapter 3.
- Fowler, J.W., 1974, *Ap. J.* 188, 295.
- Frandsen, S., 1974, *Astron. Astrophys.* 37, 139.
- Freire, R., 1977, Thèse d'Etat, Université de Paris VII.
- _____, 1979, *Astron. Astrophys.* in press.
- Freire, R., Czarny, J., Felenbok, P., Praderie, F., 1977, *Astron. Astrophys.* 61, 785.
- _____, 1978, *Astron. Astrophys.* 68, 89.
- Goldberg, L., Muller, E.A., Aller, L.H., 1960, *Ap. J. Suppl.* 5, 1.
- Hack, M., ed. 1969, *Mass Loss from Stars*, Proc. 2nd. Trieste Coll. *Astrophys.*, Sept. 1968, Reidel Publ. Co., Dordrecht, Holland.
- Hunger, K., 1960, *Zeits. für Astrophys.* 49, 129.
- Kamp, L.W., 1976, NASA TR R-455, Washington.
- Magnan, C., Pecker J-C., 1974, in *Highlights in Astronomy*, ed. G. Contopoulos, p. 171.
- Pecker, J-C., Praderie, F., Thomas, R.N., 1973, *Astron. Astrophys.* 29, 289.
- Praderie, F., 1975, *Diagnostic of Stellar Chromospheres*, Lectures at Erice Internac. School.
- Schild, R., Peterson, D.M., Oke, J.B., 1971, *Ap. J.* 166, 95.
- Simonneau, E., 1973, *Astron. Astrophys.* 29, 357.
- Slettebak, A., ed. 1969, *Stellar Rotation*, Proc. IAU Coll. N°4. Ohio St. Univ.
- Snijders, M.A.J., 1976, private communication.
- _____, 1977, *Ap. J.* 214, L35.
- Thomas, R.N., 1957, *Ap. J.* 125, 260.
- _____, 1973, *Astron. Astrophys.* 29, 297.
- Wilson, O.C., 1956, *Ap. J.* 126, 46.
- _____, 1962, *Ap. J.* 136, 793.
- Wilson, O.C., Bappu, M.K.V., 1957, *Ap. J.* 125, 661.
- Withbroe, G., 1971, *The Menzel Symposium*, Ed. K.B. Gebbie, NBS Spec. Publ. 353.

SPECTROSCOPIC OBSERVATIONS OF 27 CMa
FROM 0.14 TO 4.7 MICRONS⁺

A.C. Danks*

European Southern Observatory

and

L. Houziaux

Département d'Astrophysique

Université de Mons

Belgique

ABSTRACT: Observations of 27 CMa are presented extending from 0.14 to 4.7 microns. The UV spectrum (0.14 μ to 0.33 μ) was obtained by satellites ANS and TD1. Stellar Atmosphere model fits to these observations give an electron temperature $T_e = 20\,000^\circ\text{K}$ and a gravity $g = 6.300\text{ cm}^{-2}$. The visible spectrum exhibits complex line profiles in the Balmer series and the spectral type is determined to be B3 IV. From IR photometry the star is seen to have an IR excess. This is interpreted as a shell with $T_e = 14\,400^\circ\text{K}$, $N_e = 5.9 \times 10^{11}\text{ cm}^{-3}$ and a radius of $1.12 \times 10^{12}\text{ cm}$.

I. INTRODUCTION

The star 27 CMa was shown to exhibit a Be type spectrum (Struve, 1946). Struve and Kao (1948) discussed its large radial velocity variations. Since then it has attracted much attention and has been studied in some detail by Burbidge and Burbidge (1954), and Ringuelet-Kaswalder, Sahade *et al.*

⁺ Based on observations collected at the European Southern Observatory, La Silla, Chile.

* Visiting Astronomer, Cerro Tololo Inter-American Observatory, supported by the National Science Foundation under contract No. AST 74-04128.

(1960), Ringuelet-Kaswalder (1962, 1963a, 1963b). These later papers interpreted the radial velocity effects to filling in of lines by emission from a shell. The star has been shown to undergo photometric changes of the order of $0^m.02$ in UB ν by Feinstein (1968) and is also known to be a binary (Finsen, 1952). Its most recent spectral classification is B3 III pe (Hiltner *et al.*, 1969), and its distance is estimated at 200 pc (Rubin, 1962).

The star was one of many Be's observed by both satellites TD1 and ANS and was included in a general spectroscopic survey of bright southern Be stars made by us.

II. OBSERVATIONS

A large amount of observations have been carried out using different instruments. The spectroscopy and visual photometry were made at the European Southern Observatory, La Silla, Chile. The spectra were obtained using the Coudé spectrograph at the 1.5 m telescope and details of emulsions and dispersions are given in Table I. The photometry was made in January and February 1977

TABLE I

Plate N°	Emulsion	Date	Dispersion (Å/mm)
3533	IIa O	19/1/73	12.3
3534	103a F	19/1/73	12.3
3535	IIa D	19/1/73	12.3
934	IIa D	23/1/73	20
935	103a F	23/1/73	31.3

using the E.S.O. photometer mounted at the Cassegrain focus of the E.S.O. 50 cm telescope. The Strömgren filter system (uvby) was used and the data reduced using the reduction facilities at La Silla.

The Infra-Red (HKLM) photometry was made at Cerro Tololo in May 1975 and the CTIO Infra-Red photometer equipped with an InSb detector was used mounted at the Cassegrain focus of the 0.9 m (36 inch) reflector. The diaphragm size and sky chop used were 30 and 90 arc sec respectively. The filters' sensitivities have been described by Cohen (1975).

The Ultra-Violet data were collected by the S2/68 orbiting telescope aboard the E.S.A. satellite TD1 (Boksenberg *et al.*, 1973) and by the ANS satellite. The ANS system has been described in detail by Van Duinen *et al.* (1977).

III. SPECTRUM

Our spectroscopic observations cover the wavelength range $\lambda 3650$ to $\lambda 6800$. The spectrum consists mainly of hydrogen and neutral helium lines. The Balmer lines are visible from H α up to H 14. They exhibit complicated profiles. H α has a strong emission on the violet side cut by a weak absorption and a weaker one on the red side. H β and H γ have a strong central emission superimposed on a wide photospheric absorption. At H δ the emission is fainter but still well marked. Figure 1 shows an intensity tracing of the region H δ to H ϵ . A narrow absorption core already mentioned by

Ringuelet, Sahade and Struve (1960) appears on top of the emission. This feature is more and more conspicuous as the quantum number of the line increases, while the absorption profile of the line itself appears to be unsymmetrical, the red wing being steeper than the violet one, a fact already noted in the 1948 spectrum by Struve and Kao (1948). The spectrum of neutral helium is well developed. Observed lines are listed in Table II with their equivalent width, when measurable. Their

TABLE II

λ	Transition	W_{λ} (Å)
6678	$2p^1P^{\circ}-3d^1D$	1.57
5875	$2p^3P^{\circ}-3d^3D$	1.14
5047	$2p^1P^{\circ}-4s^1S$	0.12
5015	$2s^1S-3p^1P^{\circ}$	0.39
4921	$2p^1P^{\circ}-4d^1D$	0.23
4713	$2p^3P^{\circ}-4s^3S$	0.23
4471	$2p^3P^{\circ}-4d^3D$	1.62
4436	$2p^1P^{\circ}-5s^1S$	0.13
4387	$2p^1P^{\circ}-5d^1D$	0.68
4143	$2p^1P^{\circ}-6d^1D$	0.90
4121	$2p^3P^{\circ}-5s^3S$	0.21
4026	$2p^3P^{\circ}-5d^3D$	1.40
4009	$2p^1P^{\circ}-7d^1D$	0.67
3926	$2p^1P^{\circ}-8d^1D$	0.63
3871	$2p^1P^{\circ}-9d^1D$	0.15
3867	$2p^3P^{\circ}-6s^3S$	0.22
3819	$2p^3P^{\circ}-6d^3D$	0.96
3705	$2p^3P^{\circ}-7d^3D$	-

overall width $\Delta\lambda/\lambda = 0.0019$ leads to a projected rotational velocity of 180 km s^{-1} , a value somewhat inferior to the one quoted by Ringuelet (1963). The HeI lines show the same asymmetry as the H lines. The $2p^1P^{\circ} \rightarrow nd^1D$ series is visible up to $n = 9$, while we observe the $2p^3P^{\circ} \rightarrow ns^3S$ series up to $n = 6$. Two members of the $2p^1P^{\circ} \rightarrow ns^1S$ series are present, while the only line of the $2s^1S \rightarrow np^1P^{\circ}$ series at $\lambda 5015$ shows a marked P Cygni profile. A double line at 4269 Å with $W_{\lambda} = 0.51 \text{ Å}$ is attributed to CII.

The central emission peaks at H γ and H δ indicate a radial velocity of $+42 \text{ km s}^{-1}$. The radial velocities of the central absorption are somewhat lower. These velocities are compatible with the previous measurements by Ringuelet (1969).

IV. TEMPERATURE AND SPECTRAL TYPE OF THE STAR

It is difficult to use the hydrogen line strengths and profiles to determine the star's photospheric parameters since these lines are affected by emission and present an asymmetry due to the binary nature of the star or to a possible mass loss phenomenon.

The measured equivalent widths of the HeI spectrum are also to be used with caution when used

for comparison with theoretical values. The reason for this is:

a) the HeI line profiles are asymmetrical, showing some effect external to the photosphere of the primary component,

b) equivalent widths of strong lines (i.e. $\lambda 6678$, $\lambda 5875$) are outside of the range of expected strengths for normal photospheres.

However, using the results of NLTE computations by Auer and Mihalas (1973) for comparison with equivalent widths of weak lines, the model leading to the best agreement has the following parameters: $T_{\text{eff}} = 20\,000^\circ\text{K}$, $\log g = 3.8$.

Using blanketed model atmosphere by Kurucz, Peytremann and Avrett (1974), and the wings of H δ profiles computed by Delcroix (1976), we find also a temperature of $20\,000^\circ\text{K}$ and a gravity between 3000 and $10\,000\text{ cm s}^{-2}$.

Finally, we can compare the UV fluxes computed with Kurucz, Peytremann and Avrett models by Delcroix (1977) with the S2/68 orbiting telescope observations (Jamar *et al.*, 1976). The results, shown in Fig. 2, indicate that the agreement with a $T_e = 20\,000^\circ\text{K}$ and $\log g = 3.8$ interpolated model is also satisfactory, except in the region of the CIV line at $1550\text{ \AA}$. This line might be partly in emission, but the spectral resolution of $35\text{ \AA}$ is too low to draw any definite conclusion. In the $\lambda 1800 - \lambda 2300$ region, the observed spectrum shows deeper absorptions than the computed spectrum. It should be noticed that this wavelength range is crowded with FeIII multiplets and also includes an accumulation of lines of the third spectra of metals.

Finally, let us mention that the width of the hydrogen lines together with the low number of visible Balmer lines indicate that the star is not to be considered as a giant. We suggest a spectral type B3 IV.

V. VARIABILITY

The change in radial velocity has been noted for a long time. Spectral changes in the visible are also noticeable.

The S2/68 ultraviolet spectra mentioned in Fig. 2 have been obtained in April 1972. Beeckmans, in correspondance with one of us, mentioned that several spectra obtained from Oct. 1972 on show a marked weakening between $1800\text{ \AA}$ and $2200\text{ \AA}$. On Fig. 2, we have plotted absolute fluxes measured with the ANS photometer during April 1974. Although these are photometric measurements with a bandwidth of $200\text{ \AA}$, it is clear that the UV flux has weakened between April 1972 and April 1974.

The Strömgren photometry was carried out during January and February 1977. The star was observed once or twice during 12 nights in this period and the mean colours found were:

$$b-y = -0.054, m_1 = +0.058, c_1 = +0.142 \quad ,$$

with $V = 4.65$, compared to Crawford *et al.* (1970):

$$b-y = -0.073, m_1 = +0.078, c_1 = +0.19 \quad ,$$

with $V = 4.6$.

The differences are small, considering that our measurement error is $\sim 0.02\text{ m}$. Converting the uvby photometry to UBV using the graph given by Kilkeny and Hill (1975), we can compare these observations with available UBV data:

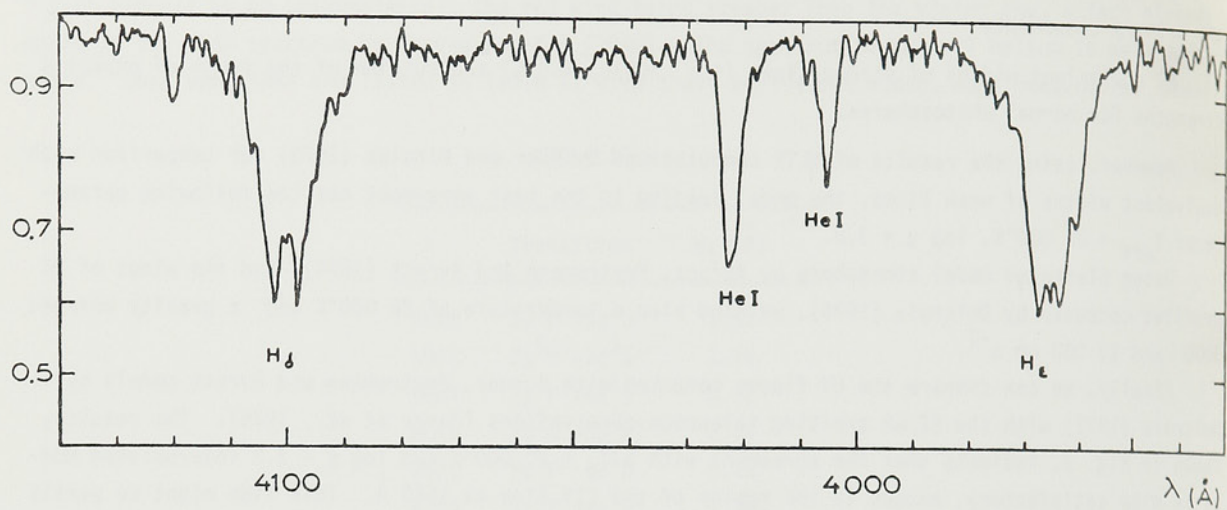


Fig. 1. Spectrum of 27 CMa on Jan. 19, 1973, in the H δ -H ϵ region. Notice the peculiar aspect of the Hydrogen line centers.

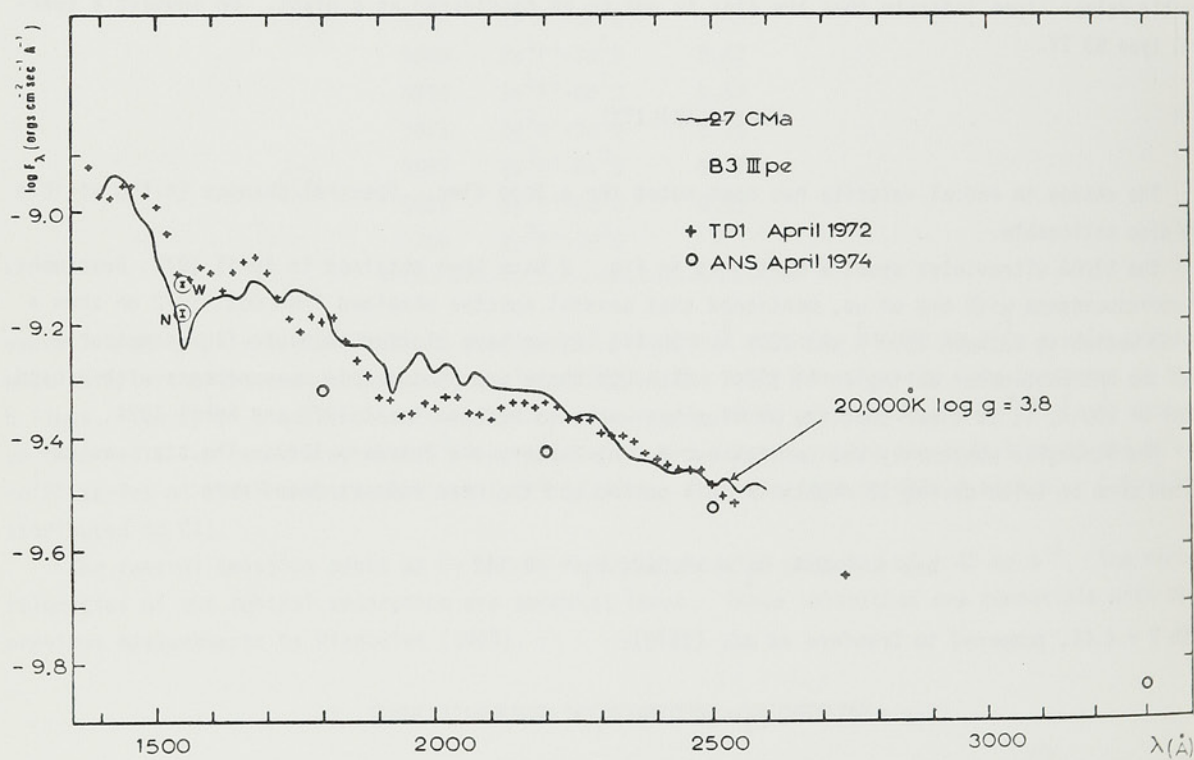


Fig. 2. Ultraviolet spectra of 27 CMa, as observed by the S2/68 spectrometer in April 1972 (crosses) and by the ANS satellite (circles). The circle marked N corresponds to a narrow filter (50 Å) and the circle marked W is related to a wider (200 Å) spectral band.

Source	B-V	U-B
Johnson <i>et al.</i> (1966)	-.20	-.89
Feinstein (1964)	-.15	-.82
Crawford <i>et al.</i> (1970)	-.14	-.78
Danks, Houziaux (1977)	-.11	-.80

These observations confirm the slow variation in colour already reported by Feinstein (1968).

VI. FLUXES FROM 0.13 TO 4.2 μ

The uvby magnitudes were converted to fluxes using the energy calibration given by Tapia *et al.* (1973).

Our measurements in the infrared lead to the following magnitudes:

H (1.57 μ)	: 4.75
K (2.27 μ)	: 4.47
L (3.8 μ)	: 4.09
M (4.2 μ)	: 4.29

For completeness, we have taken the R,I,J magnitudes from Johnson *et al.* (1966).

All the magnitudes were converted to fluxes and are plotted, together with the ANS ultraviolet data, on Fig. 3.

Let us note that for a $T = 20\,000^\circ\text{K}$, $\log g = 4.0$ model, Mihalas (1975) gives $u-y = 0.144$ while with the Kurucz, Peytremann and Avrett (1974) corresponding model one finds $+0.140$, compared to 0.096 measured by ourselves. This would suggest a filling in of the Balmer jump by bound-free emission from the shell. On the other hand, the location of the star in the H-K, K-L diagram places it in the region where Paschen lines would be exhibited (Briot, 1977). The Rayleigh-Jeans approximation ($\lambda F_\lambda \propto 1/\lambda^3$) has been used to extend the spectrum from the y wavelength into the infrared. From figure 3, it can immediately be seen that the star shows an infrared excess similar to that of other Be stars, as illustrated by Gehrz *et al.* (1974).

VII. CHARACTERISTICS OF THE SHELL

Following Cohen *et al.* (1975), we have drawn a difference spectrum indicating λ_p and λ_t , the wavelengths at which the difference spectrum peaks and turns over. The wavelengths are $\lambda_p \approx 1\mu$ and $\lambda_t \approx 5\mu$. The latter wavelength is however a lower limit.

Using the expression given by Cohen *et al.* (1975), $\lambda_p T_e = 1440$ (λ_p in μ , T_e in $^\circ\text{K}$) we derive $T_e = 14\,400^\circ\text{K}$. In the optically thin portion of the hydrogen emission spectrum we may write, according to Cohen *et al.* (1975):

$$N_e N_i R_s^3 = 1.43 \times 10^{30} F_{\text{diff}}(\lambda) \lambda^2 r^2 T_e^{-1/2} \exp(c_2/\lambda T_e) \text{ cm}^{-3},$$

where r is the distance to the star, that we take as 6.16×10^{20} cm (Rubin, 1962), and $F_{\text{diff}}(\lambda)$ is the intensity of the difference spectrum (in $\text{W cm}^{-2} \mu^{-1}$) at the wavelength λ (in μ). We take $\lambda = 1.3\mu$. Hence $N_e^2 R_s^3 = 4.849 \times 10^{59} \text{ cm}^{-3}$.

When the difference spectrum indicates that the hydrogen emission has become optically thick

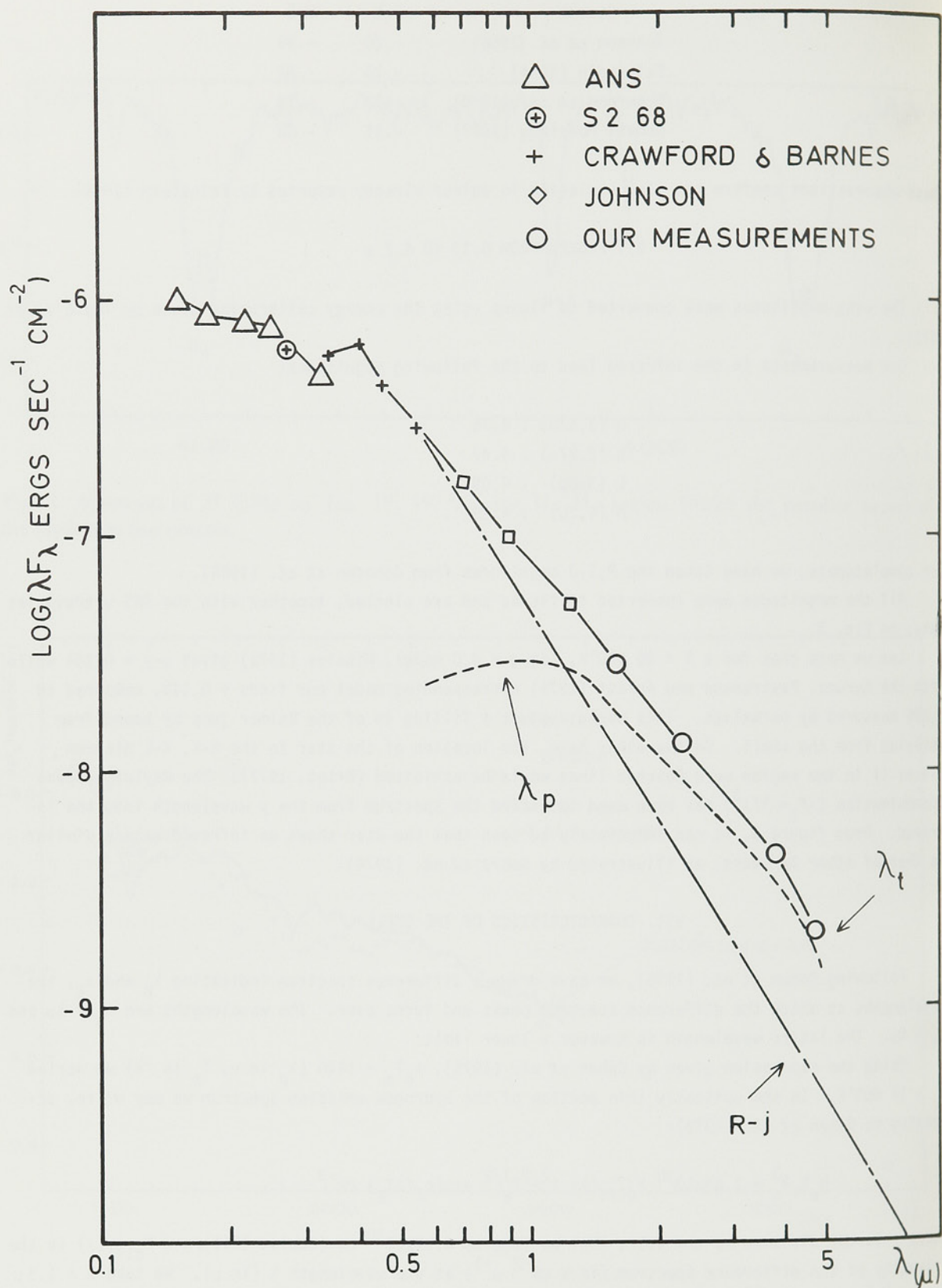


Fig. 3. Compilation of various measurements of 27 CMa in the 0.14 to 5 microns region. The Rayleigh-Jeans approximation is shown as a dash and dotted line. The dashed line is the difference spectrum. For the meaning of λ_p and λ_t , see text.

at the wavelength λ (in μ), then, following Cohen *et al.* (1975):

$$N_e N_i R_s = \frac{7.3 \times 10^{34} T_e^{1/2}}{\lambda_t^3 \left(1 - e^{-c_2 / \lambda_t T_e} \right)} \text{ cm}^{-5}.$$

Hence, in our case ($\lambda_t = 5\mu$):

$$N_e^2 R_s = 3.866 \times 10^{35} \text{ cm}^{-5}.$$

Thus $R_s = 1.12 \times 10^{12} \text{ cm}$ and $N_e = 5.875 \times 10^{11} \text{ cm}^{-3}$.

These parameters are not unlike those of ω Ori given by Gehrz *et al.* (1974).

VIII. CONCLUSION

From the above considerations we infer that the atmosphere of the central star of 27 CMa may be represented by a $T_e = 20\,000^\circ\text{K}$, $g = 6\,300 \text{ cm}^{-2}$ model. The star is certainly not a giant and is best described by spectral type B3 IV. Variations in the continuum are seen in the UV and visible variations are confirmed.

From the observed IR excess a shell is inferred with a radius of $1.2 \times 10^{12} \text{ cm}$ ($\approx 17R_\odot$) and an electron density $5.9 \times 10^{11} \text{ cm}^{-3}$. Furthermore from colour indices we expect the Paschen lines to be seen in emission and a search to confirm this will be made in the future.

ACKNOWLEDGEMENTS: It is a pleasure to thank the members of the ANS team, in particular Drs. R.J. van Duinen, P.R. Wesselius and D. Kessler for their invaluable help in understanding and reducing the ANS data.

We wish to thank F. Beeckmans for communicating to us her results on UV variability and Dr. A. Delcroix for results of his computations. One of us (ACD) is grateful to Dr. Olav Hansen for help in using the CTIO IR photometer. Finally we thank Mr. G. Houziaux and Mrs. Vicke Pippin for assistance with the data reduction. The work was partly supported by the University of Mons and FRFC, Bruxelles.

REFERENCES

- Auer, L.H., Mihalas, D., 1973, *Ap. J. Suppl.* **25**, 433.
 Boksenberg, A., Evans, R.G., Fowler, R.G., Gardner, I.S.K., Houziaux, L., Humphries, C.M., Jamar, C., Macau, D., Macau, J.P., Malaise, D., Monfils, A., Nandy, K., Thompson, G.I., Wilson, R., Wroe, H., 1973, *M.N.R.A.S.* **163**, 291.
 Briot, D., 1977, *Astron. Astrophys.* **54**, 599.
 Burbidge, M.E., Burbidge, G.R., 1954, *Ap. J.* **119**, 497.
 Cohen, M., 1975, *M.N.R.A.S.* **173**, 489.
 Cohen, M., Barlow, M.J., Kuhl, L.V., 1975, *Astron. Astrophys.* **40**, 291.
 Crawford, D.L., Barnes, J.V., Golson, J.C., 1970, *A. J.* **75**, 624.
 Delcroix, A., 1976, 1977, private communications.

- Feinstein, A., 1968, *Zeits. für Astrophys.* 68, 29.
- Finsen, W.S., 1952, *The Observatory*, 72, 125.
- Gehrz, R.D., Hackwell, J.A., Jones, T.W., 1974, *Ap. J.* 191, 675.
- Hiltner, W.A., Garrison, R.F., Schild, R.E., 1969, *Ap. J.* 157, 313.
- Jamar, C., Macau-Hercot, D., Thompson, G.I., Houziaux, L., Wilson, R., 1976, *Ultraviolet Bright-Star Spectrophotometric Catalogue*, ESA SR-27, Paris.
- Johnson, H.L., Mitchell, R.I., Iriarte, B., Wiśniewski, W.Z., 1966, *Comm. Lunar and Planetary Lab.*, 4, 58.
- Kilkenny, D., Hill, P.W., 1975, *M.N.R.A.S.* 173, 625.
- Kurucz, R.L., Peytremann, E., Avrett, E.H., 1974, *Blanketed Model Atmospheres for Early-Type Stars*, Washington D.C.
- Mihalas, D., 1975, *Dudley Observatory Reports*, N°9, 241.
- Ringuelet-Kaswalder, A.E., 1962, *Ap. J.* 135, 755.
- _____ 1963a, *P.A.S.P.* 75, 520.
- _____ 1963b, *P.A.S.P.* 75, 323.
- Ringuelet-Kaswalder, A.E., Sahade, J., Struve, O., 1960, *P.A.S.P.* 72, 317.
- Rubin, V.C., 1962, *A. J.* 67, 491.
- Struve, O., 1946, *Ap. J.* 104, 459.
- Struve, O., Kao, S.K., 1948, *Ap. J.* 108, 537.
- Tapia, S., Johnson, H.L., Crawford, D.L., 1973, *I.A.U. Symposium N°54*, 163.
- Van Duinen, R.J., Aalders, J.W.G., Wesselius, P.R., Wildeman, K.J., Wu, C.C., Luinge, W., Snel, D., 1975, *Astron. Astrophys.* 39, 159.

DISCUSSION

MENDEZ.- ¿Se pueden atribuir las diferencias entre las observaciones de TD1 y ANS a errores en las calibraciones?

DANKS.- The absolute calibration of both satellites is very good, but the accuracy between successive measurements with the same satellite is even more precise. For instance Françoise Beeckmans has observed variations of 27 CMA over a long period with the satellite TD1. There is then no doubt about the UV variations of 27 CMA. The variations are significantly larger than calibration errors.

FEINSTEIN.- Our observations J4K2 show that also there are some variations in the infrared.

DANKS.- I would be interested in more details of your observations.

THE Mn-Hg STAR HD 161698

Stella Malaroda⁺ and Hugo Levato^{*}

Observatorio Astronómico, Universidad Nacional de La Plata

ABSTRACT

HD 161698 is a Mn-Hg star which belongs to the open cluster IC 4665. We have found on coude plates among others PII, PIII, ScII, MnII, GaII, SrII, YII, ZrII, PtII and HgII to be definitely present and BeII possibly present. A curve of growth analysis gave overabundances of factor between 10 and 10 000 for Ga, Be, C, P, Cr, Mn, Y, Zr, and Hg. An underabundance of a factor 10 has been found for Si. The temperature of HD 161698 has been estimated to be 14 000°K.

The complete paper will be published elsewhere.

DISCUSION

DE LA REZA.- ¿Cuáles y cuántas son las líneas del berilio observadas?

MALARODA.- Se observa una línea de BeII y en base a ella se determinó la abundancia. Otros autores encontraron BeII en este tipo de estrellas y se observa una superabundancia del mismo. Quiero agregar que éste es un examen grueso de abundancias.

MENDOZA.- ¿Cuál es la abundancia de platino?

MALARODA.- No se pudo determinar la abundancia del platino, pues no se contaba con valores de log gf.

⁺ Member of the Carrera del Investigador Científico de la Comisión de Investigaciones Científicas de la Provincia de Buenos Aires.

^{*} Member of the Carrera del Investigador Científico del Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina.

DISTRIBUCION DE VELOCIDADES DE LOS ELECTRONES EN UN PLASMA QUE NO ESTA EN EQUILIBRIO TERMODINAMICO

Luis A. Milone

Observatorio Astronómico, Córdoba

ABSTRACT: In a medium which is in a steady state but not in thermodynamic equilibrium, the electrons' law of velocity distribution is derived. It is assumed that excitation temperature is equal to ionization temperature. It is found that the distribution function depends on the mean intensity of the radiation field, the excitation temperature, the recombination rate of the electrons ($\sim \mu^{-1}$), and the relaxation time of the free electrons ($\sim \lambda^{-1}$).

This paper will be published in full elsewhere. Additional details will be given there, as well as some physical examples.

Al estudiar la naturaleza del equilibrio en un medio que no está en equilibrio termodinámico - por ejemplo, en una atmósfera estelar - resulta de interés determinar la función de distribución de las velocidades de las partículas, por ejemplo los electrones.

Si el medio se encuentra en Equilibrio Monocromático Radiativo, con ayuda de la ecuación del equilibrio entre la energía absorbida y los electrones que recombinan, y con la única condición de que se cumpla que la temperatura de ionización es igual a la de excitación, es muy fácil probar que la función de distribución es:

$$n'(v) dv = 4\pi \frac{c^2 m^3}{2h(2\pi mkT)^{3/2}} \frac{J_\nu}{\nu^3} \left(e^{E_n/kT} - e^{-mv^2/2kT} \right) v^2 dv, \quad (1)$$

donde:

c = velocidad de la luz,

m = masa de las partículas,

h = cte. de Planck,

k = cte. de Boltzmann,

E_n = potencial de ionización del nivel n , con respecto al cual se considera el proceso de ioni-

zación y de recombinación,

$$h\nu = E_n + \frac{1}{2} m v^2,$$

T = temperatura de excitación,

J_ν = intensidad específica media del campo de radiación.

A continuación seguiremos otro camino para generalizar (1) y encontrar la función de distribución de velocidades correspondiente a la condición de "equilibrio mezclado".

En Equilibrio Termodinámico, el número de fotones de frecuencia ν emitidos y absorbidos, respectivamente, por segundo y por gramo de materia, es:

$$4\pi j_{\nu n} \frac{d\nu}{h\nu}, \quad , \quad 4\pi \kappa_{\nu n} B_\nu \frac{d\nu}{h\nu},$$

donde $j_{\nu n}$, $\kappa_{\nu n}$ y B_ν son, respectivamente, coeficientes de emisividad y de absorción de la materia, y función de Planck. Y el número de electrones que se desprenden o recombinan desde el nivel n , por gramo de materia, relacionado con esas emisiones y absorciones es $f(\nu)d\nu$, debiendo cumplirse:

$$4\pi j_{\nu n} \frac{d\nu}{h\nu} = 4\pi \kappa_{\nu n} B_\nu \frac{d\nu}{h\nu} = f(\nu) d\nu \quad . \quad (2)$$

Llamando $n(\nu)$ a la función de distribución de velocidades de los electrones libres, se cumple:

$$f(\nu) d\nu = \mu N_E n(\nu) d\nu \quad , \quad (3)$$

siendo N_E el número de electrones libres por cm^3 , y μ una constante inversamente proporcional al tiempo medio de recombinación de los electrones en el nivel n .

Equilibrio Mezclado

Cuando coexisten condiciones de ET y de EMR (equilibrio mezclado), se cumple para la recombinación de los electrones:

$$4\pi j_\nu \frac{d\nu}{h\nu} = 4\pi \kappa_\nu \left(\frac{\mu}{\lambda + \mu} J_\nu + \frac{\lambda}{\lambda + \mu} B_\nu \right) \frac{d\nu}{h\nu} = f'(\nu) d\nu \quad , \quad (4)$$

donde ahora es:

$$f'(\nu) d\nu = \mu N_E n'(\nu) d\nu \quad , \quad (5)$$

y λ es inversamente proporcional al tiempo medio entre colisiones de los electrones.

De (4), (2), (3) y (5), resulta:

$$n'(\nu) d\nu = \left(\frac{\mu}{\lambda + \mu} \frac{J_\nu}{B_\nu} + \frac{\lambda}{\lambda + \mu} \right) n(\nu) d\nu \quad (6)$$

Si $\lambda/\mu = 0$ estamos en condiciones de EMR; si $\lambda/\mu = \infty$ estamos en ET. En el primer caso, (6) se reduce a (1).

Este trabajo será publicado "in extenso" en otro lugar. Allí se darán detalles adicionales y se incluirán ejemplos.

ESTUDIO EN FOTOMETRIA UBV DE TY MENSAE

Emilio Lapasset

Observatorio Astronómico, Córdoba
CONICET, Argentina

La binaria tipo W UMa, TY Mensae, ha sido observada fotoeléctricamente desde 1972 hasta 1977 en la Estación Astrofísica de Bosque Alegre del Observatorio Astronómico de Córdoba con el telescopio reflector de 154 cm, obteniéndose un total de 1074 observaciones U, B y V. De ellas, se pudieron extraer 10 tiempos de mínimo en cada color, los que unidos a otros de Schöffell y Mauder (1967), Austin *et al.* (1975), Naqvi y Crønboch (1976), permitieron determinar las siguientes efemérides:

$$\begin{aligned} \text{Mín. } I_{D.J.\text{hel.}} &= 2442054.7973 + 0.46166701 E \\ &\pm .0006 \quad \pm .00000029 \end{aligned}$$

A partir de éstas, se dedujeron las fases de todas las observaciones y las curvas de luz UBV, cuyas magnitudes diferenciales son de la forma variable-menos-comparación (estrella HD 37134). La figura 1 muestra esas curvas de luz reducidas a puntos normales.

Utilizando el modelo clásico rectificable de Russell y Merrill (1952), se analizaron independientemente las tres curvas de luz, adoptando para la parte no eclipsada un desarrollo en serie de Fourier de esta forma:

$$I = A_0 + A_1 \cos \theta + A_2 \cos 2\theta + B_1 \sin \theta + B_2 \sin 2\theta .$$

Los coeficientes de este desarrollo aparecen en primer término en la Tabla I. Con ellos se rectificaron las curvas de luz, y finalmente se obtuvieron los elementos orbitales que se detallan en la misma Tabla.

Sin embargo, desde un comienzo se presentaban varios problemas, a saber:

- a) existe una visible diferencia entre los dos máximos de cada curva de luz, y
- b) el mínimo secundario está desplazado de la fase 0.5, y esto se acentúa al rectificar las curvas debido a los coeficientes relativamente grandes B_1 y B_2 de los términos de asimetría. Estas anomalías se pueden explicar por una zona más caliente ubicada en la superficie de la componente primaria del sistema, la cual se va haciendo visible alrededor de la fase 0.0 y va aumentando la

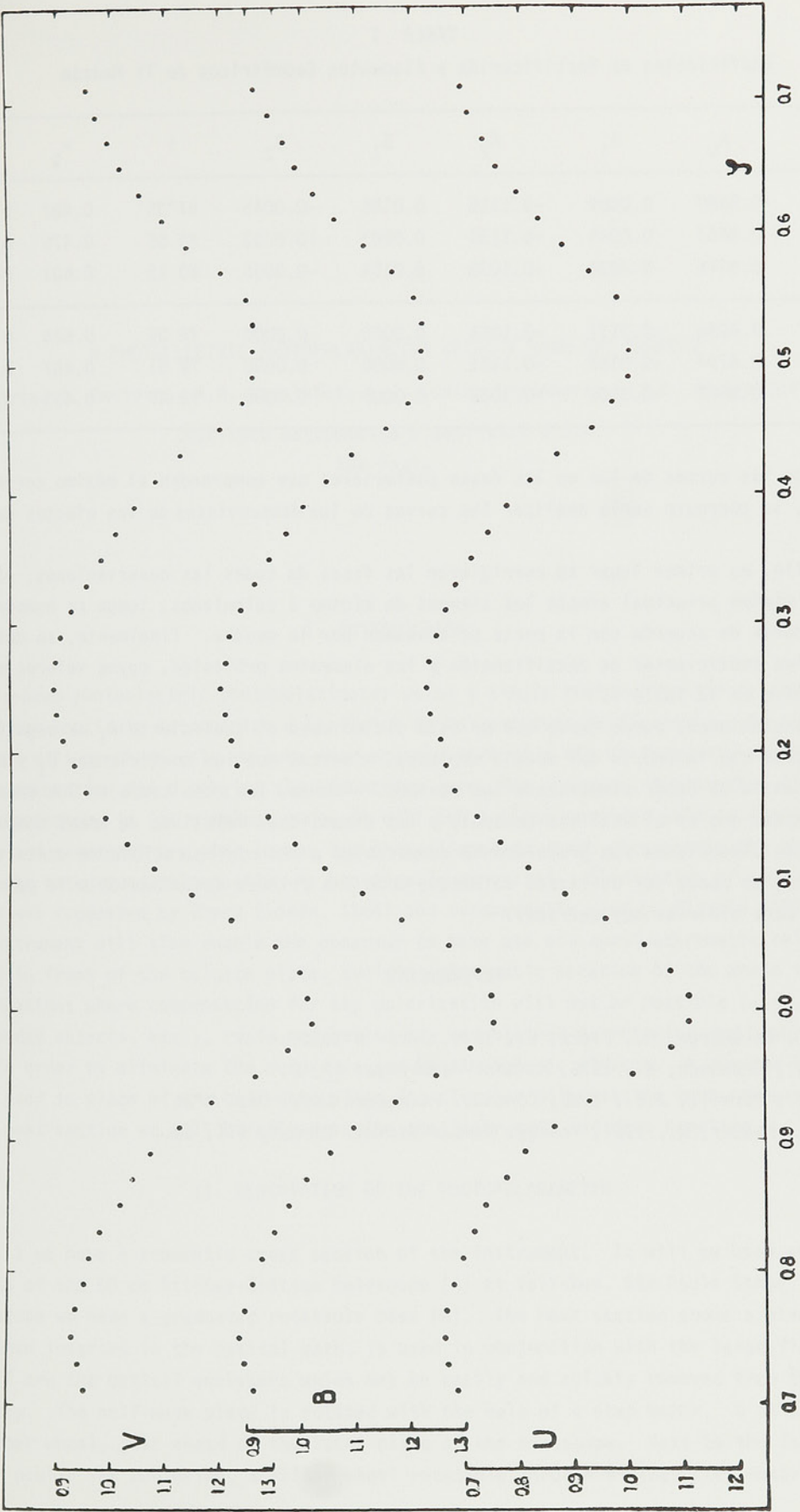


Fig. 1. Curvas de Luz de TY Mensae.

TABLA I
Coeficientes de Rectificación y Elementos Geométricos de TY Mensae

		A ₀	A ₁	A ₂	B ₁	B ₂	i	r _g	r _s
I)	V	0.8680	0.0009	-0.1118	0.0186	-0.0045	87°35'	0.462	0.156
	B	0.8687	0.0045	-0.1135	0.0203	-0.0033	83 56	0.475	0.167
	U	0.8744	0.0034	-0.1098	0.0154	-0.0065	80 15	0.501	0.178
II)	V	0.8895	-0.0171	-0.1054	0.0000	0.0000	78 09	0.524	0.177
	B	0.8797	-0.0162	-0.1121	0.0000	0.0000	79 51	0.487	0.165
	U	0.8881	-0.0101	-0.1088	0.0000	0.0000	78 47	0.499	0.182

intensidad de las curvas de luz en las fases posteriores que comprenden al máximo correspondiente; en ese caso, lo correcto sería analizar las curvas de luz desprovistas de los efectos de esa mancha caliente.

Para ello, en primer lugar se corrigieron las fases de todas las observaciones, ya que la distorsión del mínimo principal afecta los tiempos de mínimo I calculados; luego se homogeneizaron las intensidades de acuerdo con la parte no afectada por la mancha. Finalmente, se determinaron nuevamente los coeficientes de rectificación y los elementos orbitales, cuyos valores se dan en segundo término en la Tabla I.

Como conclusiones, puede verse que en este último caso el coeficiente A_1 es negativo, lo cual está de acuerdo con la teoría del modelo empleado, mientras que los coeficientes B_1 y B_2 son nulos como consecuencia de haber simetrizado los máximos. Además, los resultados en los tres colores son más consistentes que en el análisis general, y las dimensiones relativas de ambas componentes son mayores; estas dimensiones son groseramente comparables a las configuraciones de contacto, si bien el modelo clásico puede ser utilizado solamente como una primera aproximación a la geometría real del sistema para binarias muy cerradas.

REFERENCIAS

- Austin, R.D., De George, M., Fleck, R., 1975, *IBVS* N°1013.
 Naqvi, S.I.H., Grønbech, B., 1976, *Astron. Astrophys.* **47**, 2.
 Russell, H.N., Merrill, J.E., 1952, *Contrib. Princeton Univ. Obs.* N°26.
 Schöffel, E., Mauder, H., 1967, *Veröff. Remeis-Sternw. Bamberg* VII, 60.

A PHOTOELECTRIC PHOTOPOLARIMETER USING A STAR-SKY CHOPPER

R. Laporte, C. Gneiding, A.M. Magalhães, S.J. Codina Landaberry e J.A. de Freitas Pacheco

Instituto Astronômico e Geofísico U.S.P.

São Paulo

I. INTRODUCTION

A double-beam photoelectric photopolarimeter using a single photomultiplier is now being implemented at the Instituto Astronômico e Geofísico da Universidade de São Paulo. As a photometer, the instrument will synchronously measure star and sky through a 480 Hz frequency chopper. This will allow compensation for a varying sky brightness [see, for instance, Visvanathan (1972)].

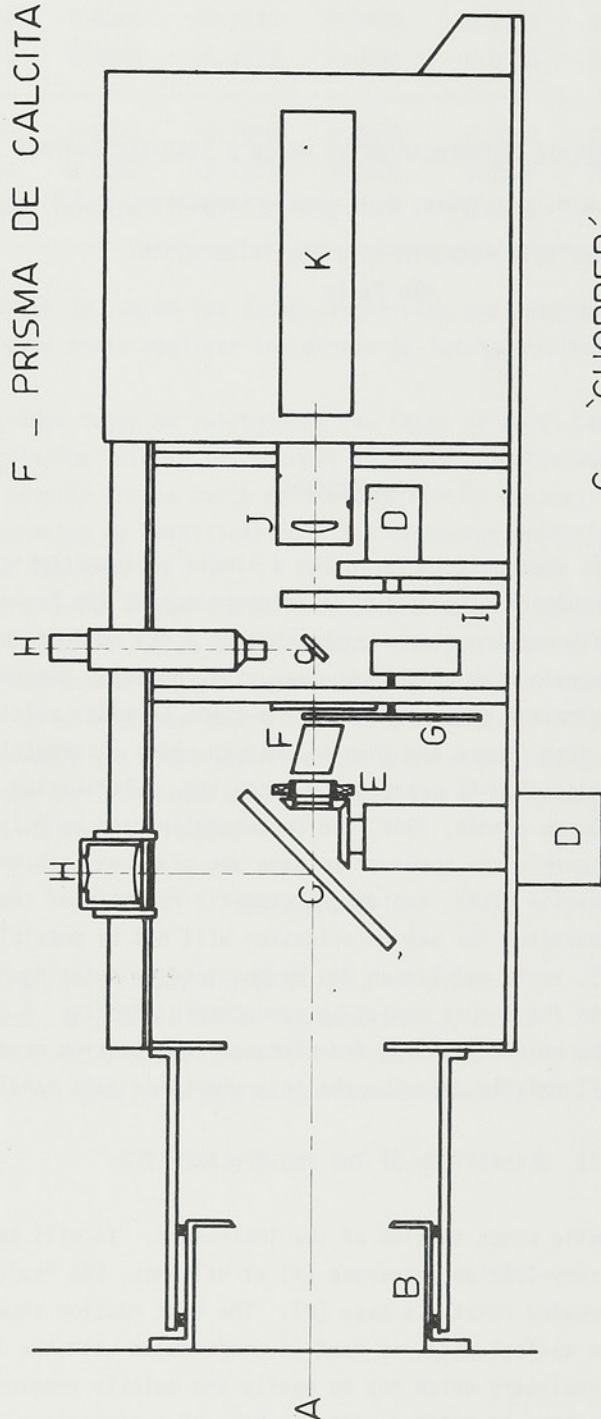
As a polarimeter, in its simplest mode, it will use a plane parallel calcite plate as analyser. The ordinary and extraordinary star images are then allowed to reach alternately the photomultiplier, and the sky background polarization is practically cancelled. Elimination of sky background polarization was suggested by Öhman (Lodén, 1964) and successfully used by Piirola (1975). However, our instrument will also enable the observer to make use of a quasi-achromatic half-wave plate, step rotated in front of the calcite plate, avoiding systematic rotation of the whole instrument. Also, in situations where compensation for sky polarization will not be possible (e.g. crowded star fields, extended objects, etc.), rapid modulation may be obtained by rotating continuously the half-wave plate in order to eliminate the errors caused by atmospheric effects. A quarter-wave plate may also be used in place of the half-wave plate for circular polarization measurements.

In the next section we will briefly describe the instrument and data handling.

II. DESCRIPTION OF THE PHOTOPOLARIMETER

In Fig. 1 we have a schematic cross section of the instrument. It will be used at the Cassegrain focus of the 60 cm Ritchey-Crétien telescope (A) at Valinhos, São Paulo State. Attached to the telescope we have a graduated rotatable base (B). The next section shows a plane mirror (C) which, when inserted in the optical path, is used in conjunction with the large-field ocular (H). E and F are the optical analysers which may be easily and quickly removed from the light beam for photometry. The half-wave plate is rotated with the help of a step motor. G is a continuously rotated chopper wheel, just ahead of the focal plane of the telescope. Next to the focal plane we have another ocular for centering, a filter wheel rotatable through another step motor and finally

- A - TELESCOPIO
 B - BASE GIRATORIA
 C - ESPELHO PLANO
 D - 'STEP' MOTOR
 E - LAMINA $\lambda/2$
 F - PRISMA DE CALCITA



- G - 'CHOPPER'
 H - OCULAR
 I - RODA DE FILTROS
 J - LENTE DE FABRY
 K - FOTOMULTIPLICADORA

Fig. 1.

the photomultiplier together with its Fabry lens.

III. DATA HANDLING

The PMT signal cable is fed into an SSR mod. 1120 amplifier-discriminator. The pulses may then have two destinies. In one mode of operation, the preamplifier output is fed into an SSR mod. 1105 photon counter and the integration is synchronized with the signal of a photodiode which tells which chopper wheel aperture is open at a given time. After each integration, the counts are printed on a teletypewriter.

It will be possible also to reduce the data at the end of each integration with the help of a NOVA minicomputer on line with the instrument. The computer will control the step motors for the retarder and the filters, will integrate the PMT output synchronously with the photodiode output and will use a 10 kHz external oscillator as a time basis for integration within each chopper cycle. The pertinent data will be printed on a Teletype mod. 33 on line with the computer.

ACKNOWLEDGEMENTS: A.M. Magalhães would like to acknowledge the support of the Fundação de Amparo à Pesquisa do Estado de São Paulo through grant N° 77/1498.

REFERENCES

- Lodén, L.O., 1964, *Stockholms Obs. Ann.* 22, N°7.
Piirola, V., 1975, *Ann. Acad. Sci. Fenn. Ser. A. VI*, N°418.
Visvanathan, N., 1972, *P.A.S.P.* 84, 248.

DISCUSSION

STRAUSS.- ¿Es sensible la fotomultiplicadora que usaron al infrarrojo cercano? La luz del sistema codificado de la posición del Chopper ¿no puede molestar al ser detectada por el fotomultiplicador?

MAGALHÃES.- A fotomultiplicadora presentemente utilizada, uma EMI 9558QB, tem uma resposta espectral que vai a zero em $\lambda \sim 8300 \text{ \AA}$. O fotoemissor usado, um TIL 31, tem emissividade distinta de zero no intervalo $8800 \text{ \AA} < \lambda < 9800 \text{ \AA}$, com um pico estreito em $\lambda \sim 9300 \text{ \AA}$. Isto, aliado a uma alta diretividade do feixe infravermelho do emissor, faz com que a fotomultiplicadora não seja molestada pelo fotodiodo.

LASKER.- What programming language will you use with your minicomputer?

MAGALHÃES.- The Programs are being written in Assembly language, which is the appropriate one when one deals with controlling peripheral equipment. There will also be a provision for reducing data punched by the teletypewriter, in the first mode of operation I described, using Data General's Single User Basic.

OBSERVACIONES ESTELARES EN HIDROGENO Y OXIGENO NEUTROS

Discurso Invitado

Eugenio E. Mendoza V.

Instituto de Astronomía
Universidad Nacional Autónoma de México

RESUMEN: Se describe un sistema fotométrico que mide las intensidades de las líneas de hidrógeno ($H\alpha$) y del oxígeno neutro (tripleto en $\lambda 7774 \text{ \AA}$).

El sistema separa ampliamente a las estrellas supergigantes, de B3 a G5, de las otras estrellas. Entre las estrellas de tipo espectral A de la secuencia principal, quedan también claramente segregadas las estrellas Ap de las Am, y ambas de las estrellas de tipo espectral A-normales (clase de luminosidad V).

ABSTRACT: This paper describes a photometric system that measures the total absorption of the hydrogen line $H\alpha$, and also the total absorption of the neutral oxygen triplet at $\lambda 7774 \text{ \AA}$, each line, through three interference filters.

This system amply separates supergiants from other luminosity classes stars, from B3 to G5. Among A-type stars the Ap are neatly separated from the Am stars, and both from main sequence normal A-type stars (luminosity class V).

I. INTRODUCCION

Desde hace muchos años se han venido empleando las líneas del hidrógeno (principalmente la serie de Balmer), como indicadores de la luminosidad de las estrellas de tipos espectrales A y B. Entre los trabajos más destacados, podemos mencionar las contribuciones de Petrie (vea, por ejemplo Petrie, 1947) quien midió la línea $H\gamma$ a partir de espectrogramas de moderada dispersión. Johnson e Iriarte (1958) también midieron esta línea con un espectrofotómetro. Strömgren ha propuesto un

índice β , que se obtiene fotoeléctricamente (vea, por ejemplo, Strömgren, 1963, donde se encontrará vasta información al respecto). Más adelante se describirá un sistema fotoeléctrico que mide la intensidad de la línea $H\alpha$.

Merrill (1934) notó que las líneas de oxígeno neutro en $\lambda 7774 \text{ \AA}$ y $\lambda 8446 \text{ \AA}$ eran más intensas en las estrellas supergigantes que en las estrellas de más baja luminosidad. Keenan y Hynek (1950) investigaron la conducta y abundancia de oxígeno en estrellas con tipos espectrales desde B-tardías hasta G-tempranas, usando las líneas de OI $\lambda 7774 \text{ \AA}$ y $\lambda 8446 \text{ \AA}$. Estas líneas son las únicas que adquieren una apreciable intensidad en la región fotográfica del espectro. La línea $\lambda 7774 \text{ \AA}$ tiene en realidad tres componentes: $\lambda \lambda 7771.90, 7774.18$ y 7775.40 , que se originan de la transición

$$3^5S^{\circ} - 3^5P.$$

También la línea $\lambda 8446 \text{ \AA}$ tiene tres componentes, que se originan de la transición

$$3^3S^{\circ} - 3^3P.$$

La conclusión de los trabajos acabados de mencionar es, que el triplete de oxígeno neutro es uno de los criterios más sensibles para reconocer las estrellas supergigantes entre B5 y G0, de acuerdo a Merrill (1934) y Keenan y Hynek (1950). A continuación se describirá un sistema fotoeléctrico que mide la intensidad del OI en $\lambda 7774 \text{ \AA}$.

II. LOS SISTEMAS $\Lambda(25)$, $\Lambda(16)$, $\Lambda(9)$, $\alpha(35)$ y $\alpha(16)$

Las primeras observaciones fotoeléctricas para medir la absorción total del oxígeno neutro ($\lambda 7774 \text{ \AA}$) se realizaron en 1971 en el Observatorio de San Pedro Mártir, B.C. (México). Para ello se utilizó un fotomultiplicador RCA 7102 y tres filtros de interferencia con un ancho medio de $25 \text{ \AA}$, aproximadamente (vea Mendoza, 1971). Dos filtros miden el continuo a cada lado de la línea. El tercero está centrado sobre ella. Este sistema define un índice $\Lambda(25)$. Posteriormente en 1975 se consiguieron mejores filtros y detector (vea Mendoza, 1975). Con ellos se definió el índice $\Lambda(16)$; el filtro que mide la línea tiene un ancho medio de $16 \text{ \AA}$. En 1976 se decidió cambiar este último filtro por otro, que resultó con un ancho medio de sólo $9 \text{ \AA}$, para definir el índice $\Lambda(9)$.

Cuando se cambió el foto-multiplicador RCA 7102 por la celdilla RCA C-31034A, que tiene mayor eficiencia cuántica, menor corriente oscura y sensibilidad más uniforme entre 0.4 y 0.9 micrones, se añadieron tres filtros para medir la absorción total de la línea de hidrógeno $H\alpha$. Una vez más, dos filtros miden el continuo, a cada lado de la línea. El tercero queda centrado, aproximadamente, sobre la línea. Este sistema mide un índice $\alpha(35)$ (vea Mendoza, 1976a, b). Posteriormente se cambió el filtro de la línea por uno más angosto para obtener el índice $\alpha(16)$ (vea Mendoza, 1976b).

Cada uno de los índices mencionados se obtiene con ayuda de la siguiente expresión:

$$\text{índice} = \text{mag}(F_{\ell}) - \frac{1}{2} [\text{mag}(F_{cb}) + \text{mag}(F_{cr})] ,$$

en donde:

Índice es cualquiera de $\Lambda(25)$, $\Lambda(16)$, $\Lambda(9)$, $\alpha(35)$ ó $\alpha(16)$; $\text{mag}(F_{\ell})$, $\text{mag}(F_{cb})$ y $\text{mag}(F_{cr})$ son las magnitudes medidas a través de los filtros centrados en la línea, en el continuo del lado azul y en el continuo del lado rojo, respectivamente. Los índices, así obtenidos, son insensibles a la

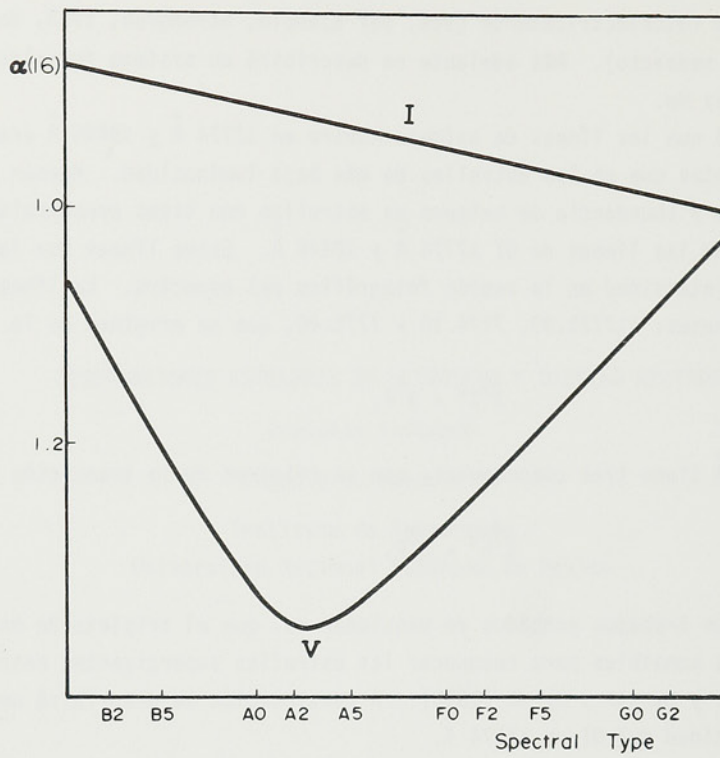


Fig. 1. La relación tipo espectral - $\alpha(16)$. La línea recta (parte superior) representa a las estrellas supergigantes de luminosidad Ia entre B0 y G5. Las supergigantes G tienen luminosidad Ia0. La curva inferior (V) representa a las estrellas de la secuencia principal entre B0 y G5.

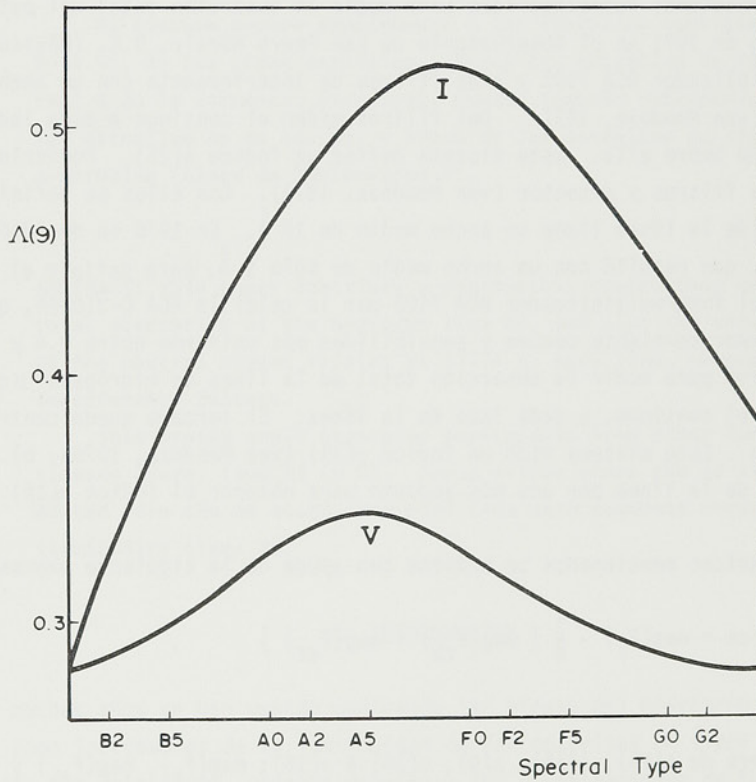


Fig. 2. La relación tipo espectral - $\Lambda(9)$. La curva I representa a las estrellas supergigantes. La curva V representa a las estrellas de la secuencia principal. Se usaron las mismas estrellas que en la Figura 1.

influencia de la absorción interestelar.

III. RESULTADOS

Los resultados más interesantes de los sistemas $\Lambda(25)$, $\Lambda(16)$ y $\alpha(35)$ han sido ya publicados (vea Mendoza, 1971 y 1976a). Aquí sólo mencionaremos los nuevos resultados obtenidos con los índices $\Lambda(9)$ y $\alpha(16)$.

Primero veamos la relación entre el índice $\alpha(16)$ y el tipo espectral. Esta se muestra en la figura 1, en donde únicamente se dan dos clases de estrellas: supergigantes y secuencia principal, ambas entre B0 y G5.

Algunas estrellas supergigantes tienen contaminada la línea de hidrógeno $H\alpha$ con emisión. En consecuencia la dispersión en el índice $\alpha(16)$ es alta para estas estrellas. La línea (I) mostrada en la figura 1 es una línea promedio, que corresponde principalmente a estrellas sin emisión, es decir, representa una cota inferior promedio para las estrellas supergigantes con tipos espectrales entre B0 y G5, corresponde a la clase de luminosidad Ia y Ia0 para las estrellas de tipo espectral G. También debe señalarse que la dispersión cósmica del índice $\alpha(16)$ en las estrellas de la secuencia principal, entre A0 y A1 aproximadamente, es mayor que para las otras regiones de la secuencia principal. No hemos estudiado la causa.

Ahora pasamos a la relación entre el índice $\Lambda(9)$ y el tipo espectral. Esta se muestra en la figura 2, en donde se han empleado las mismas estrellas que en la figura 1. Probablemente ninguna de las estrellas supergigantes estudiadas tiene el OI ($\lambda 7774 \text{ \AA}$) contaminado por emisión. Por tanto, la desviación alrededor de la línea (I) dibujada en la figura 2 es bastante pequeña y representa muy adecuadamente a todas las supergigantes de clase de luminosidad Ia y Ia0 con tipos espectrales entre B0 y G5. También la secuencia principal de estrellas "normales" tiene poca dispersión (curva V, figura 2) en el índice $\Lambda(9)$.

Se debe señalar que las estrellas de clase de luminosidad Iab, Ib y II también quedan segregadas de las otras estrellas. La curva Ia sería la superior, por debajo de ella la curva Iab y debajo de ésta la Ib y un poco más abajo la II; todas quedan arriba de la curva V, en la figura 2.

En la figura 3 hemos combinado los dos índices, $\Lambda(9)$ y $\alpha(16)$, en donde otra vez, únicamente se han graficado dos clases de luminosidad, I y V; de hecho, se han utilizado las mismas estrellas que se usaron en la construcción de las Figs. 1 y 2. Lo mencionado acerca del índice $\alpha(16)$ para todas las supergigantes y las estrellas de la secuencia principal entre A0 y A1 sigue siendo válido en el plano $\alpha(16)\Lambda(9)$.

Durante las observaciones de estrellas de la secuencia principal con tipos espectrales entre B-tardío y F-temprano, se encontró que el índice $\Lambda(9)$ era diferente para tres clases de estrellas: A-normal, Am y Ap.

Estas diferencias se aprecian más fácilmente en forma gráfica como se ilustra en la figura 4. En esta figura se han graficado solamente estrellas de la secuencia principal con tipos espectrales entre B8 y F2. También estrellas Am (vea Mendoza, 1976b) y estrellas Ap (vea Mendoza, 1977).

IV. CONCLUSIONES

Los resultados dados en la sección anterior muestran:

- i) Las estrellas supergigantes quedan ampliamente separadas en los diagramas tipo espectral versus $\alpha(16)$, tipo espectral versus $\Lambda(9)$ y $\alpha(16)$ versus $\Lambda(9)$. Las relaciones que contienen al índice $\alpha(16)$ tienen mayor dispersión. La separación entre supergigantes y estre-

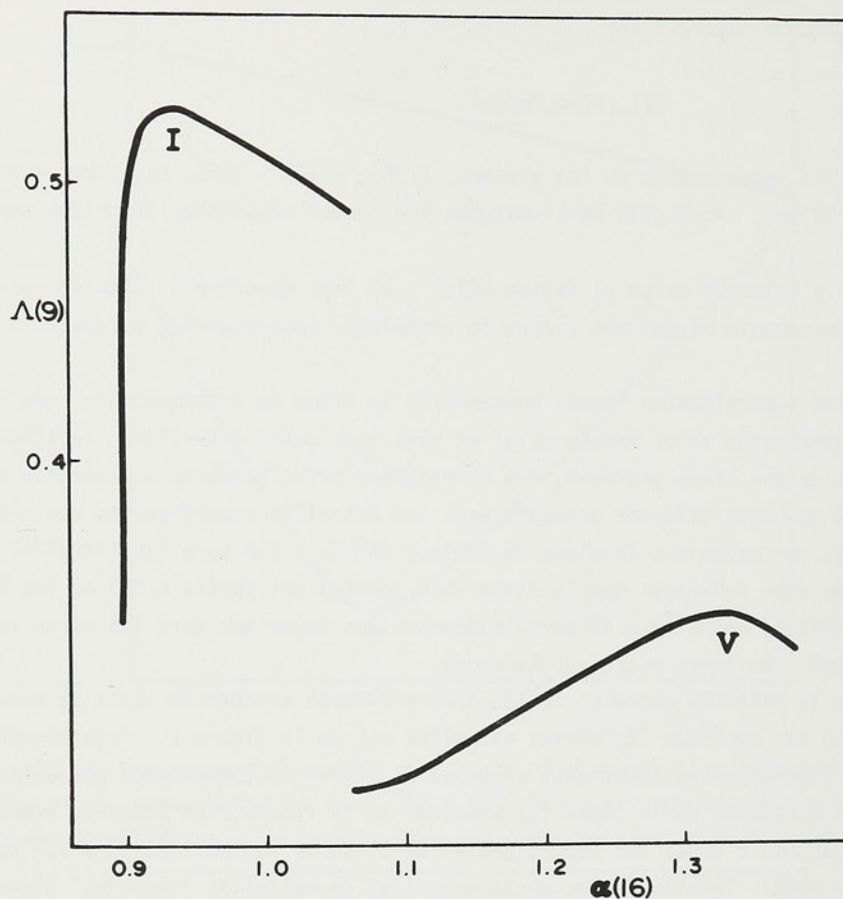


Fig. 3. El plano $\alpha(16)\Lambda(9)$. Las curvas representan a las mismas estrellas graficadas en Figs. 1 y 2.

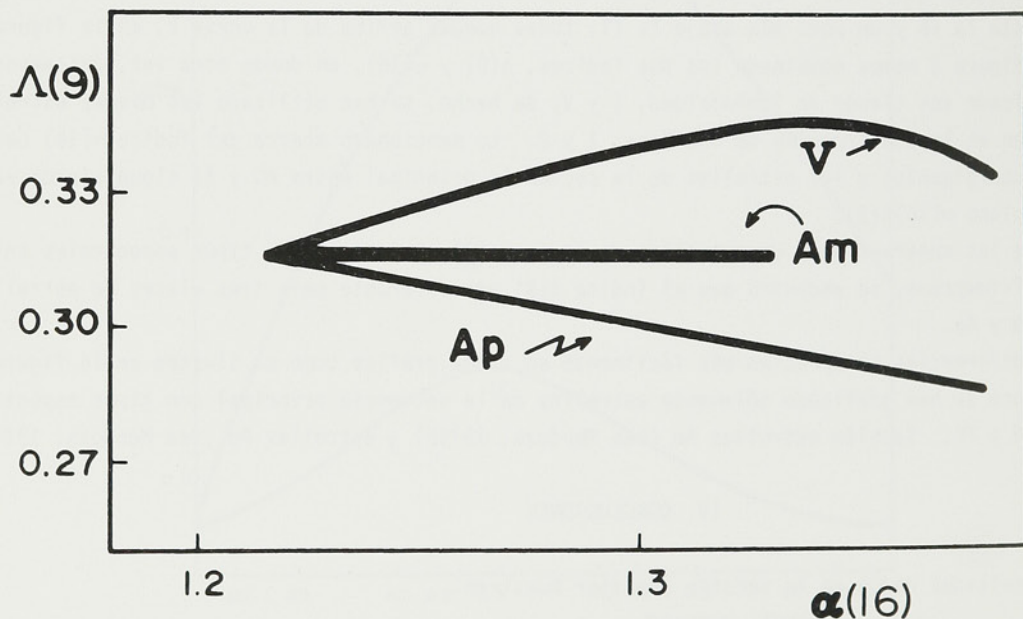


Fig. 4. La relación $\alpha(16)$ versus $\Lambda(9)$ para estrellas A de la secuencia principal. La curva superior (V) representa a las estrellas A-normales; la del medio, (Am), a las estrellas A con líneas metálicas; y la inferior, (Ap), a las estrellas con composición química bizarra (vea Mendoza, 1977).

- llas de la secuencia principal, es mayor en el plano $\alpha(16)\Lambda(9)$. El índice $\Lambda(9)$ separa ampliamente a las estrellas supergigantes entre B3 y G5. Las estrellas supergigantes G observadas tienen clase de luminosidad Ia0 (vea Morgan y Keenan, 1973).
- ii) Las estrellas de la secuencia principal con tipo espectral A tienen un índice $\Lambda(9)$ decreciente de A-normal a Am a Ap, dando como resultado que estas estrellas quedan limpiamente separadas unas de las otras en el plano $\Lambda(9)\alpha(16)$ - vea figura 4.

REFERENCIAS

- Johnson, H.L., Iriarte, B., 1958, *Lowell Obs. Bull.* 4, 47 (No. 91).
- Keenan, P.C., Hynek, J.A., 1950, *Ap. J.* 111, 1.
- Mendoza, E.E., 1971, *Bol. Obs. Tonantzintla y Tacubaya* 6, 137.
- _____, 1975, *P.A.S.P.* 87, 505.
- _____, 1976a, *Rev. Mex. Astron. Astrof.* 1, 363.
- _____, 1976b, *Rev. Mex. Astron. Astrof.* 2, 29.
- _____, 1977, *Rev. Mex. Astron. Astrof.* 2, 259.
- Merrill, P.W., 1934, *Ap. J.* 79, 183.
- Morgan, W.W., Keenan, P.C., 1973, *Ann. Rev. Astron. Astrophys.* 11, 29.
- Petrie, R.M., 1947, *Pub. Dom. Ap. Obs. Victoria* 1, 321.
- Strömgren, B., 1963, in *Basic Astronomical Data*, edited by K.Aa. Strand. Univ. Chicago Press, Chicago, p. 123.

DISCUSION

MORENO.- ¿A qué corresponden las dos estrellas que se salen del gráfico que Ud. mostró?

MENDOZA.- Vea la referencia Mendoza, 1976 b).

MUZZIO.- ¿Cómo se compara la magnitud límite de este sistema con la correspondiente a otros sistemas como el uvby H β o el DDO (utilizando equipo similar, por supuesto)?

MENDOZA.- En el sistema fotométrico descrito una estrella de tipo espectral A de magnitud $V = 7.0$ requiere 15 segundos para tener un error probable de 0.003 magnitudes, cuando la observación se hace con un telescopio de un metro de apertura.

THE CONTINUUM DISTRIBUTION OF V 1500 CYGNI

W. Wamsteker

European Southern Observatory

Infrared observations of the early stage of Nova Cygni 1975 are presented. The results show that at the longer wavelengths the maximum is reached considerably later than in the visual. A model for the continuum radiation is proposed that explains the complete radiative evolution of this nova in terms of thermal bremsstrahlung. The change of the optical thickness in a plasma shell and the wavelength dependence of the optical thickness under expansion gives good agreement with the observed times of maximum brightness. The time of onset of radiative energy loss from the nova is determined to be 29.9 August 1975, at which time the nova must have been at maximum in the Lyman limit at 912 Å. This time does not have to coincide with the time at which the nova shell is generated. The development of the emission system in H β is expected to precede that of H α .

DISCUSSION

PACHECO.- Have you checked if the shell is also thin against Thomson scattering when it is thin against free-free absorption?

WAMSTEKER.- No, apart from the assumptions mentioned no model parameters have been used. We are making detailed calculations on a more elaborate model. One of the problems we are facing is that the results will be strongly dependent on what one uses as the input radiation field for the shell itself.

EFFECTS OF INTERSTELLAR REDDENING ON SPECTROPHOTOMETRIC GRADIENTS

A. Gutiérrez-Moreno and H. Moreno

Observatorio Astronómico Nacional, Cerro Calán
Departamento de Astronomía
Universidad de Chile

I. INTRODUCTION

In a previous paper we have made an analysis of spectrophotometric data in two stellar associations (Gutiérrez-Moreno and Moreno, 1978). The observations included stars in the Upper Scorpius region and in the Orion Belt and Sword, with different amounts of reddening (from 0.00 to 0.67 magnitudes). While making the necessary calculations, we found some difficulties in the transformation of the spectrophotometric gradients to the absolute system of the Institute d'Astrophysique de Paris (Divan, 1966), and in the correction for reddening of the absolute gradients thus obtained. These problems have moved us to present a critical review of the subject.

II. REDDENING OF THE GRADIENTS

It is a well known fact, that for limited wavelength intervals, the observed spectrophotometric gradient of a star affected by interstellar absorption, may be expressed as (Ardeberg, 1969):

$$\phi = \phi_0 + \phi_A, \quad (1)$$

where ϕ_0 is the intrinsic gradient of the star and ϕ_A is the additional amount due to the interstellar absorption. It is easy to see that ϕ_A is directly the gradient of the interstellar absorption curve in the wavelength interval considered. For practical purposes, we need a relation which gives ϕ_A as a function of observed quantities. Generally, an expression of the form:

$$\phi_A(1/\lambda, E) = k(1/\lambda) E_{B-V} \quad (2)$$

is used, with $k(1/\lambda)$ constant for a given wavelength interval. The problem, then, is to determine the value of $k(1/\lambda)$ for the different observed spectral regions. This is usually done in two ways:

by using pairs of stars of the same spectral type with known different reddenings (see, for example, Navach, 1973), or by the direct determination of $k(1/\lambda)$ from the interstellar absorption curve. The first method may be applied with relative security (depending on the accuracy of the observations) for gradients in wavelengths to the red of the Balmer discontinuity; but it cannot be used for the ultraviolet gradients, which depend not only on the spectral type of the star and on the interstellar absorption, but also on the emission in the Balmer continuum (Gutiérrez-Moreno and Moreno, 1978); besides, the determination in this region becomes more difficult due to the smaller precision of the measures. Ardeberg (1969) uses both methods; he gives for $k(1/\lambda)$ the values:

$$\begin{aligned} k &= 2.035 & , & \quad 0.93 \leq 1/\lambda \leq 2.20 & , \\ k &= 1.630 & , & \quad 2.20 < 1/\lambda \leq 2.48 & , \\ k &= 1.220 & , & \quad 2.75 \leq 1/\lambda \leq 3.13 & . \end{aligned} \quad (3)$$

The first value was obtained from star pairs, and the last one from the shape of the mean of the interstellar absorption curves given by Nandy (1968). The value for $2.20 < 1/\lambda \leq 2.48$ was obtained considering the change of slope of the absorption curve in this wavelength interval.

In practice, the determination of $k(1/\lambda)$ is not so simple, and there are two main reasons for this: a) the variation of the effective wavelengths of the UBV system with the change of spectral type of the stars observed, or with the increase of the amount of reddening, which causes the proportionality in (2) not to be maintained; and b) the extinction curves are different, and have different gradients, in different parts of the galaxy. An additional difficulty is introduced when the gradients are obtained in relative systems, which may differ systematically from the absolute system

III. ANALYSIS OF THE VALUE OF $k(1/\lambda)$

The effects mentioned in the preceding paragraph have been studied by numerical computations, and the results may be summarized as follows:

1) Effects of the change of effective wavelengths.- The dependence between the values of $k(1/\lambda)$ and the effective wavelengths of the UBV system may be seen clearly if we take into account the easily shown relations:

$$\begin{aligned} k(1/\lambda) &= 0.921 (1/\lambda_B - 1/\lambda_V)^{-1} & , & \quad 0.93 \leq 1/\lambda \leq 2.20 & , \\ k(1/\lambda) &= 0.921 (1/\lambda_B - 1/\lambda_V)^{-1} Y & , & \quad 2.75 \leq 1/\lambda \leq 3.13 & , \end{aligned} \quad (4)$$

where Y is the ratio of the slopes of the reddening curve in both sides of $1/\lambda = 2.33$. For the mean of the curves determined by Nandy (1968), Ardeberg (1969) uses $Y = 0.6$.

To analyze this effect we have used numerical integrations made previously by the authors (Gutiérrez-Moreno and Moreno, 1970, 1972), which give the amount of reddening obtained by applying the same extinction curve to different stars, multiplying the initial amount of interstellar matter, designed as x , by 2, 3, 4, ... 8. The results are given in figure 1, which shows clearly, for both gradients (ultraviolet and blue-yellow), the difference between the relation (ϕ_A, E_{B-V}) corresponding to two stars of different spectral types. The fact that the two relations are practically straight lines shows that the total amount of reddening is relatively unimportant for the problem we are studying. In any case, we have shown that, although this effect is not too important, the value of $k(1/\lambda)$ for a given group will depend on the spectral composition of the sample. The effect

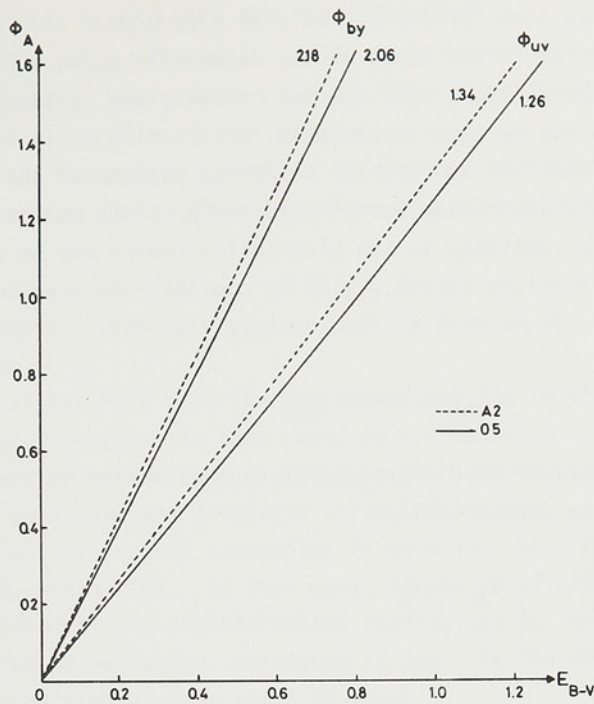


Fig. 1. Change of the "constant" $k(1/\lambda)$ with the change of spectral type and the increase of reddening. This effect, due to the change of effective wavelength, is more important for the blue-yellow gradient. Notice that the lines representing the (ϕ_A, E_{B-V}) relations are not exactly straight lines. For example, for the blue-yellow gradient of the 05 star, the value of k for $E = 0.2$ is 1.98; and similar values can be quoted for the other relations.

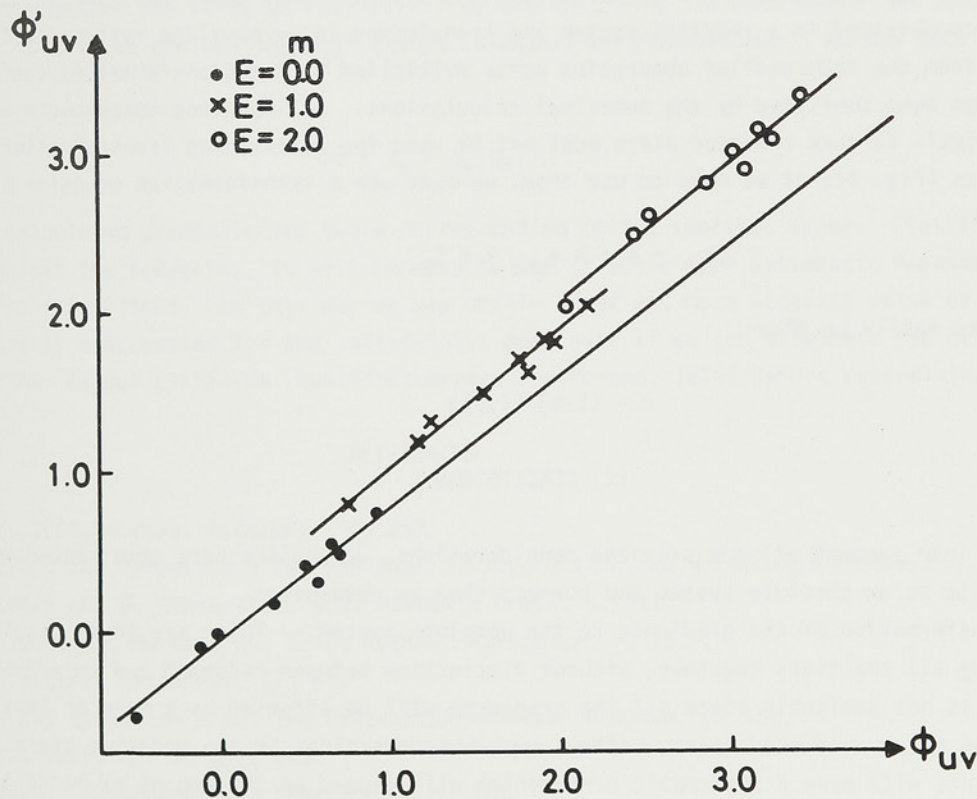


Fig. 2. Effects of reddening on the transformations between gradients. The relation corresponds to a value of $b = 0.812$.

is stronger for the blue-yellow than for the ultraviolet gradient.

2) Effects of the difference in the shape of the absorption curve.- These effects may be quite important. In his work, Ardeberg (1969) uses the mean curve given by Nandy. Nevertheless, this simplifying assumption, which may be considered valid for $1/\lambda < 2.33$, is not valid for $1/\lambda > 2.33$, where the value of Y varies from 0.46 to 0.64 for different regions of the galaxy. The problem is still more difficult if we take absorption curves obtained by other authors, for example Johnson (1965), for which not even the constancy in the blue-yellow region may be assumed.

3) Transformation to an absolute system.- Let us consider now gradients obtained in a relative system, which we will call ϕ . If we call ϕ' the absolute gradients, in general we will have:

$$\phi'_{\text{obs}} = a + b \phi_{\text{obs}} \quad (5)$$

where the coefficient b eliminates the differences in the definition of the gradients and any color dependent effect. From here we deduce easily:

$$\phi'_A = b \phi_A \quad , \quad (6)$$

and:

$$k'(1/\lambda) = b k(1/\lambda) \quad (7)$$

where the values of $k(1/\lambda)$ are the values discussed in the preceding paragraphs since, as long as the wavelength intervals do not change too much, the gradient of the absorption curve for unit reddening does not change with the use of a relative system. This means that the value of $k(1/\lambda)$ for gradients obtained in a relative system and transformed to an absolute system, is the value determined from the interstellar absorption curve multiplied by the transformation coefficient b . This fact has been confirmed by the numerical calculations. An important consequence of this numerical analysis is that reddened stars must not be used for determining transformation equations for gradients (Fig. 2); if we need to use them, we must use a transformation equation of the form:

$$\phi'_{\text{obs}} = a + b \phi_{\text{obs}} + c E_{B-V} \quad (8)$$

where, as may easily be shown:

$$c = (1-b) k(1/\lambda) \quad (9)$$

IV. CONCLUSIONS

Taking into account all the previous considerations, we outline here some procedures to transform gradients to an absolute system and correct them by reddening:

1) Transformation of the gradients to the absolute system.- There are three possibilities:

a) Using all the stars together, without distinction between reddened and unreddened stars.

This method is not advisable since all the gradients will be affected by a more or less gross error.

b) Using only unreddened stars, without applying corrections to the reddened stars. The reddened gradients will have a systematic error which will depend on the amount of reddening.

c) Using reddened and unreddened stars, and a transformation equation of the form (8). The

reddening dependent systematic errors will then be eliminated.

2) Determination of the value of $k(1/\lambda)$.— There are also several possibilities:

a) By using pairs of stars, one reddened and the other unreddened, of the same spectral type.

This method is not advisable for ultraviolet gradients.

b) By direct use of the absorption curve, if it is known; in this case the value of $k(1/\lambda)$ may be determined by the method a) for the blue-yellow region and by the relation:

$$k(1/\lambda_{ub}) = Y k(1/\lambda_{by}) \quad , \quad (10)$$

for the ultraviolet region.

c) If the procedure c) has been used for the transformation to the absolute system, $k(1/\lambda)$ may be determined from relation (9). In this case, we are making a certain error since, in general, the standard stars will not be in the same region than the program stars, and, consequently, we may expect different absorption curves and different values of $k(1/\lambda)$.

3) Determination of $k'(1/\lambda)$.— This correction is necessary when the transformation to the absolute system is made by method 1b). In this case, the value of $k(1/\lambda)$ obtained from the absorption curve must be multiplied by the transformation coefficient b . This procedure eliminates the systematic errors depending on reddening, mentioned in 1b). On the other hand, this correction is not necessary if $k(1/\lambda)$ is determined from pairs of stars.

4) Correction of the reddened absolute gradients, to obtain the intrinsic gradients:

$$\phi'_0 = \phi' - k'(1/\lambda) E_{B-V} \quad (11)$$

5) Improvement of the value of $k(1/\lambda)$.— If we are observing isolated stars, we cannot improve our results. But if we are dealing with groups (clusters or associations), we may obtain the residuals:

$$\Delta\phi = \phi'_0 - \phi_0(MK) \quad , \quad (12)$$

between the calculated gradients and those corresponding to the spectral types. Plotting these residuals against the reddening, it will be easy to see if there is a systematic dependence, and to correct for this effect. In this way we may obtain a new and more accurate value of $k(1/\lambda)$. This procedure is made easier for the ultraviolet gradients if we can eliminate the effect of the emission in the Balmer continuum (Gutiérrez-Moreno and Moreno, 1978) before determining $\Delta\phi$.

REFERENCES

- Ardeberg, A., 1969, *Astron. Astrophys.* 3, 257.
 Divan, L., 1966, IAU Symposium N°24. *Spectral Classification and Multicolor Photometry*. K. Lodén, L.O. Lodén and U. Sinnerstad, eds. Academic Press, p. 311.
 Gutiérrez-Moreno, A., Moreno, H., 1970, *Astron. Astrophys.* 7, 35.
 ——— 1972, *Astron. Astrophys.* 17, 41.
 ——— 1978, IAU Symposium N°80. *The Hertzsprung-Russell Diagram*. p. 139.
 Johnson, H.L., 1965, *Ap. J.* 141, 923.
 Nandy, K., 1968, *Edinburgh Obs. Publication* 6, 169.

DISCUSSION

MENDOZA.- ¿Han hecho cálculos usando mediciones UV en longitudes de onda más cortas que 3000 Å?

GUTIERREZ.- No, ya que sólo hemos usado datos obtenidos desde observatorios terrestres.

FOTOMETRIA UBVRI DE ESTRELLAS Am

Eugenio E. Mendoza V.

Instituto de Astronomía
Universidad Nacional Autónoma de México

A la fecha tenemos medidas 321 estrellas diferentes de tipo A con líneas metálicas (Am) en el sistema fotométrico UBVRI, las cuales han sido seleccionadas del catálogo de Mendoza (1974). Este catálogo contiene:

- a) Estrellas Am clásicas (ver Roman *et al.*, 1948 y Abt y Morgan, 1976).
- b) Estrellas A con características marginales de Am (ver Mendoza, 1956).
- c) Estrellas A, sospechosas de ser Am.

Las observaciones han sido reportadas por Mendoza (1975) y Mendoza *et al.* (1978).

Generalmente se acepta que una estrella Am se parece a una estrella A-normal, cuando la comparación se hace usando las líneas del hidrógeno. En consecuencia, primero analizamos la relación entre el índice β y el tipo espectral obtenido a través de la serie de Balmer de estrellas Am, que se han medido en el sistema UBVRI, tienen índice β , y tipo espectral clasificado por los Jaschek, Morgan u Osawa (ver Mendoza *et al.*, 1978). Solamente cuarenta estrellas Am llenan los requisitos anteriores. Esta relación muestra una dispersión mucho mayor que la dada por las estrellas A de tipo normal de la secuencia principal.

Debido a que la relación anterior, entre el índice β y el tipo espectral, para las estrellas Am no es satisfactoria, el siguiente paso es estudiar las relaciones entre el índice β y los distintos colores del sistema UBVRI.

En esta ocasión se han empleado primero las cuarenta estrellas de la comparación anterior, y después todas las estrellas que tienen índice β y fotometría UBVRI, las cuales suman ciento treinta y una estrellas. Los resultados indican que la relación β versus V-I es la más parecida a la que tienen las estrellas de la secuencia principal entre A0 y F3. Es interesante mencionar dos detalles: el primero es que las estrellas Am clasificadas como A7 se localizan a todo lo largo de la secuencia principal entre A2 y F3, en el plano (V-I, β). El segundo es que aunque la relación β versus V-I para estrellas Am es más parecida a la que tienen las estrellas A-normales, no es completamente satisfactoria, pues algunas estrellas Am caen por debajo de la secuencia principal.

También debe señalarse que los análisis descritos arriba reflejan la gran dificultad de clasificar a las estrellas Am solamente con las líneas del hidrógeno en una placa fotográfica. Sería

más fácil, si se pudiera, utilizar cocientes de líneas. Desafortunadamente esta técnica no es aplicable con las estrellas Am.

En vista de lo anterior se justifica la hipótesis de que en primera aproximación el color V-I de estrellas Am no enrojecidas por absorción interestelar es igual al color intrínseco de las estrellas A-F de la secuencia principal. En base a esto ahora estudiamos los diagramas de dos colores para todas las estrellas Am.

- a) V-I versus U-V. Esta relación confirma plenamente que las estrellas Am tienen una deficiencia ultravioleta. 66% de nuestras estrellas caen muy por debajo de la secuencia principal.
- b) V-I versus B-V. En este diagrama también la mayoría de las estrellas Am caen debajo de la secuencia principal, aunque menos lejos de ella que en el plano (V-I, U-V), indicando también una deficiencia en el azul, menor que la ultravioleta.
- c) V-I versus V-R. En esta relación las estrellas Am caen muy cerca de la secuencia principal. Aquéllas con $V-R < 0.25$, ligeramente arriba, y las que tienen $V-R > 0.30$, ligeramente abajo. Las demás, en el promedio quedan localizadas sobre la secuencia principal. Una interpretación, es que las estrellas Am de tipo temprano tienen una pequeñísima deficiencia en V-R. Las de tipo tardío un pequeñísimo exceso y las de tipo intermedio ninguna diferencia. Sin embargo, debido a que el color V-I no es cien por ciento normal, esta interpretación podría no ser válida.

Puesto que lo más sobresaliente de la presente fotometría es lo mostrado en el diagrama (V-I, U-V), podemos definir a una estrella Am-fotométrica, como una estrella que se localiza por debajo de la secuencia principal en el plano (V-I, U-V).

En conclusión podemos derivar cuantitativamente cuáles son las diferencias de color entre las estrellas Am y las estrellas A-normales, usando la definición anterior. Los resultados se dan en la Tabla I, la cual muestra, en otra forma, los resultados arriba mencionados. También en esta Tabla se dan las diferencias en el índice β . Debido a que la dispersión cósmica es grande en las estrellas de tipo espectral A0 y A1 con clase de luminosidad V, quizás las diferencias dadas en la Tabla I para las estrellas Am de tipo temprano no tengan significado, en el índice β .

TABLA I
Diferencias Promedio, entre Estrellas
Am y A-Normales, como Función de V-I.

V-I	$\Delta(U-V)$	$\Delta(B-V)$	$-\Delta(V-R)$	$\Delta\beta$
0.05	0.08	0.04	0.01	0.012
0.10	0.06	0.04	0.01	-0.014
0.15	0.05	0.03	0.01	-0.005
0.20	0.05	0.04	0.01	0.001
0.25	0.06	0.03	0.00	0.005
0.30	0.06	0.04	0.00	0.011
0.35	0.07	0.03	-0.01	0.014
0.40	0.08	0.04	-0.01	0.007
0.45	0.11	0.04	-0.01	0.009

REFERENCIAS

- Abt, H.A., Morgan, W.W., 1976, *Ap. J.* 205, 446.
Mendoza, E.E., 1956, *Ap. J.* 123, 54.
_____, 1974, *Rev. Mex. Astron. Astrof.* 1, 175.
_____, 1975, *Dudley Obs. Report* 9, 407.
Mendoza, E.E., Gómez, T., González, S., 1978. Por publicarse.
Roman, N.G., Morgan, W.W., Eggen, O.J., 1948, *Ap. J.* 107, 107.

DISCUSION

FEINSTEIN.- No me resulta claro por qué las estrellas Am presentan valores de $H\beta$ distintos a los de las estrellas A normales.

MENDOZA.- Las relaciones mencionadas indican claramente la gran dificultad en asignar un tipo espectral "viendo" únicamente las líneas del hidrógeno.

THE SPECTROSCOPIC BINARY γ -2 VELORUM

Virpi S. Niemela

Villa Elisa, Buenos Aires

and

Jorge Sahade*

Instituto de Astronomía y Física del Espacio, Buenos Aires

ABSTRACT

A new spectrographic orbit for the WC8 + O9I binary system γ -2 Velorum has been determined using primarily 42 Å/mm Cassegrain spectra obtained at the Córdoba Observatory, and a few 9 and 18 Å/mm coudé spectra obtained at the Cerro Tololo Interamerican Observatory. The orbit of the O9I star is based on the measurement of about 13 absorption lines per spectrum, and the derived elements are as follows:

$$\begin{aligned}P &= 78.5002 \pm .0001 \text{ days} \\ \gamma &= +12 \pm 1 \text{ km/s} \\ K_{09} &= 68 \pm 2 \text{ km/s} \\ e &= 0.40 \pm .01 \\ \omega &= 256^\circ \pm 3^\circ\end{aligned}$$

The radial velocities from the emission lines show quite a large scatter, therefore the orbital solution of the absorption lines was adopted, and the radial velocities of the emission were used only to determine the semi-amplitude of the WC8 component, namely, $K_{WC} = 130 \pm 10$ km/s. The minimum masses corresponding to our orbital parameters are :

$$M_{09} \sin^3 i = 32 \pm 6 M_{\odot} \quad \text{and} \quad M_{WC} \sin^3 i = 17 \pm 2 M_{\odot} \quad ,$$

* Miembro de la Carrera del Investigador Científico, CONICET, Argentina.

and, therefore, our mass-ratio is much smaller than either one of those derived earlier by Ganesh and Bappu (*Kodaikanal Obs. Bull.*, N°183, 1967).

The violet-shifted absorptions that flank the emission lines follow the orbital motion of the WCB star. The correlation between the γ -velocity of the violet-shifted absorptions with the excitation potentials of their corresponding upper levels, and the correlation of the γ -velocity of the emissions with their ionization potentials can be interpreted in terms of an outwards accelerated atmosphere of the WCB star, as is the case in other WR stars.

When we are viewing the system around the conjunction at which the O9I star is in front, the violet-shifted absorption of HeI $\lambda 3888 \text{ \AA}$ shows an abnormal intensity that suggests the effect of diluted radiation. At quadratures the HeI $\lambda 3888$ line has a complex structure and at around the conjunctions where the WCB star is in front this absorption has definitely a stellar appearance and behaves velocity-wise similarly to the other violet absorptions that border the emission lines. The corresponding γ -velocity is in keeping with the above mentioned correlation and suggests that HeI $\lambda 3888 \text{ \AA}$ originates in the outer layers of the outwards accelerated atmosphere of the WCB star. The phase-dependent variations of HeI $\lambda 3888 \text{ \AA}$ absorption obviously indicate that such outer layers are not spherically symmetric.

DISCUSSION

BLAAUW.- In view of the rather high eccentricity of the orbit, could apsidal motion be detectable?

NIEMELA.- Our observations are not sufficient to detect the possible apsidal motion.

DISCOVERY OF OPTICAL PULSATIONS IN HD 77581 $\equiv$ VELA X-1*

J.E. Steiner

Instituto Astronômico e Geofísico, U.S.P.
São Paulo

ABSTRACT

Pulsed $H\beta$ flux from HD 77581, the optical counterpart of Vela X-1, was detected. The observed period is $P = 282.8$ sec, coincident with the X-ray period. The modulation in flux is up to 2%.

* Published in extenso in *Astronomy and Astrophysics* 61, L35, 1977.

ANALISIS DE LA ESTRELLA RY Sgr

Mónica M. V. de Arnedo

Observatorio Astronómico, Córdoba

ABSTRACT: The present study is based on spectra obtained at Bosque Alegre (Córdoba) with a dispersion of 42 Å/mm, while RY Sagitarii was at its maximum brightness.

Practically no modifications were found in the appearance of the spectra. The special characteristics were taken to be anomalies in the abundances, or due to the very low electronic pressure existing in the atmosphere of this star. Its classification is G0 Ia pec. The H and K line profiles are analyzed in function of the number of Ca atoms "above the photosphere" which produces them, and a good agreement was found between the abundance of Ca in RY Sgr and δ CMa, an F8 Ia normal star, and β Aqr, a G0 Ib normal star.

RY Sgr es una estrella variable del tipo R Coronae Borealis, con $\alpha = 19^h 10^m$ y $\delta = -33^\circ 42'$ (1900.0). Su magnitud en el máximo de luz es $m = 6.0$.

Los espectros empleados en el desarrollo de este trabajo se obtuvieron con el telescopio de Bosque Alegre y el espectrógrafo de 42 Å/mm de dispersión, mientras la estrella permanecía en su máximo de luz.

Siguiendo los criterios de Keenan para clasificar según luminosidad a las estrellas en los alrededores de G0, se emplearon las relaciones 4376/4383, 4383/4444 y 4390/4395, del hierro. Todas ellas indican clase de luminosidad Ia.

Como criterio independiente se utilizaron relaciones entre 4215 Sr II - Fe I, 4233 Fe II - Cr II, 4226 y 4455 del Ca I; se comparó con las mismas en δ CMa y se clasificó a la estrella como Ia⁺ ó 0, o bien deficiente en calcio. Para determinar su tipo espectral se utilizaron las líneas antes mencionadas, concluyendo que es F8.

Los demás elementos identificados son los comunes a las estrellas normales alrededor de G0.

Se adoptó el modelo Schuster - Schwarzschild para determinar la abundancia de calcio en la

atmósfera de RY Sgr; se aplicó el mismo procedimiento para δ CMa y β Aqr, estrellas normales F8 Ia y G0 Ib respectivamente.

Las líneas empleadas fueron las H y K del CaII; se graficaron las intensidades residuales promedios, en el caso de RY Sgr de cuatro espectros, de δ CMa de tres y de β Aqr de cinco placas.

El acuerdo en los resultados entre δ CMa y β Aqr es muy bueno [suponiendo nulo el amortiguamiento por colisiones, se tiene que: $NII(\delta \text{ CMa}) = 9.8 \times 10^{19}$ y $NII(\beta \text{ Aqr}) = 7.9 \times 10^{19}$; en ambos casos NII es el número de átomos de calcio ionizado en el nivel fundamental en una columna de 1 cm^2 de base y altura de la atmósfera]; se pone en evidencia que la abundancia de calcio en RY Sgr es algo menor que en las anteriores [$NII(\text{RY Sgr}) = 5.3 \times 10^{19}$].

La zona de la banda G es enteramente similar en RY Sgr y δ CMa.

La absorción del CN en la zona 3840 Å en RY Sgr y δ CMa es también semejante, lo que indicaría la existencia de una abundancia similar de nitrógeno en ambas estrellas.

AGRADECIMIENTOS: Deseo expresar mi sincero agradecimiento al Dr. Luis A. Milone, bajo cuya dirección fue realizado este trabajo.

ON THE PROPERTIES OF THE HELIUM VARIABLE HD 184927

Hugo Levato* and Stella Malaroda⁺

Observatorio Astronómico, Universidad Nacional de La Plata

ABSTRACT

The helium variable HD 184927 has been studied on 18 coudé spectrograms with a dispersion of 16.9 Å/mm. Equivalent widths and radial velocities of several lines have been measured. We have found variations of the equivalent widths of helium and hydrogen lines in antiphase. The period is 9.48 days. In addition there are variations in the equivalent widths of SiII, SiIII, NII and MgII, and probably in CII. The results of the radial velocities are compatible with a binary interpretation because helium and hydrogen vary with the same amplitude and in phase.

The complete results will be published elsewhere.

* Member of the Carrera del Investigador Científico del Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina

⁺ Member of the Carrera del Investigador Científico de la Comisión de Investigaciones Científicas de la Provincia de Buenos Aires.

ESTRELAS PADRÃO PARA FOTOMETRIA $H\alpha$ *

F.M. Strauss e J.R. Ducati

Instituto de Física, Universidade Federal do Rio Grande do Sul
Porto Alegre

RESUMO

Dois filtros interferenciais, de 208 e 37 Å, centrados em $H\alpha$, foram usados para definir um sistema padrão baseado em 168 estrelas brilhantes distribuídas uniformemente pelo hemisfério celeste sul, de tipos espectrais entre B0 e G5, classes I a V. Todas elas têm índices β publicados. O índice α varia entre 1.870 e 2.070 para estrelas com pouca ou nenhuma emissão. O erro rms de uma medida é de 0.004, sendo que os valores finais tem erro rms de 0.0014. Os resultados são comparados com outros sistemas $H\alpha$.

* Financiado parcialmente pelas Instituições Brasileiras CNPq e FINEP.

CUARTA PARTE
A S T R O M E T R I A

PROCEDIMIENTO PARA REDUCCION EN DECLINACION DE SERIES KUSTNER.
RESULTADOS OBTENIDOS CON EL CIRCULO MERIDIANO DE SAN JUAN (ARGENTINA)*

R.A. Carestia, A. Zaragoza y M. Gallego

Observatorio Astronómico Felix Aguilar, Universidad Nacional de San Juan

ABSTRACT: Preliminary results obtained from 7183 declination observations series FK4 are presented. Some reduction details are discussed, and the observed declination system is compared with FK4 in Dd.

I. INTRODUCCION

7183 observaciones sobre 774 estrellas del FK4, realizadas en 211 series Küstner, desde abril de 1974 a julio de 1975, usando alternativamente ambos círculos graduados del REPSOLD M.C. (190 mm.), fueron reducidas en declinación siguiendo un procedimiento propuesto por el primero de los autores y que se trata de exponer brevemente a continuación.

II. PROCEDIMIENTO

Dentro de cada serie se calcula para cada estrella una declinación preliminar $D_p = L_a - Z_m$, en función de una latitud adoptada L_a y de la distancia cenital medida Z_m , corregida por refracción, run, trazos, curvatura, flexión, etc. El "punto cenital" se obtiene mediante el baño nadiral de mercurio. Para cada estrella de la serie se obtienen los valores provisorios:

$$(O-C) = D_p - D_c$$

donde D_c es la declinación aparente dada por el Catálogo FK4. Es fácil deducir que los $(O-C)$ así

* Trabajo presentado con el apoyo del Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina).

obtenidos para cada estrella de la serie responden a una expresión de la forma:

$$(O-C) = DL - a(\text{sig.} Z) - b \tan Z + Dd \quad , \quad (1)$$

donde DL es la diferencia entre la latitud adoptada y la latitud instantánea, a es un coeficiente de corrección a la distancia cenital por ecuación personal, b un coeficiente que contempla errores en las correcciones de refracción, flexión y ecuación personal y finalmente, Dd es la corrección que requeriría la declinación aparente dada por el Catálogo FK4. Nuestro objetivo final es determinar el Dd de cada estrella; será entonces necesario determinar previamente los coeficientes DL, a y b. Los dos primeros se calculan para cada serie, combinando una "estrella promedio Sur" con una "estrella promedio Norte", tomando para dichos promedios todas las estrellas observadas con distancia cenital menor que 30°. Las fórmulas que se pueden deducir de (1) son:

$$a = \frac{1}{2} \left[\overline{(O-C)}_n - \overline{(O-C)}_s \right] + \frac{1}{2} b (\overline{\tan Z}_n - \overline{\tan Z}_s) + \frac{1}{2} (\overline{Dd}_s - \overline{Dd}_n) \quad , \quad (2)$$

$$DL = \frac{1}{2} \left[\overline{(O-C)}_n + \overline{(O-C)}_s \right] + \frac{1}{2} b (\overline{\tan Z}_n + \overline{\tan Z}_s) - \frac{1}{2} (\overline{Dd}_s + \overline{Dd}_n) \quad .$$

Hacemos notar que los guiones sobre las respectivas expresiones significan promedio y además que los segundos y terceros términos del segundo miembro de ambas son de segundo orden respecto al primero, de modo que, prescindiendo de ellos, podemos calcular valores a' y DL' de primera aproximación para a y DL respectivamente, y con ellos corregir los (O-C) de una serie, obteniendo lo que llamaremos (O-C)', cuyo valor numérico y expresión se puede escribir:

$$\begin{aligned} (O-C)' &= (O-C) + a'(\text{sig.} Z) - DL' = -b' \tan Z + Dd' \quad \text{para Culm. Sup.} \quad , \\ &= -b' \tan Z - Dd' \quad \quad \quad \text{" " Inf.} \end{aligned} \quad (3)$$

Estas dos últimas ecuaciones muestran que podemos calcular un valor de b' por cada observador, combinando para cada uno el conjunto de las estrellas tomadas en culminación superior contra el mismo conjunto tomado en culminación inferior durante todo el período de observación:

$$-b' = \frac{\overline{(O-C)}'_{\text{sup}} + \overline{(O-C)}'_{\text{inf}}}{\overline{\tan Z}_{\text{sup}} + \overline{\tan Z}_{\text{inf}}} \quad (4)$$

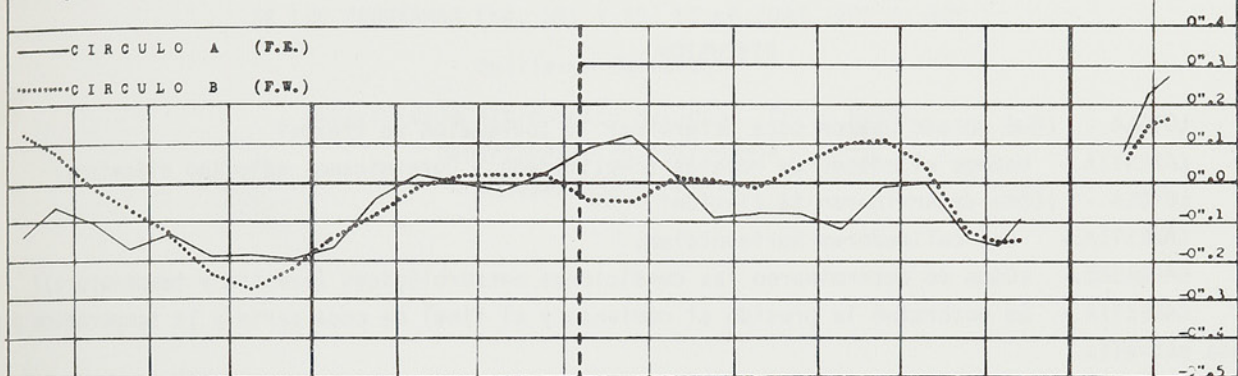
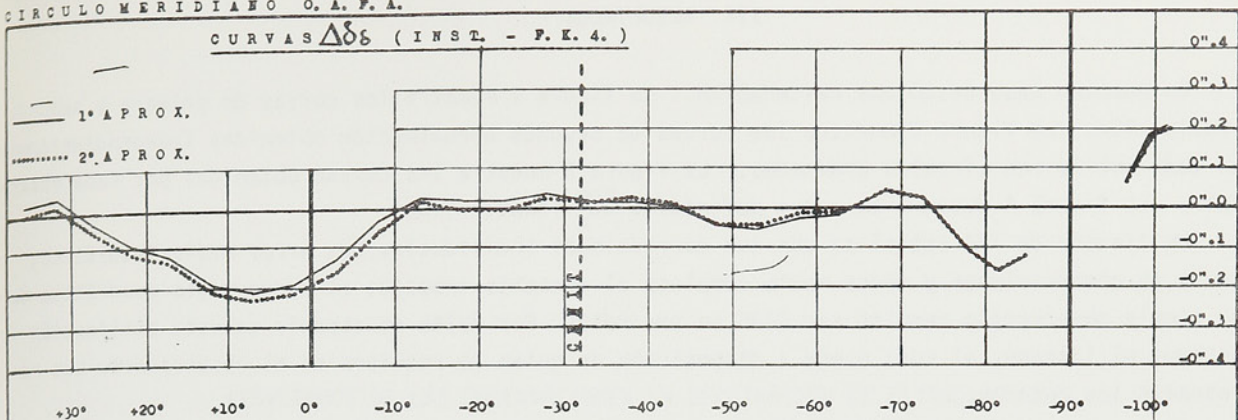
y con éste calcular:

$$(O-C)'' = (O-C)' + b' \tan Z = Dd'$$

con lo que tenemos en primera aproximación valores Dd de corrección al FK4. Con ellos podemos obtener también en primera aproximación la curva $\widetilde{Dd}_d$ que nos da la diferencia sistemática en el sentido INSTRUMENTO - FK4 en función de la declinación. Ahora, el proceso de cálculo puede ser reiterativo a partir de las ecuaciones (2), con los b' calculados según (4) y los valores $\overline{Dd}$ extraídos de la última curva general $\widetilde{Dd}_d$.

CIRCULO MERIDIANO O. A. F. A.

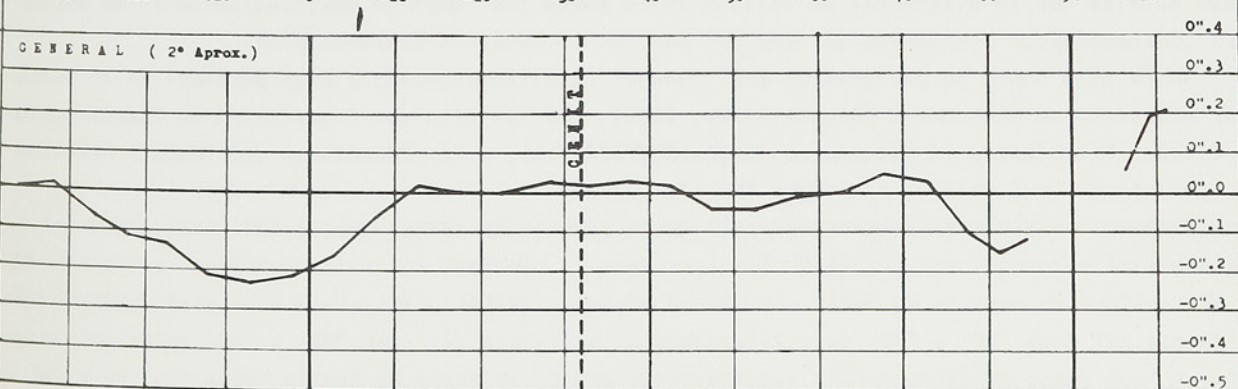
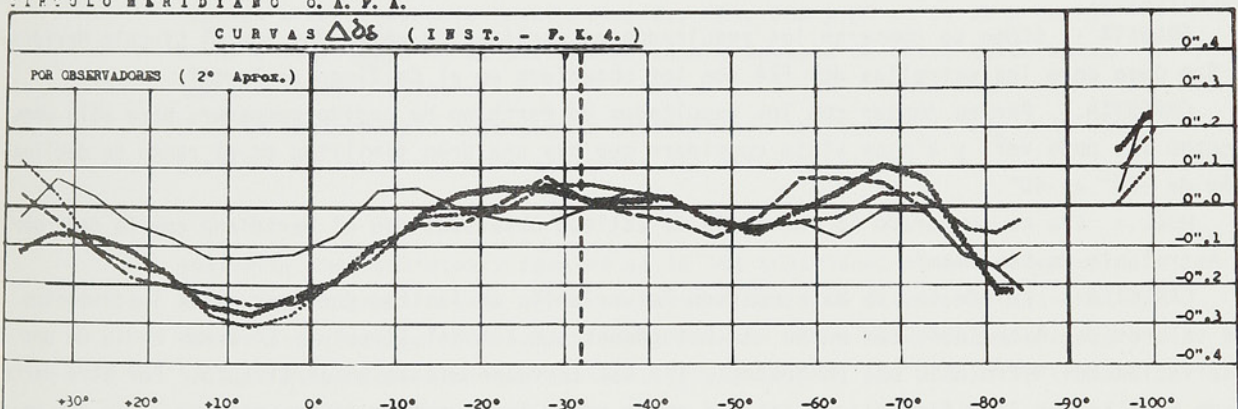
CURVAS $\Delta\delta$ (INST. - F. K. 4.)



Figs. 1-2.

CIRCULO MERIDIANO O. A. F. A.

CURVAS $\Delta\delta$ (INST. - F. K. 4.)



Figs. 3-4.

III. RESULTADOS

En nuestro caso bastó una reiteración. La figura 1 muestra las curvas de primera y segunda aproximación. La figura 2 muestra las curvas de segunda aproximación obtenidas independientemente con cada uno de los círculos graduados. La figura 3 muestra las curvas obtenidas por cada observador. La figura 4 muestra la curva definitiva $\widetilde{Dd}_d$ (Inst. - FK4).

Un listado de 774 estrellas con sus correcciones individuales Dd , error medio cuadrático, número de observaciones y época media completa el presente trabajo; el error medio cuadrático de una simple observación resultó ser 0"36 en promedio. Por falta de espacio en esta publicación omitimos el listado, el cual queda a disposición de quien lo requiera en el observatorio que representan los autores.

DISCUSION

LOYOLA.- ¿Qué método usaron para determinar la corrección de trazos?

CARESTIA.- Usamos el método de rosetas simplificado. Determinamos sólo 180 diámetros.

LOYOLA.- ¿Cómo determinaron la flexión?

CARESTIA.- Con colimadores horizontales.

CARRASCO.- ¿Cómo se determinaron las condiciones meteorológicas (presión y temperatura)?

CARESTIA.- Se determinó la presión al comienzo y al final de cada serie y la temperatura para cada estrella.

CARRASCO.- ¿Cada cuántas divisiones se efectuó la investigación del círculo?

CARESTIA.- Tenemos las correcciones para cada división del círculo (de 4' en 4') y para ambos círculos.

ANGUITA.- ¿Cómo se comparan los resultados en declinación obtenidos por el Círculo Meridiano de San Juan para las estrellas del FK4 con los obtenidos en el Catálogo de Perth?

CARESTIA.- Por no contar con los resultados de Perth no he podido comparar; hace sólo unos minutos los pude ver, y a ojos vista considero que hay una gran similitud en el rango de declinación de -20° a -40° .

NOËL.- ¿Se ha comparado la variación de latitud observada con el Meridiano con lo dado por el Astrolabio de San Juan?

CARESTIA.- En efecto, se ha comparado la variación en latitud dada por ambos instrumentos. Los valores del Astrolabio son mucho más homogéneos que los del Círculo. El error medio de una observación del Astrolabio es, en general, 1/2 del correspondiente en el Círculo. Por otra parte, puedo señalar que la diferencia en latitud entre ambos instrumentos varía hasta en 2" en dos noches consecutivas.

Sobre este punto se presentaron dos trabajos detallados en la XX Reunión Anual de la Asociación Argentina de Astronomía (Buenos Aires, 1975), con los títulos: *Correlación en Latitud entre el Círculo Meridiano y el Astrolabio Danjon del O.A.F.A.*, y *Comportamiento del Círculo Meridiano de San Juan en Declinación; Error por Ilusión Óptica*.

RESULTADOS DE LAS OBSERVACIONES EN DECLINACION DE ESTRELLAS
DE LOS PROGRAMAS FK4, SRS Y BS, EN LA ZONA -20° A -40°

Guillermo Carrasco

Observatorio Astronómico Nacional, Cerro Calán
Departamento de Astronomía
Universidad de Chile

RESUMEN: Se presentan los resultados preliminares de 18 583 observaciones individuales en declinación, correspondientes a 3319 estrellas pertenecientes a los Programas Internacionales FK4, SRS y BS en la zona de -20° a -40° , observadas en el Círculo Meridiano Repsold de Cerro Calán entre los años 1963 y 1970.

Se incluyen las diferencias sistemáticas de tipo $\Delta\delta_{\delta}$ y $\Delta\delta_{\alpha}$ y la comparación de los resultados obtenidos con otros catálogos.

ABSTRACT: The preliminary results of 18 583 individual observations of stars in declination made with the Repsold Meridian Circle of Cerro Calán Observatory between 1963 and 1970 are given. These observations belong to 3319 stars from the International Programme FK4, SRS and BS in the declination zone -20° to -40° .

The systematic differences $\Delta\delta_{\delta}$ and $\Delta\delta_{\alpha}$ and the comparison with other catalogues are presented.

I. INTRODUCCION

Entre los años 1963 y 1970 fueron observadas en el Círculo Meridiano Repsold de Cerro Calán 3319 estrellas pertenecientes al Catálogo Fundamental FK4 (215) y a los Programas Internacionales Southern Reference Stars, SRS, (2745) y Bright Stars, BS, (359) en la zona de declinación comprendida entre -20° y -40° para las estrellas fundamentales y de -25° a -35° para las estrellas del SRS y BS. El autor obtuvo un total de 18 583 observaciones individuales en ambas posiciones del instrumento.

La investigación de los errores sistemáticos y periódicos del tornillo de declinación y de los

tornillos de los microscopios para la lectura visual del círculo, como también la investigación del círculo principal, fueron realizadas en 1962, antes del comienzo de las observaciones (Anguita *et al.*, 1963). Posteriormente, en 1966, se realizó fotográficamente la investigación de los errores de división, con el objeto de determinar las correcciones a la lectura del círculo para cada una de sus divisiones (Zverev, 1970).

II. OBSERVACIONES

Las observaciones, con una duración aproximada de 5 horas, fueron realizadas en su totalidad por el autor; consistieron en la observación de un promedio de 70 estrellas de los programas SRS y BS, intercalando 4 a 6 estrellas fundamentales por hora de observación, para aplicar el método diferencial descrito por Zverev (1969).

La lectura del círculo de declinación se registró con 8 cámaras fotográficas de 35 mm marca FOLM, ocupándose 4 para cada posición del instrumento. La totalidad de estos registros fue medida, entre los años 1971 y 1972, en la máquina semi-automática diseñada por el Dr. Platonov y construida en el Observatorio de Pulkovo, Leningrado.

Durante el transcurso de una serie de observaciones la temperatura ambiente y la presión atmosférica fueron medidas con un intervalo de 1 hora.

Usando el espejo de mercurio se determinó el valor de la vuelta del tornillo de declinación a lo largo de todo el período de las observaciones. Desde Abril de 1965 se determinó la lectura del nadir en cada una de las series de observaciones para poder calcular las declinaciones de las estrellas conociendo sus distancias cenitales y comparar posteriormente estos resultados con los obtenidos aplicando el método diferencial.

III. REDUCCION Y COMPILACION DE LAS OBSERVACIONES

La reducción y la compilación de las observaciones se hicieron con el computador IBM-360 de la Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile.

El punto del Ecuador, calculado para cada estrella, está dado por:

$$E = \bar{M} + \bar{\Delta}_{\text{mdiv}} - R''_{\delta} (\bar{m}_{\delta} - m_0) \pm \bar{\Delta}_{\text{mk}} \pm M_{\rho} \pm \delta, \quad ,$$

en que: E es el punto del Ecuador; $\bar{M}$, la lectura media de los cuatro microscopios; $\bar{\Delta}_{\text{mdiv}}$, la corrección de la lectura del círculo (1962); R''_{δ} , el valor adoptado para la vuelta del tornillo de declinación (18"38); $\bar{m}_{\delta}$, el promedio de las lecturas del micrómetro; m_0 , la vuelta 4.00 del tornillo; $\bar{\Delta}_{\text{mk}}$, la corrección por curvatura del paralelo; M_{ρ} , la corrección por refracción, calculada con las Tablas de Pulkovo, y δ , la declinación aparente de la estrella. El signo superior corresponde a las observaciones con clamp al E mientras que el signo inferior es para el clamp W.

Luego se determinó el punto del Ecuador E_0 para cada serie, con las estrellas del catálogo FK4. Con los valores E_0 de cada estrella fundamental se determinó una variación lineal del punto del Ecuador con el tiempo y con estos parámetros se determinó un nuevo punto del Ecuador, E_c , para cada estrella observada, obteniéndose finalmente las diferencias:

$$\Delta E = \pm (E - E_c) \quad ,$$

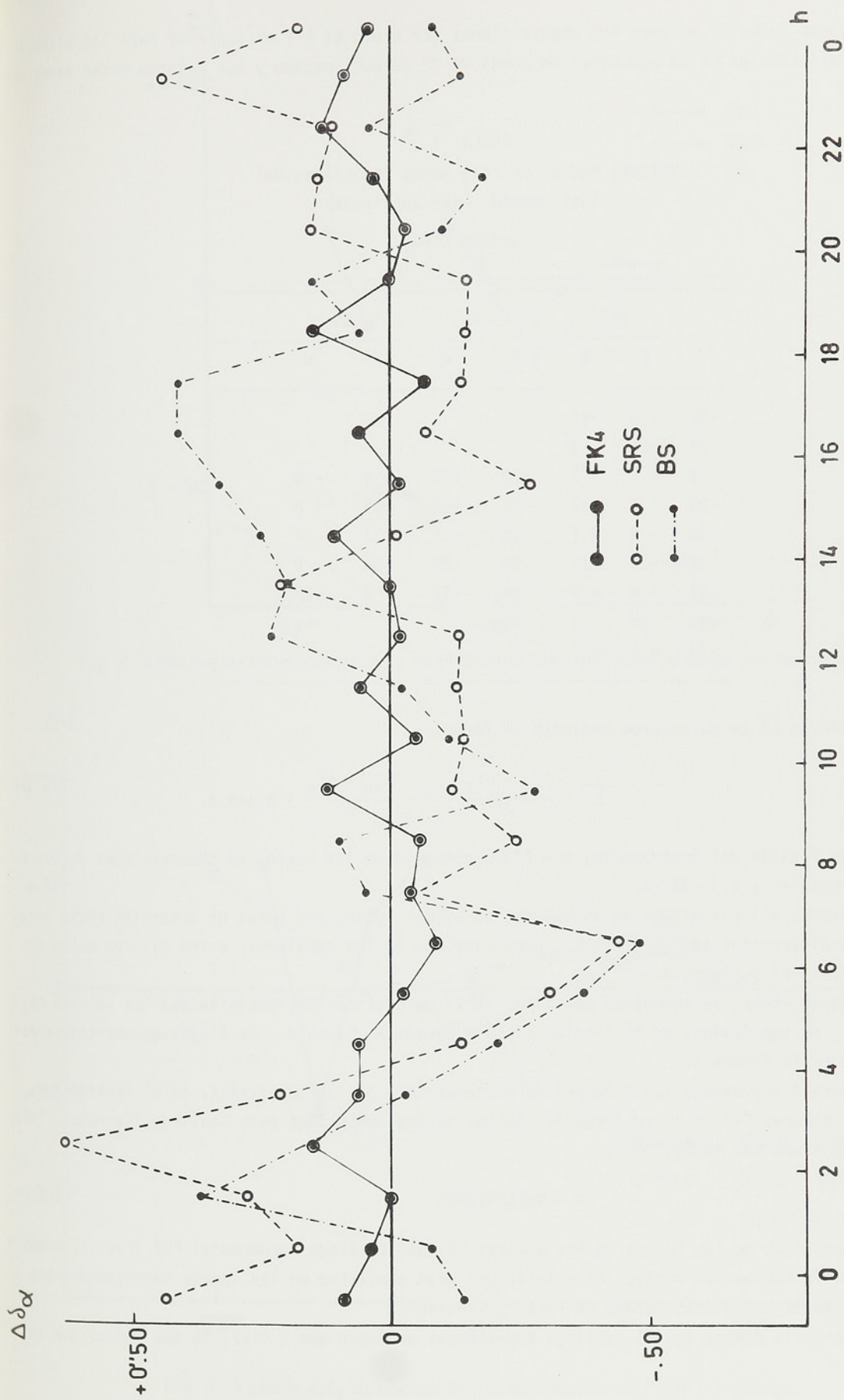


Fig. 1. Diferencias sistemáticas $\Delta\delta_\alpha$ en el sentido Instrumento-Catálogo (no suavizadas).

en que el signo inferior es para las observaciones con clamp al E y el superior para las clamp W.

Estas diferencias ΔE se agruparon en zonas de 2° de declinación y sus valores están dados en la Tabla I.

TABLA I
Valores Medios ΔE para ambas Posiciones del
Instrumento. (No Suavizada)

Unidad $0''.01$

δ	FK4		SRS		BS	
	E	W	E	W	E	W
-22°	- 8	+19				
-24	-16	-19				
-26	+ 7	- 1	+33	+30	+ 1	- 6
-28	+ 7	+12	+27	+45	+19	+ 8
-30	- 8	+ 1	-13	- 1	- 7	- 5
-32	- 9	-12	-20	-20	-28	- 8
-34	- 4	+ 5	-44	-52	- 2	-20
-36	+18	- 8				
-38	+ 9	+ 3				

Los valores $\overline{\Delta\delta}$ se calcularon mediante la fórmula:

$$\overline{\Delta\delta} = \frac{\Delta E_W - \Delta E_E}{2} - f = \frac{\Delta E_W - \Delta E_E}{2} - b \sin z ,$$

siendo f , la flexión del instrumento; $b = 0''.32$, obtenido de las series de observaciones de estrellas fundamentales y $z = -33^\circ - \delta$.

Los valores así calculados se agruparon, en primer lugar, por horas de ascensión recta para obtener las diferencias sistemáticas $\Delta\delta_\alpha$ para cada uno de los catálogos; estos valores están dados en la Tabla II y figura 1.

En segundo lugar, se agruparon por zonas de 2° de declinación, obteniéndose los valores $\Delta\delta_\delta$ (Tabla III), no suavizados, en el sentido Círculo Meridiano Repsold - Catálogo; encontrándose representados en la figura 2.

La figura 3 representa las diferencias sistemáticas $\Delta\delta_\delta$, no suavizadas, en el sentido instrumento - Catálogo FK4, y su comparación con los valores obtenidos para Santiago (Carrasco, 1973) y Perth (Høg y von der Heide, 1976).

IV. CONCLUSIONES

La comparación de las curvas de los valores $\Delta\delta_\delta$ del Catálogo Fundamental FK4 (Fig. 3) muestra que dichas diferencias son reales, al existir una gran similitud en las curvas correspondientes a las observaciones meridianas hechas en Perth y Santiago.

La diferencia máxima con el Catálogo Fundamental es menor que $\pm 0''.12$, lo que indica que la

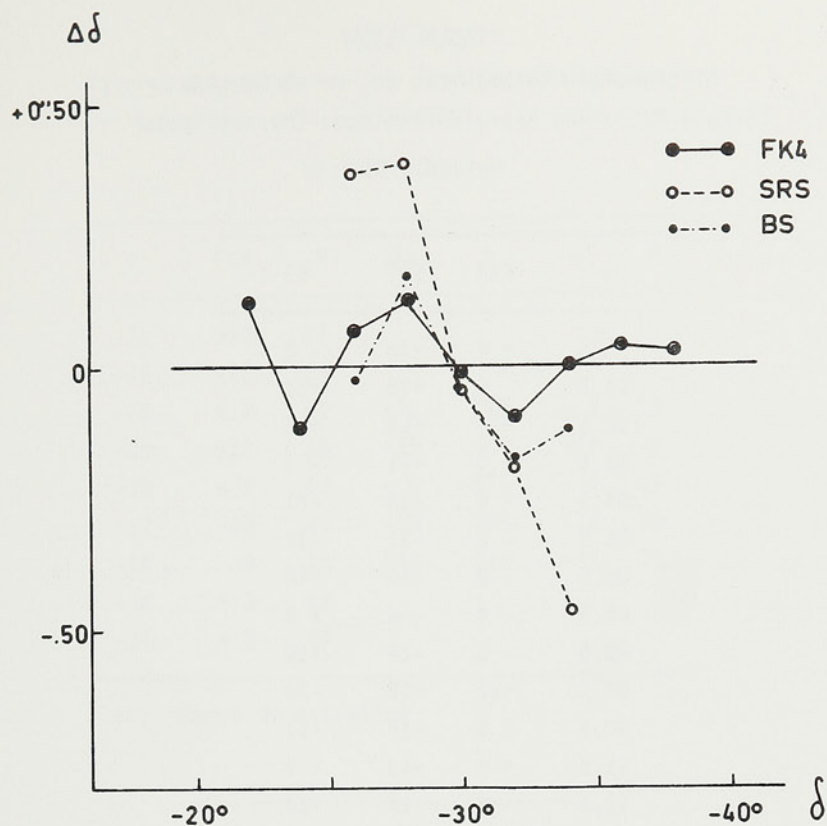


Fig. 2. Diferencias sistemáticas $\Delta\delta_\delta$ en el sentido Instrumento-Catálogo (no suavizadas).

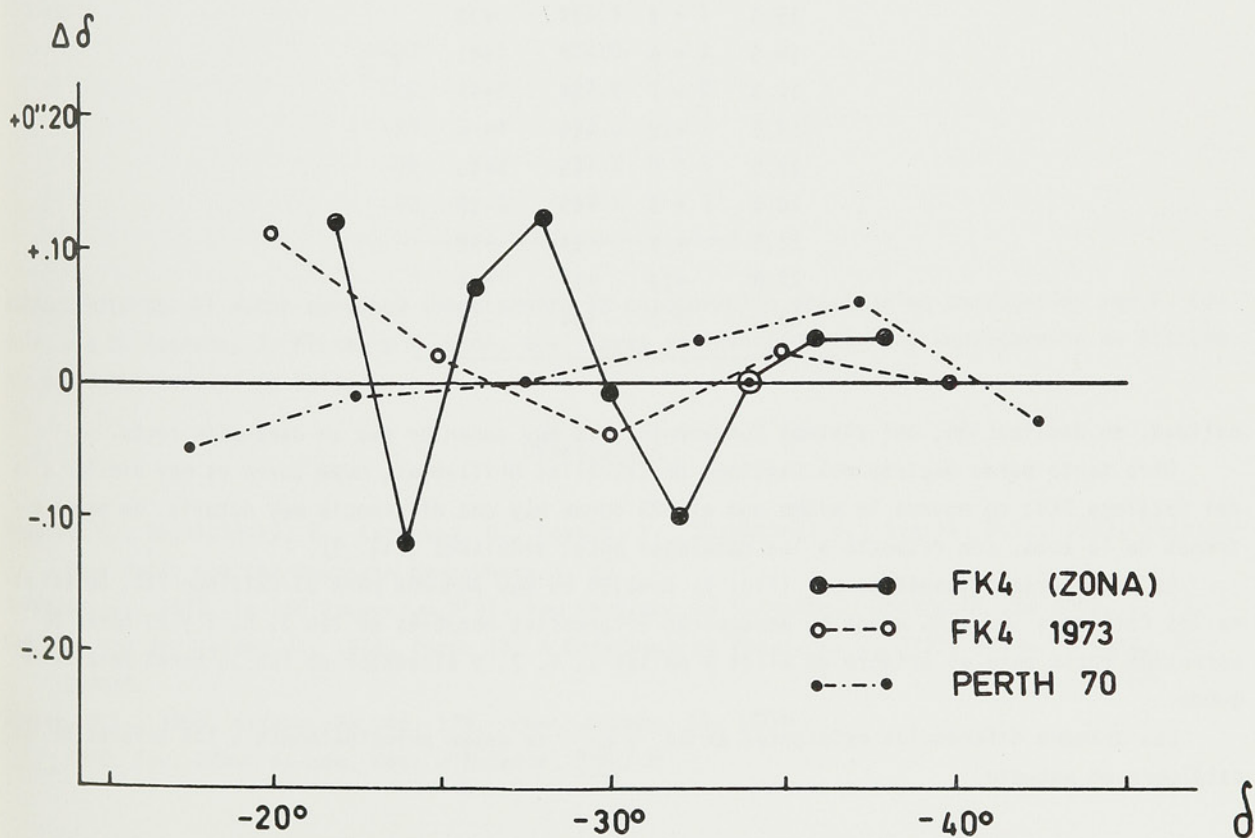


Fig. 3. Valores $\Delta\delta_\delta$ de observaciones meridianas en Perth y Santiago.

TABLA II
Diferencias Sistemáticas $\Delta\delta_\alpha$ en el Sentido
Círculo Meridiano Repsold-Catálogo. (No suavizada)
Unidad 0"01

α	FK4	SRS	BS
00.5	+ 4	+18	- 8
01.5	0	+28	+37
02.5	+15	+65	+16
03.5	+ 6	+21	- 3
04.5	+ 6	-14	-21
05.5	- 2	-31	-37
06.5	- 9	-44	-48
07.5	- 4	- 4	+ 5
08.5	- 6	-24	+10
09.5	+12	-12	-28
10.5	- 5	-14	-11
11.5	+ 6	-13	- 2
12.5	- 2	-13	+23
13.5	0	+21	+20
14.5	+11	- 1	+25
15.5	- 2	-27	+33
16.5	+ 6	- 7	+41
17.5	- 7	-14	+41
18.5	+15	-15	+ 6
19.5	0	-15	+15
20.5	- 3	+15	-10
21.5	+ 3	+14	-18
22.5	+13	+11	+ 4
23.5	+ 9	+44	-14

calidad, en declinación, del sistema fundamental es muy superior que en ascensión recta.

Otro tanto puede decirse del Catálogo de Estrellas Brillantes, cuya curva es muy similar a la del Catálogo FK4; no ocurre lo mismo con el SRS donde hay una diferencia muy notoria, en ambos extremos de la zona, con respecto a los catálogos antes señalados (Fig. 2).

La diferencia sistemática $\Delta\delta_\alpha$ (Fig. 1) también es muy pequeña para el Catálogo FK4, no así para los Catálogos SRS y BS donde se encuentran diferencias notables en las 3, 5, 7 y 23 horas de ascensión recta para el primero de ellos y en las 1, 5, 7, y alrededor de las 16 horas para el segundo.

Las grandes diferencias existentes en $\Delta\delta_\delta$ y $\Delta\delta_\alpha$ se deben principalmente a los errores de los catálogos en estudio.

TABLA III
Valores $\Delta\delta_\delta$ en el Sentido Instrumento-Catálogo,
(No Suavizada)

Unidad 0".01

δ	FK4	N	SRS	N	BS	N
-22°	+12	27				
-24	-12	23				
-26	+ 7	19	+36	543	- 2	85
-28	+12	28	+38	489	+17	74
-30	- 1	18	- 5	575	- 4	64
-32	-10	24	-19	575	-18	61
-34	0	18	-47	573	-12	75
-36	+ 3	22				
-38	+ 3	17				

N = Número de estrellas

δ	FK4 1973	δ	PERTH 70
		-17°5	- 5
-20°	+11	-22.5	- 1
-25	+ 2	-27.5	0
-30	- 4	-32.5	+ 3
-35	+ 2	-37.5	+ 6
-40	0	-42.5	- 3

AGRADECIMIENTOS: El autor agradece sinceramente la colaboración prestada en computación por P. Loyola, y a M. Estrada, J. Flores y M. León, auxiliares de investigación del Departamento de Astronomía de la Universidad de Chile.

REFERENCIAS

- Anguita, C., Bagildinsky, B., Carrasco, G., Loyola, P., Shishkina, V., Zverev, M.S., 1963, *Information Bull. for the Southern Hemisphere* 3, 30.
- Carrasco, G., 1973, in IAU Symposium N°61, *New Problems in Astronomy*. Dordrecht, Holanda, p. 73.
- Høg, E., von der Heide, J., 1976, *Perth 70. A Catalogue of Positions of 24900 Stars*, Hamburg, Bergedorf.
- Zverev, M.S., 1969, *Astron. Zh.* 46, 129. (*Sov. Astron.* 13, 1008).
- _____, 1970, *Izv. Glav. Astron. Obs. v Pulkove*, 185, 3.

ANDREI.- Nos gráficos apresentados, $\Delta\delta$ tende a aumentar proximo à declinação de -20° , o oposto acontece próximo à declinação de -40° . ¿A que se deve este efeito?

CARRASCO.- En el gráfico de la figura se observa que la curva correspondiente al Catálogo SRS presenta diferencias apreciables en los puntos indicados; este efecto se debe a los errores de tipo $\Delta\delta_\delta$ del catálogo en estudio.

ANGUITA.- Hay que hacer notar que lo que se menciona aquí como Catálogo SRS no es tal. No existe aún el Catálogo SRS. Este está en preparación y los errores que aquí se mencionan corresponden a la lista preliminar que preparó el Dr. Francis P. Scott con las estrellas que, con una distribución de una estrella por grado cuadrado, formarán el Catálogo SRS después de que todos los observadores involucrados en el programa hayan entregado sus observaciones para la compilación final del Catálogo. Habiendo preparado el Dr. Scott esta lista preliminar SRS de diferentes catálogos, con la intención de que sirviera de lista de observación, hay que sorprenderse realmente de que los errores sean tan pequeños.

CARESTIA.- ¿La observación se realizó con posición del observador en el mismo sentido o cambiándolo según que la estrella transitara al Norte o al Sur del cenit?

CARRASCO.- La observación se realizó con posición del observador en el mismo sentido, aun cuando la estrella transitara al Sur del cenit.

CARESTIA.- ¿Se observó con un solo círculo?

CARRASCO.- Sí, sólo se observó con el círculo principal (cinta de aleación de platino y paladio), opuesto al clamp. Según la investigación realizada en 1963, sus divisiones son de mejor calidad y los diámetros tienen un error sistemático menor que el segundo círculo (cinta de plata).

NOËL.- La similitud de las curvas de los tres catálogos ¿es sólo una coincidencia o representa algo?

CARRASCO.- La semejanza de las curvas de los tres catálogos en la figura 2, en los -30° , es sólo coincidencia; sólo se puede afirmar que las diferencias sistemáticas $\Delta\delta_\delta$ de los Catálogos FK4 y BS son muy similares.

NOËL.- ¿Es necesario adoptar una latitud en el método de reducción expuesto?

CARRASCO.- Sí, el valor adoptado para la latitud del meridiano es de $-33^\circ 23'8''$; se usa para el cálculo de la refracción y posteriormente en la determinación de la flexión del instrumento.

CUIDADOS COM A REFRAÇÃO DE SALA NA INSTALAÇÃO DO ASTROLÁBIO DANJON
NO OBSERVATÓRIO NACIONAL*

Alexandre Humberto Andrei, Jucira Lousada Penna,

Margaret de Queiroze e Victor Amorim D'Ávila

CNPq - Observatório Nacional Rio de Janeiro

A observação ao Astrolábio oferece resultados tanto mais satisfatórios, quanto mais uniforme for a repartição azimutal das estrelas ao redor de todo o almucantaro. Impõe-se ainda que em todos os azimutes tenhamos aproximadamente as mesmas condições de irradiação de calor, exigindo portanto os maiores cuidados no sentido de minimizar a refração de sala.

Em cooperação com o Instituto Astronômico e Geofísico - Universidade de São Paulo, iniciamos em Setembro de 1976, a instalação de um astrolábio no Observatório Nacional, Rio de Janeiro, sendo a primeira vez que é utilizado um instrumento do tipo no Observatório Nacional, tivemos a oportunidade de planificar sua instalação. Desde que o Observatório de Valinhos (IAG-USP) e o Observatório Nacional quase se situam sobre o mesmo Paralelo, tornou-se evidente que havia grande utilidade em serem observadas as mesmas estrelas e comparar os resultados obtidos. Essa circunstância possibilitou-nos atacar, entre outros, dois dos problemas que afetam a qualidade das medidas obtidas e que são ligados a efeitos térmicos sobre a observação. Esses dois problemas são, a deformação do Prisma equilateral do Astrolábio e a refração de sala que afeta a estabilidade e qualidade das imagens obtidas. Para o primeiro deles além de uma melhor compreensão da curva de variação térmica do prisma, e para tanto são a cada grupo efetuadas leituras da temperatura, é da maior importância a geometria e o material de construção da cúpula. São também estes os parâmetros principais que determinam a refração de sala.

O instrumento foi instalado numa versão modificada de casa pré-fabricada em fibra de vidro, branca, semi-esférica com raio de 2,15 m, com revestimento interno antitérmico de espuma de Poliuretano.

A simetria azimutal da construção sugere um efeito nulo da refração de sala. A cor branca exterior tem por fim diminuir as trocas de calor por radiação evitando-se assim que as paredes da cúpula entrem em equilíbrio térmico com o fundo do céu noturno que possui uma temperatura de radiação

* Trabalho subvencionado pelo CNPq.

extremamente baixa. Por outro lado, a pequena capacidade calorífica da sala deve permitir um rápido equilíbrio térmico por condução com o ar circunvizinho, minimizando-se assim as perturbações térmicas do ambiente. Por outro lado, a baixa condutividade das paredes, aliada ao sistema de refrigeração natural por convecção, protege o instrumento do aquecimento diurno. Sobre a parte superior do domo foi realizada uma abertura circular com 1.40 m de diâmetro com um dispositivo de tampa removível. O Astrolábio foi postado sobre um pilar de 1.30 m de altura de tal modo que os raios de luz percorrem somente 30 cm no interior da casa para atingir o instrumento. No ponto máximo de aproximação, os raios de luz passam a 20 cm da borda da abertura. O pilar do instrumento está assentado diretamente sobre a rocha e desvinculado mecanicamente do piso da cúpula a fim de evitar vibrações nocivas ao banho de mercúrio.

Durante os plantões de observação o fluxo convectivo ascendente de ar é invertido por meio de três exaustores separados de 120 graus e ao nível do chão. Isto assegura que o ar interposto no caminho dos raios de luz vem de fora da casa e não está, portanto, perturbado tecnicamente.

Com início das observações em Fevereiro de 1977 pudemos constatar que a qualidade e a estabilidade das imagens obtidas justificaram plenamente nossos esforços. Após o primeiro ano de observações, será iniciado o trabalho de análise final dos dados obtidos, o que permitirá uma comparação com os resultados do Astrolábio de Valinhos (São Paulo), e um estudo do desempenho da cúpula com o sistema acima descrito. Cabe ainda no encerramento desta comunicação fazer um agradecimento à Coordenadoria de Astronomia e a Direção do Observatório Nacional que nos proveu de todos os meios, recursos e apoio necessários a tornar realidade a planificação proposta, e as alterações que a prática diária impôs para a otimização dos trabalhos.

DISCUSION

NOËL.- ¿De cuantos grupos de estrellas consta el programa fundamental de vuestro astrolabio?

ANDREI.- Nosso programa consta de doze grupos fundamentais, cada qual com trinta e três estrelas.

NOËL.- ¿Por qué adoptaron un número par? Al adoptar un número par se presenta el problema de que si se reemplaza el grupo del medio por un grupo de catálogo al aplicar el método en cadena a los grupos fundamentales se obtendrán dos sistemas de correcciones de grupo independientes.

ANDREI.- Adotamos um programa com doze grupos fundamentais (F) com duração aproximada de 1^h30^m e tendo início sempre em horas siderais ímpares. O plantão de observação é mantido por dois observadores, cobrindo a noite toda. Observamos assim, usualmente 5 grupos por noite. Em futuro próximo, pretendemos iniciar a observação de grupos de catalogo (C) quando adotaremos uma configuração do tipo FFCFF, o que permitirá obter a partir das observações de grupos fundamentais consecutivos um unico sistema de correções de grupo, com a vantagem adicional de podermos relacionar os grupos de catalogo aos grupos fundamentais por interpolação.

Equações pessoais deverão ser deduzidas para minimizar os efeitos da troca de observador durante a noite.

RESULTADOS FINALES EN ASCENSION RECTA DE 6876 ESTRELLAS
OBSERVADAS EN EL CIRCULO MERIDIANO REPSOLD DE CERRO CALAN

G. Carrasco y P. Loyola

Observatorio Astronómico Nacional, Cerro Calán

Departamento de Astronomía

Universidad de Chile

RESUMEN: Se analizan los resultados de 48 257 observaciones diferenciales en ascensión recta, de estrellas pertenecientes al catálogo FK4 y a los Programas Internacionales SRS y BS en la Zona -25° a -47° de declinación. Se estudian las variaciones sistemáticas $\Delta\alpha_{\delta}$ y $\Delta\alpha_{\alpha}$ y la influencia de la magnitud y tipo espectral en los errores de observación.

ABSTRACT: The final results of 48 257 differential observations in Right Ascension of stars from FK4, SRS and BS International Programmes in the declination zone -25° to -47° are examined. The systematic differences $\Delta\alpha_{\delta}$ and $\Delta\alpha_{\alpha}$ and the influence of the magnitude and spectral type in the errors of the observation are given.

I. INTRODUCCION

Durante los años 1963-1972 se observaron, en el Círculo Meridiano Repsold de Cerro Calán, 7042 estrellas FK4, SRS y BS, pertenecientes a las zonas -25° a -35° y -35° a -47° de declinación.

En total se obtuvieron 40 995 observaciones, en ambas coordenadas, por método diferencial (Zverev, 1969). De ellas, 21 736 observaciones se hicieron con el instrumento en posición "Clamp East" y 19 259 con "Clamp West".

Las estrellas FK4 se observaron en promedio 12 veces y las estrellas SRS y BS un promedio de 2.5 veces, en cada posición del instrumento.

II. REDUCCION

La totalidad de los cálculos, desde las posiciones aparentes, los "O-C" y el análisis final, se hicieron con el Computador IBM-360 de la Facultad de Ciencias Físicas y Matemáticas de la Universidad de Chile.

La reducción en ascensión recta de las series se hizo con la fórmula de Bessel. Para cada serie de observaciones se obtuvieron los parámetros n y $u + m$, por el método de cuadrados mínimos, con estrellas fundamentales de la zona y del norte ($20^\circ < \delta < 40^\circ$). El error medio de una observación, reducido al ecuador, es de ± 0.5015 tanto para las estrellas del FK4 como para las SRS y BS.

Las correcciones de las estrellas SRS y BS están afectadas por los errores sistemáticos del catálogo FK4, ya que los valores iniciales de las ascensiones rectas de las estrellas fundamentales no se corrigieron por su dependencia con la declinación. (Anguita *et al.*, 1971; Zverev *et al.*, 1973).

III. INVESTIGACION DE LAS DIFERENCIAS

SISTEMATICAS $\Delta\alpha_\delta \cos\delta$ y $\Delta\alpha_\alpha \cos\delta$

Las diferencias sistemáticas (E-W) del tipo $\Delta\alpha_\delta \cos\delta$, para las estrellas FK4, SRS y BS, se agruparon en zonas de 2° de declinación. Sus valores se dan en la Tabla I.

TABLA I
Diferencias Instrumentales (E-W) $\Delta\alpha_\delta \cos\delta$
Unidad 0.5001

δ	FK4	SRS	BS
-22°	+4		
-24	+5		
-26	+4	+1	+4
-28	-2	-2	0
-30	+2	-1	0
-32	0	-2	-2
-34	-2	-3	0
-36	-2	-2	-1
-38	+2	0	-8
-40	-4	+2	-3
-42	-1	0	0
-44	+3	+2	0
-46	+2	+2	-2
-48	+2		
-50	+2		

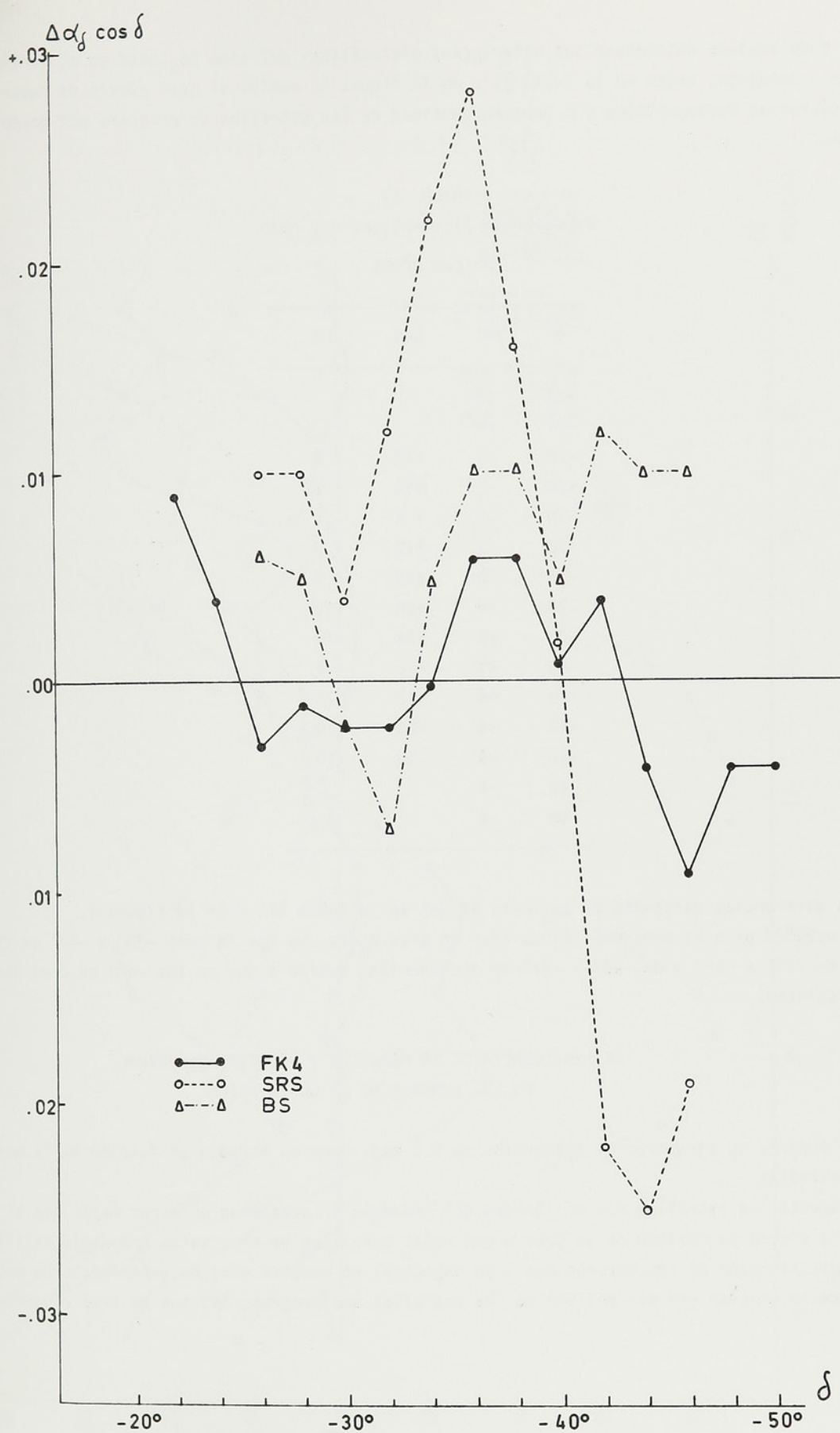


Fig. 1. Diferencias sistemáticas tipo $\Delta\alpha_\delta \cos \delta$.

Ha sido posible determinar las diferencias sistemáticas del tipo $\Delta\alpha_\delta \cos\delta$ en el sentido instrumento - catálogo, dadas en la Tabla II y en la figura 1, debido al gran número de observaciones de las estrellas fundamentales y a la gran densidad de las estrellas de programa por grado de declinación.

TABLA II
Diferencias Sistemáticas $\Delta\alpha_\delta \cos\delta$
Unidad $0^s.001$

δ	FK4	SRS	BS
-22°	+9		
-24	+4		
-26	-3	+10	+ 6
-28	-1	+10	+ 5
-30	-2	+ 4	- 2
-32	-2	+12	- 7
-34	0	+22	+ 5
-36	+6	+28	+10
-38	+6	+16	+10
-40	+1	+ 2	+ 5
-42	+4	-22	+12
-44	-4	-25	+10
-46	-9	-19	+10
-48	-4		
-50	-4		

Las diferencias sistemáticas $\Delta\alpha_\alpha \cos\delta$ se dan en la Tabla III y en la figura 2.

El estudio para el programa SRS se hizo en tres zonas, ya que la zona -35° a -47° se dividió en dos: de -35° a -40° y de -40° a -47° de declinación, debido a que en los -40° se unen dos catálogos distintos.

IV. INFLUENCIA DE LA MAGNITUD Y DEL TIPO ESPECTRAL EN LOS ERRORES DE LA OBSERVACION

Los errores se agruparon en intervalos de 0.5 mag. para su estudio en función de la magnitud de las estrellas.

Solamente las estrellas más brillantes del FK4 ($m < 2.5$) presentan un error mayor que el promedio. Este efecto probablemente se debe a que estas estrellas se observaron con doble rejilla.

La distribución de los errores por tipo espectral no muestra ninguna dependencia de éste. Es importante señalar que más del 50% de las estrellas del programa SRS son de tipo espectral K.

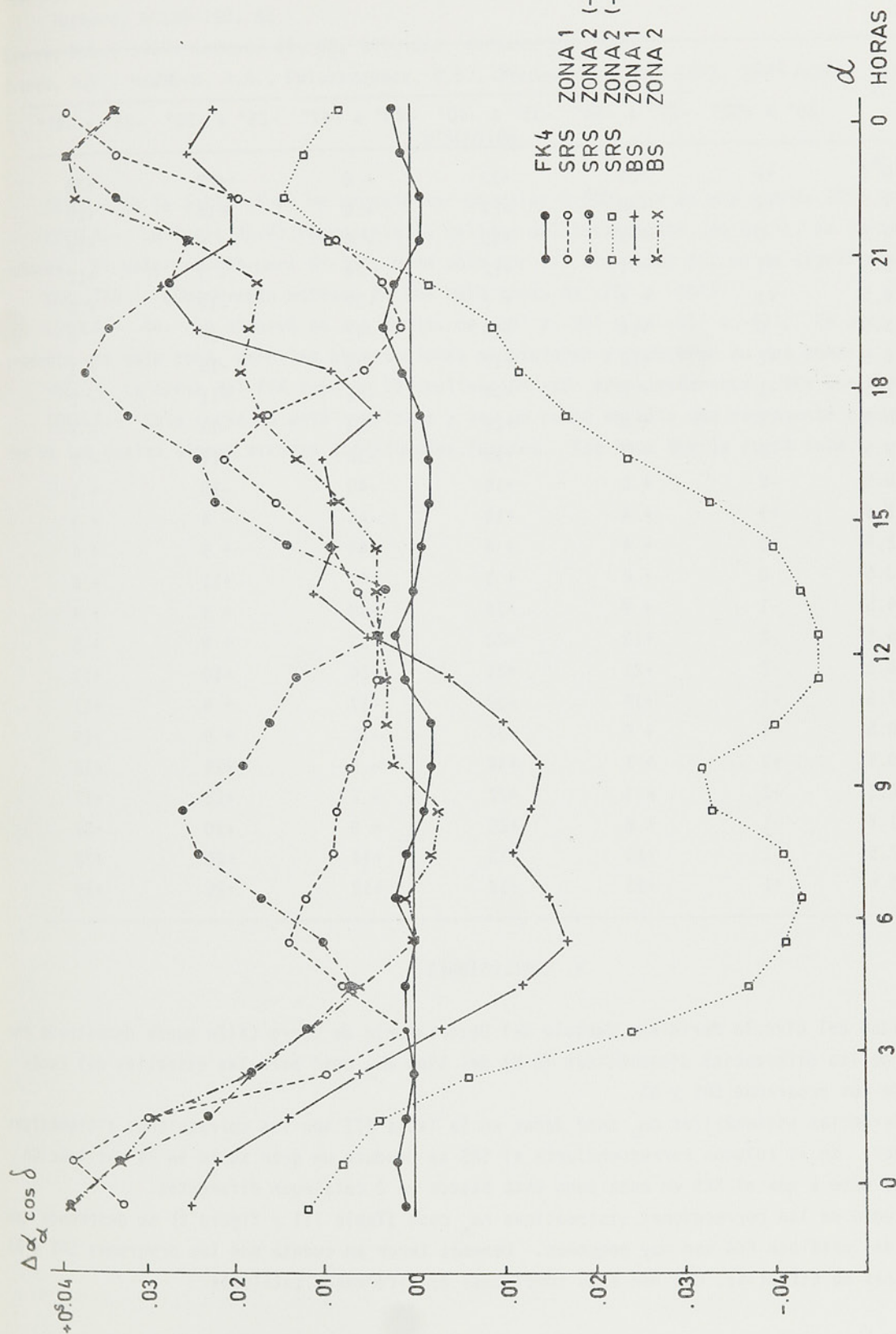


Fig. 2. Correcciones sistemáticas tipo $\Delta\alpha_\alpha \cos \delta$.

TABLA III
Diferencias Sistemáticas $\Delta\alpha_{\alpha} \cos\delta$. Suavizadas
Unidad 0.001

α	FK4	SRS				BS	
	-20° a -52°	-25° a -35°	-35° a -40°	-40° a -47°	-25° a -35°	-35° a -47°	
0.5	+2	+39	+33	+ 8	+22	+33	
1.5	+1	+30	+23	+ 4	+14	+29	
2.5	0	+10	+18	- 6	+ 6	+19	
3.5	+1	+ 1	+12	-24	- 3	+12	
4.5	+1	+ 8	+ 7	-37	-12	+ 6	
5.5	0	+14	+10	-41	-17	0	
6.5	+2	+12	+17	-43	-15	+ 1	
7.5	+1	+ 9	+24	-41	-11	- 2	
8.5	-1	+ 8	+26	-33	-13	- 3	
9.5	-2	+ 7	+19	-32	-14	+ 2	
10.5	-2	+ 5	+16	-40	-10	+ 3	
11.5	+1	+ 4	+13	-45	- 4	+ 3	
12.5	+2	+ 4	+ 4	-45	+ 5	+ 4	
13.5	0	+ 6	+ 3	-43	+11	+ 4	
14.5	-1	+ 9	+14	-40	+ 9	+ 4	
15.5	-2	+15	+22	-33	+ 9	+ 8	
16.5	-2	+21	+24	-24	+10	+13	
17.5	-1	+16	+32	-17	+ 4	+17	
18.5	+1	+ 5	+37	-12	+ 9	+19	
19.5	+3	+ 1	+34	- 9	+24	+18	
20.5	+2	+ 3	+27	- 2	+28	+17	
21.5	-1	+ 8	+25	+ 9	+20	+25	
22.5	-1	+19	+33	+14	+20	+38	
23.5	+1	+33	+39	+12	+25	+39	

V. CONCLUSIONES

La calidad del Círculo Meridiano Repsold del Observatorio de Cerro Calán queda demostrada por la pequeñez de las diferencias sistemáticas (E-W) del tipo $\Delta\alpha_{\delta} \cos\delta$ para las estrellas del catálogo FK4 y de los programas SRS y BS.

Las diferencias sistemáticas $\Delta\alpha_{\alpha} \cos\delta$ dadas en la Tabla III son las correcciones sistemáticas en estas zonas. En la columna correspondiente al SRS se produce un gran salto en la declinación -40°; esto se debe a que el SRS en esta zona está basado en 2 catálogos diferentes.

Del estudio de las correcciones sistemáticas $\Delta\alpha_{\alpha} \cos\delta$ (Tabla III y figura 2) se desprende que los errores del catálogo FK4 son muy pequeños. Debemos tener en cuenta que los programas SRS y BS son sólo listas de estrellas, que han sido compiladas de diferentes catálogos.

REFERENCIAS

- Anguita, C., Zverev, M.S., Carrasco, G., Polozhentsev, D.D., 1971, *Izv. Glav. Astron. Obs. Pulkovo*, N°189-190, 83.
- Zverev, M.S., 1969, *Astron. Zh.* 46, 129 (*Sov. Astron.* 13, 1008).
- Zverev, M.S., Naumova, A.A., Polozhentsev, D.D., Stepanova, E.A., 1973, *Sov. Astron.* 17, 279.

DISCUSION

CESCO.- En la Tabla (E-W) me pareció ver un valor 0.008, que es muy grande. ¿Por qué ese salto?

LOYOLA.- La Tabla (E-W) representa la calidad del instrumento, es decir, la calidad de los muñones. El valor -0.008 para $\delta = -38^\circ$, dado sólo por las estrellas BS, no es significativo.

CARESTIA.- ¿Observaron ustedes en una sola zona, de -25° a -40° ?

LOYOLA.- No. Se observó en dos zonas: de -25° a -35° y de -35° a -47° . En este trabajo se presenta una sola zona, pero las observaciones se hicieron y redujeron en dos zonas.

NOËL.- La curva del FK4 sube en la declinación -45° aproximadamente. ¿Es eso real?

LOYOLA.- Esta curva no está suavizada y hay un punto en ella que representa pocas estrellas, dos de las cuales tienen errores individuales fuertes. Eso hace que la curva suba.

POSITION DETERMINATIONS FROM OBJECTIVE PRISM PLATES

Jurgen Stock

Centro de Investigación de Astronomía "Francisco J. Duarte"
Mérida

ABSTRACT: Pairs of plates taken with objective prism having opposed dispersion permit the derivation of stellar positions of high accuracy. These positions are free of systematic errors of a chromatic nature. A catalogue of positions for 5870 stars demonstrates that position catalogues obtained from large field refractor plates, such as the *Vale Catalogue of the Positions and Proper Motions of Stars Between Declinations -30° and -35°* , contain systematic errors which depend on the color of the stars.

Theoretical considerations by Stock and Uppgren (1968) as well as numerical experiments by the author have shown that the field distortion caused by an objective prism is negligible in the direction perpendicular to the dispersion even for a large field such as that of a Schmidt telescope. In the direction of the dispersion, only one important distortion term appears when the prism is oriented within one degree of the angle of minimum deflection. The distortion term is proportional to the square of the distance from the optical axis. When coordinates combined from two plates with opposed dispersion are used, this term vanishes. Thus one has to consider only those distortion terms which are due either to the optical system of the telescope itself or to atmospheric refraction. In other words, one has to deal only with the same field distortion which one would encounter on direct plates taken with the same telescope.

Plates taken with the Curtis Schmidt telescope at Cerro Tololo, equipped with a four-degree prism, were used for an empirical test. These plates were actually taken for the determination of radial velocities, and the same measurements were used to test the accuracy of positions derived from the spectra.

A non-negligible radial velocity or an asymmetry of a line due to blends would cause an apparent displacement of a line in the direction of the dispersion in a single spectrum. These effects drop out when positions combined from two plates with opposite dispersion are considered.

To compare the positions measured on a plate pair with those from a different source, in this

case the Yale Catalogue of the Positions and Proper Motions of Stars Between Declination -30° and -35° (Hoffleit, 1967), the following procedure was used:

- 1.- A plate pair was measured in a Zeiss PSK-2 stereo comparator. In each pair of spectra the positions of as many lines were measured as could be safely identified. The X-coordinate was chosen perpendicular to the dispersion, the Y-coordinate in the direction of the dispersion. The latter also coincides with the direction North-South. Averaging the coordinates from both plates, we obtain a set of values of $X(I,L)$ and $Y(I,L)$, where I identifies the star, and L identifies the spectral line. A total of eighteen lines was chosen for measurement. Naturally, in each spectrum only a certain number of these lines was present. On the average, eight or nine lines were measured for the star in common with the Yale Catalogue.
- 2.- The Yale positions, corrected for proper motion, were transformed into plane rectangular ξ, η coordinates, which are in the direction North-South. For the transformation, the equations of the "concentric projection" were used, since it is the most adequate one for curved Schmidt plates.
- 3.- The XY-coordinates and the $\xi\eta$ -coordinates were then compared, assuming the relations:

$$\xi = \sum_{i,j=0}^{i+j=3} A_{ij}(\lambda) X^i Y^j, \quad (1)$$

$$\eta = \sum_{i,j=0}^{i+j=3} B_{ij}(\lambda) X^i Y^j. \quad (2)$$

The coefficients A_{ij} and B_{ij} may be functions of the wavelength; hence equations (1) and (2) have to be solved separately for every spectral line. A combined solution could be obtained, since theory shows that all coefficients, if wavelength dependent at all, will be linear functions of the refractive index of either the air or the prism, both of which are known. This, however, was found to be impractical because the data showed that the coefficients depend on the spectral type of the stars and not on the wavelength. A typical example is shown in Table I for one coefficient. All coefficients for both coordinates show similar effects. The table exhibits clearly that there is no appreciable wavelength dependence, but there is a striking spectral type dependence. In fact, many more plate pairs, covering different fields of the sky, were measured, and they all show the same type of effect although quantitatively different.

It is obviously impossible to construct an effect which would produce a spectral-type dependent displacement of a spectrum perpendicular to the direction of the dispersion. The effects hence must be present in the data of the Yale Catalogue. No doubt they are due to color-dependent displacements on the Yale refractor plates. The coefficients found for equations (1) and (2) indicate that systematic errors in the Yale positions due to color terms may, in extreme cases, exceed two seconds of arc in both coordinates.

Naturally, the effects just mentioned do not affect the determination of proper motions if the plates for both epochs have been taken with the same telescope using the same plate center. However, that implies that no changes in the optical system of the telescope have occurred between the two epochs. The latter is not necessarily true, particularly if large epoch differences are involved, and these are particularly desirable. Furthermore, no combination of different epochs from different telescopes appear to be possible, unless the color-dependent errors are removed. Therefore, it would be desirable to determine the exact nature of these systematic errors for the Yale

TABLE I
Coefficient A20 for Plate Pair 6828 - 6830

λ	A-stars	K-stars
4861 Å	-0.29×10^{-5}	
4340	- .16	
4227		-0.05×10^{-5}
4102	- .17	
3889	- .20	
3835	- .22	
3798	- .15	
3771	- .22	
3750	- .26	
3748		- .00
3735		- .03
3720		- .03
3706		- .03

refractor, as well as for others, and to carry out a new reduction of the original measurements. Only in this way will the Yale data be usable to full accuracy even when the Yale telescope no longer exists.

REFERENCES

- Dieckvoss, W., 1972, in *The Role of Schmidt Telescopes in Astronomy*, ed. U. Haug. Hamburg, European Southern Observatory, p. 39.
Hoffleit, D., 1967, *Transactions of the Astronomical Observatory of Yale University*, 28.
Stock, J., Upgren, A., 1968, *Publ. Dep. Astr. Univ. Chile.* 2, 11.

DISCUSSION

LOYOLA.- Las posiciones obtenidas por este método, ¿no estarían afectadas por un error estacionario? Es decir, la posición obtenida cuando la tierra se acerca a la estrella sería distinta a la posición determinada cuando la tierra se aleja de la estrella.

STOCK.- La paralaje afecta las posiciones, pero es importante solamente para estrellas cercanas, y se anula cuando las placas se toman cerca de la oposición de la zona.

TORRES.- Ud. mencionó dos pares de placas para cada zona, ¿se refiere a dos placas con el prisma en una posición y dos con el prisma girado en 180° respecto a la posición anterior?

STOCK.- Eso es correcto.

CORRECCIONES PRELIMINARES $\Delta\alpha$ Y $\Delta\delta$ DE 120 ESTRELLAS DEL FK4 Y FK4 SUP.

W. Manrique, E. Actis y A. Serafino

Observatorio Astronómico Félix Aguilar, Universidad Nacional de San Juan

ABSTRACT: Preliminary corrections $\Delta\alpha$ y $\Delta\delta$ for 120 stars from the FK4 and FK4 Suppl. have been obtained from Astrolabe observations at San Juan, Argentina.

I. INTRODUCCION

Desde la puesta en servicio del Astrolabio Impersonal Danjon en el Observatorio Astronómico "Félix Aguilar" de San Juan, Argentina, en Julio de 1968, se ha observado sistemáticamente un programa de 12 grupos de composición invariable. Este programa se ha destinado especialmente a la determinación de Tiempo y Latitud y se lo ha designado Programa Fundamental. Basándose en el estudio de aproximadamente 31 200 residuos de series seleccionadas, procesados por métodos conocidos (Guinot, 1958), se han deducido las correcciones $\Delta\alpha$ y $\Delta\delta$ de 112 estrellas de doble pasaje, como asimismo los errores sistemáticos del FK4. Estos resultados fueron comunicados en la XX Reunión de la Asociación Argentina de Astronomía y publicados en el Suplemento 26 (381-387) de *Astronomy and Astrophysics*, constituyendo el Primer Catálogo Astrolabio de San Juan.

II. PROGRAMA DEL CATALOGO

Con el objeto de ampliar este primer catálogo, se ha asociado a la observación de los grupos fundamentales la observación de grupos especiales denominados grupos de Catálogo. De esta manera se ha formado un programa compuesto por 12 grupos de 30 estrellas en promedio cada uno, incluyendo 92 del FK4 y 88 del FK4 Sup., todas de doble pasaje. Su duración aproximada es de 1 hora 40 minutos.

Este programa se ha observado sistemáticamente, sin descuidar la observación de los grupos fundamentales que han servido de base para el procesamiento posterior.

III. OBTENCION DE RESIDUOS

Debido a las malas condiciones atmosféricas reinantes durante un largo período, varios grupos de catálogo han sido observados aisladamente, perdiendo su vinculación con los fundamentales. Por esta razón se ha tentado procesar estos datos de una manera un tanto diferente al propósito original. No obstante que los grupos de catálogo no cumplen estrictamente las condiciones de simetría de los fundamentales, fueron procesados de la misma manera, obteniéndose valores ΔT , $\Delta \phi$ y Δz aceptables y comparables a los calculados a partir de los grupos fundamentales. Es así que los residuos se dedujeron de los valores determinados por el mismo grupo de catálogo utilizando la ecuación de condición ya conocida:

$$x \sin Z + y \cos Z - z + \delta h = 0$$

IV. CALCULO DE $\Delta \alpha$ Y $\Delta \delta$

Si llamamos m el residuo promedio pesado correspondiente a una estrella de determinado grupo, Z su acimut y ϕ la latitud del instrumento, y dx , dy , dz son respectivamente las correcciones de grupo en Tiempo, Latitud y Distancia Cenital, el residuo M de la estrella con respecto a un grupo promedio del sistema de grupos observados está dado por:

$$M = m + dx \sin Z \cos \phi + dy \cos Z - z = m + dm$$

Para vincular estos residuos al mismo grupo promedio de los fundamentales, las correcciones dx , dy , dz se derivaron de la siguiente manera (Serafino, Actis): se obtuvieron los promedios de las diferencias sistemáticas en Tiempo, Latitud y Distancia Cenital entre grupos fundamentales y de catálogo observados en la misma noche por un mismo observador, utilizando series seleccionadas de peso 1 como mínimo:

$$\text{Gr. Fund.} - \text{Gr. Cat.}$$

Como las correcciones de los grupos fundamentales con respecto a un grupo promedio, conocidas con bastante precisión, son de la forma:

$$\text{Gr. Prom.} - \text{Gr. Fund.} \quad ,$$

la simple suma de estas expresiones dará:

$$\text{Gr. Prom.} - \text{Gr. Cat.} \quad .$$

Por lo tanto:

$$\Delta T \text{ Fund.} - \Delta T \text{ Cat.} = A \quad ,$$

$$\Delta T \text{ Prom.} - \Delta T \text{ Fund.} = B \quad ,$$

$$dx = \Delta T \text{ Prom.} - \Delta T \text{ Cat.} = A + B \quad .$$

TABLA I
Programa de Catálogo

Correcciones Preliminares $\Delta\alpha$ y $\Delta\delta$ de 120 Estrellas del FK4 y FK4 Sup.

N	FK4	Mag	$\Delta\alpha$	$\Delta\delta$	N	FK4Sup	Mag	$\Delta\alpha$	$\Delta\delta$
1	3	3.9	-0.039		1	2014	5.7	-0.054	
2	1013	5.6	-0.015		2	2048	4.9	+0.022	-0.36
3	1014	5.6	-0.012	-0.74	3	2364	5.8	+0.027	
4	1018	5.5	+0.010	+0.52	4	2377	5.0	-0.011	-1.06
5	1139	6.0	+0.017		5	2685	4.4	-0.064	-0.13
6	1230	5.2	-0.008	+0.15	6	2725	5.5	-0.042	+0.57
7	1240	5.8	-0.006	+0.43	7	2763	5.7	-0.017	+0.28
8	1242	5.8	+0.005	-0.12	8	2830	4.6	-0.022	+0.53
9	1243	4.9	-0.024	-0.56	9	2848	5.1	-0.001	
10	364	5.0	+0.015	+0.14	10	2871	5.8	-0.021	+0.50
11	366	5.0	-0.024		11	2884	5.9	+0.014	-1.22
12	375	3.7	-0.025	-0.36	12	2885	5.5	-0.006	
13	1265	5.6	-0.013		13	2894	5.8	-0.018	
14	415	4.6	+0.007		14	2948	6.0	-0.062	
15	1289	4.0	-0.005	-0.08	15	2950	5.5	-0.016	+0.59
16	463	5.7	-0.011		16	2956	5.6	-0.108	-0.30
17	471	2.8	0.000	+0.21	17	2961	5.3	-0.021	+0.45
18	1352	5.8	+0.011	+0.04	18	2988	5.4	-0.023	+0.45
19	519	3.5	-0.010	-0.41	19	2989	3.6	+0.021	-0.24
20	520	2.3	-0.004		20	2992	5.4	-0.006	
21	523	4.3	+0.010	-0.15	21	3018	4.9	-0.057	+0.19
22	525	4.2	+0.009	-0.90	22	3029	5.6	+0.015	
23	1376	5.4	-0.005	+0.14	23	3055	6.0	-0.088	-0.95
24	532	5.0	+0.010		24	3078	5.9	-0.019	+0.28
25	556	3.4	+0.006	-0.71	25	3084	6.0	+0.088	
26	594	2.5	-0.022	-0.27	26	3091	5.2	-0.041	
27	599	4.3	+0.018		27	3112	4.2	+0.015	
28	620	2.9	-0.008		28	3137	5.7	-0.014	
29	1445	5.0	+0.005	-0.30	29	3138	6.0	-0.052	-0.80
30	638	3.4	-0.002		30	3143	5.7	-0.004	-0.24

TABLA I (Continuación)

N	FK4	Mag	$\Delta\alpha$	$\Delta\delta$	N	FK4Sup	Mag	$\Delta\alpha$	$\Delta\delta$
31	1457	4.3	-0.035	-0.17	31	3184	5.9	+0.020	
32	647	4.6	-0.017	-0.05	32	3198	5.6	-0.034	+0.12
33	1464	Var	-0.034		33	3266	4.7	+0.004	+0.26
34	669	3.3	-0.038		34	3277	5.6	-0.065	
35	689	2.0	-0.032		35	3295	5.4	-0.081	
36	692	2.9	-0.015	-0.23	36	3297	5.8	-0.026	-0.69
37	1489	4.5	-0.006	+0.05	37	3307	4.6	+0.017	-0.28
38	727	4.6	+0.004	+0.02	38	3321	5.9	-0.122	-0.33
39	735	5.0	+0.007	+0.64	39	3342	5.4	+0.007	-0.08
40	737	5.0	-0.012	+0.27	40	3354	5.1	-0.044	
41	1512	5.5	+0.010	-0.29	41	3425	5.0	-0.069	
42	751	4.4	-0.003		42	3444	5.9	+0.036	
43	763	5.6	+0.012		43	3500	6.0	-0.004	+0.15
44	1546	4.2	+0.030		44	3511	5.1	+0.096	-0.20
45	1556	5.6	+0.006		45	3512	4.9	+0.009	
46	1561	4.3	+0.016	-0.26	46	3519	4.9	+0.038	
47	1567	5.7	+0.003		47	3534	5.6	+0.001	+0.23
48	1577	5.2	+0.033	+0.06	48	3544	5.1	-0.008	+0.19
49	1581	4.6	-0.025		49	3552	5.8	+0.012	+0.50
50	818	5.4	+0.030	+0.19	50	3558	5.9	-0.007	
51	819	3.0	+0.016	-0.17	51	3560	5.9	-0.035	
52	822	3.2	+0.007		52	3597	6.0	-0.064	
53	838	5.4	-0.002		53	3680	5.2	-0.066	-0.15
54	1599	5.4	-0.022		54	3684	5.6	+0.013	
55	1607	4.4	+0.006	-0.19	55	3719	5.4	-0.056	
56	886	4.5	-0.011		56	3767	5.8	+0.021	
57	1618	5.3	+0.005		57	3791	5.9	+0.020	-0.16
58	1621	5.3	+0.008	-0.26	58	3832	5.9	-0.013	-0.91
59	896	4.6	-0.017		59	3860	5.6	-0.025	+0.44
					60	3876	5.6	+0.053	-0.83
					61	3932	5.0	-0.016	

Aplicando el mismo razonamiento a $\Delta\phi$ y Δz se obtienen dy y dz respectivamente, correcciones de los grupos de catálogo para referirlos al mismo grupo promedio de los fundamentales.

Si M_E y M_W son los residuos M de las estrellas en su pasaje Este y Oeste y S es el ángulo paraláctico, las correcciones preliminares $\Delta\alpha$ y $\Delta\delta$ a las Ascensiones Rectas y Declinaciones en el sentido (Astr. - Cat.) han sido obtenidas por las fórmulas siguientes (Guinot, 1958):

$$\Delta\alpha = (M_E - M_W)/2 |\sin Z| \cos \phi$$

$$\Delta\delta = -(M_E + M_W)/2 \cos S$$

REFERENCIAS

Guinot, B., 1955, *Bull. Astron.* 18, 283.

_____ 1955, *Bull. Astron.* 20, 119.

_____ 1958, *Bull. Astron.* 22, 1.

Guinot, B., Debarbát, S., Krieger Field, J., 1961, *Bull. Astron.* 23, 307.

Manrique, W., Actis, E., Baldivieso, J., Serafino, A., 1976, *Astron. Astrophys. Supp.* 26, 381.

DISCUSION

CAMPUSANO.- ¿Se han estimado los errores $\Delta\alpha$ y $\Delta\delta$ correspondientes a cada instrumento? Esto en relación a la posibilidad de comparar los valores asignados de $\Delta\alpha$ y $\Delta\delta$ para estrellas del FK4.

MANRIQUE.- Los errores de las correcciones $\Delta\alpha$ y $\Delta\delta$ son variables para cada estrella. En el caso del Astrolabio de San Juan se han obtenido errores del orden de 0.003 como mínimo, para $\Delta\alpha$ y 0.05 para $\Delta\delta$. Además con Astrolabio $\Delta\alpha$ y $\Delta\delta$ se obtienen a menos de una constante y dos constantes respectivamente.

ANDREI.- O método exposto segue a proposição de Guinot e Debarbát? No ouveram modificações a essa proposição?

MANRIQUE.- Básicamente es el mismo.

EL LEONCITO: PROGRAMAS ACTUALES Y PLANES PARA EL PROXIMO FUTURO

Carlos U. Cesco

Observatorio Astronómico Félix Aguilar, Universidad Nacional de San Juan

RESUMEN

El Astrográfico Doble ha sido empleado principalmente en la observación de Asteroides con posiciones conocidas, no muy precisas, y en la búsqueda de posibles variables entre las estrellas muy rojas descubiertas en este observatorio. Se dan algunos resultados. Se proyecta utilizar el nuevo telescopio reflector de 76 cm de abertura en la medición visual de estrellas dobles y en problemas de fotometría fotoeléctrica.

QUINTA PARTE
SISTEMA SOLAR

MODELO DE UNA OCULTACION DE EUROPA POR IO*

Z. Abraham y F.M. Strauss

Instituto de Física, Universidade Federal do Rio Grande do Sul
Porto Alegre

RESUMEN

Se ajustó un modelo teórico a las observaciones de la ocultación de Europa por Io del 6 de Septiembre de 1973, obtenidas en el Observatorio de la UFRGS. El modelo tiene cinco parámetros: la relación entre los brillos de los satélites, la hora en que ocurrió la máxima ocultación, la velocidad relativa media entre los satélites, el radio de Europa y el parámetro de impacto. Se supuso brillo uniforme en la superficie de Europa y se usaron valores fijos para el radio de Io y el ángulo de fase solar. Los residuos O-C entre el mejor modelo y las observaciones son muy pequeños (~ 0.002 mag) y completamente aleatorios, sin presentar ninguna evidencia de inhomogeneidad de la distribución de brillo en la superficie de Europa.

DISCUSION

WALBORN.- ¿Existen razones observacionales para tomar uno de los radios como dado y el otro a determinar?

ABRAHAM.- El diámetro de Io se conoce con mucha precisión a partir de la ocultación de β Scorpii por Io, siempre que se suponga forma esférica para el satélite.

WALBORN.- ¿Cómo se comparan las velocidades relativas (y sus errores) determinadas en su trabajo y en base a la teoría de las órbitas?

ABRAHAM.- La precisión de los resultados de la teoría es muy baja como para utilizarlos en los modelos de curva de luz, ya que variaciones muy pequeñas de los parámetros dan residuos que podrían interpretarse como falta de uniformidad del albedo. Las correcciones a los parámetros orbitales obtenidas del análisis de muchos eventos resultan muchas veces inconsistentes entre sí.

* Financiado parcialmente por las Instituciones Brasileñas CNPq y FINEP.

ALTAVISTA.- En la reunión de Austin, Texas, sobre problemas de satélites de Júpiter, se hizo hincapié sobre la necesidad de observaciones sumamente precisas de los satélites galileanos. En los que respecta a la teoría, actualmente el Dr. Ferraz Mello se halla en la tarea de completar trabajos anteriores al respecto. El objeto principal es la prueba espacial de la NASA en 1981, en donde se espera usar a esos satélites para cambiar la trayectoria del satélite artificial que se enviará a Júpiter.

SOBRE EL DESARROLLO DE LA FUNCION PERTURBADORA EN TERMINOS DE
FUNCIONES DE BESSEL CON ARGUMENTOS IMAGINARIOS PUROS

Carlos A. Altavista

Observatorio Astronómico de la Universidad de la Plata

RESUMEN

Para obtener una representación de la parte principal de la función perturbadora planetaria se puede proceder del siguiente modo:

Si Δ indica la distancia entre dos planetas cualesquiera (exceptuamos por ahora Plutón), es muy sencillo demostrar que $1/\Delta$ se puede expresar simbólicamente como un producto de factores binomiales, en donde se pueden asociar por pares, en forma convenientemente elegida, los binomios que representan, en esa forma simbólica, las tres etapas en que usualmente se divide el proceso para la representación de $1/\Delta$:

- 1) Pares de binomios asociados correspondientes al caso de órbitas circulares coplanares.
- 2) Pares de binomios asociados correspondientes al caso de órbitas circulares no coplanares.
- 3) Pares de binomios asociados correspondientes al caso en que se introducen las excentricidades planetarias.

Si designamos con X a un par cualquiera de factores binomiales asociados mencionados en los casos anteriores, al aplicar la identidad:

$$X = E^{\text{Ln } X} \quad (E = 2.71828\dots)$$

se llega inmediatamente al resultado buscado: la representación de $1/\Delta$ en términos de funciones de Bessel con argumentos imaginarios puros.

Este trabajo será publicado "in extenso" en otro lugar.

DETERMINATION OF JUPITER'S MAGNETOSPHERIC ROTATION
PERIOD THROUGH THE ANALYSIS OF DECAMETRIC OBSERVATIONS

Jorge May

Observatorio Radioastronómico, Maipú
Departamento de Astronomía
Universidad de Chile

Thomas D. Carr and Michael D. Desch
Department of Physics and Astronomy
University of Florida
Gainesville, Florida, U.S.A.

It is believed that the radio emission from Jupiter at decameter wavelengths originates in the corotating portion of the magnetosphere of the planet. The asymmetries in the radio emission patterns (sources) provide then a mean for measuring the average magnetospheric period over certain interval of time. Relatively recent investigations have shown that there exist a slow sinusoidal drift in the apparent rotation period due to an asymmetrical beaming of the radiation (different parts of the beam being observed at times of different values of the Jovicentric declination of the Earth). Consequently, the true rotation period of the decametric radio source is the mean value obtained over an interval of 11.89 years, the time for one complete orbital revolution of Jupiter.

The method used here is a refined version of the one used at Florida years ago by Gulkiss and Carr, that is, the visual location of the source centers is replaced by cross correlating all the source regions instead of one source to improve the statistics. 26 pairs of occurrence probability versus central meridian longitude histograms, corresponding to apparitions 11.9 years apart, were cross correlated in order to obtain the best longitude shift for each pair. By finding the correction to the system III (1957), longitude system which best eliminated the drift, a mean rotation period of $9^{\text{h}} 55^{\text{m}} 29^{\text{s}}.693$ with a mean standard deviation of $0^{\text{s}}.011$ was determined. This mean standard deviation might be attributed to the wandering of the Jovian magnetic poles.

EVOLUCION ORBITAL DEL COMETA KOHOUTEK 1973f

Silvia Fernández Martín

Observatorio Astronómico, Córdoba
CONICET, Buenos Aires

I. INTRODUCCION

En una placa tomada con una cámara Schmidt, en marzo de 1973, Lubos Kohoutek descubrió un cometa cuya magnitud era aproximadamente 15.7 y su distancia al Sol de 4.75 UA. Sus elementos orbitales mostraron que dicho objeto se encontraría en su distancia mínima al Sol en diciembre del mismo año, y su magnitud llegaría a -2.3. Este evento atrajo la atención pública mundial y provocó un interés inusitado en el conocimiento de la naturaleza y origen de los cometas.

Desafortunadamente, el brillo fue mucho menor que el anunciado, aunque hubo astrónomos como Opik que calcularon su valor correcto. Pero, aunque existía esa incerteza sobre la magnitud del cometa, su órbita fue predicha correctamente y con alta precisión.

Obtenida la órbita definitiva de un cometa, es de gran interés cosmológico hacer un estudio de la evolución orbital del mismo. Esto significa calcular la órbita del objeto antes de que entre a la esfera de atracción del sistema solar y después de salir de ella. El paso a través del sistema implica un intercambio de energía con los planetas, cuyas perturbaciones pueden modificar los elementos orbitales del cometa. De esta forma, la energía total en la fecha de osculación puede ser muy distinta a la energía original o a la futura.

Los cambios de energía en los cometas han sido objeto de numerosas investigaciones. Bilo y van de Hulst (1960), y Sekanina (1966) han dado una extensa base histórica del problema.

Existe, además, un trabajo publicado por Everhart y Raghavan (1970), el cual consiste en un estudio del cambio de energía de 392 cometas de largo período. Para ello consideraron separadamente los cambios de energía debidos a cada planeta y luego sumaron para obtener el total.

En el presente trabajo se encontraron las cantidades U_b y U_a para el cometa Kohoutek 1973f, o sea los cambios de energía antes y después del pasaje por el perihelio.

II. DESARROLLO

Como datos iniciales se usaron dos grupos de elementos orbitales, obtenidos por Hurukawa y Marsden, respectivamente, a partir de 40 observaciones comprendidas entre el 28/I/73 y el 26/IX/73.

Se tomó como instante de osculación el 28/IV/73, por ser una fecha media dentro del intervalo mencionado y para la cual se calcularon las coordenadas y componentes de la velocidad mediante la IBM 1130 de la Universidad Nacional de Córdoba.

Con esos dos grupos de valores se inició el cómputo con el programa de N-cuerpos de Schubart y Stumpff para la IBM/360 del Ministerio de Hacienda de la Prov. de Córdoba. Las coordenadas planetarias heliocéntricas para la fecha elegida, se obtuvieron de una publicación para la cual se había utilizado este mismo programa.

El programa de N-cuerpos integra todas las ecuaciones a la vez, es decir considera todos los planetas al mismo tiempo. Esto implica que el paso de integración se debe tomar de acuerdo con la velocidad del planeta más cercano al Sol que se esté considerando.

La integración se hizo en varias etapas, para ir modificando la longitud del paso. En total se cubrió el intervalo comprendido entre junio de 1917 y julio de 2030 (41 290 días julianos) (Tabla I).

TABLA I
Longitud del Paso de Integración

Intervalo a integrar	Paso(días)	Baricentro
242 1400.5 - 244 1400.5	40	Sol + Plan. Inter.
244 1400.5 - 1800.5	2	Sol + Mercurio
1800.5 - 2020.5	0.5	Sol
2020.5 - 2070.5	0.2	Sol
2070.5 - 2290.5	0.5	Sol
2290.5 - 2690.5	2	Sol + Mercurio
2690.5 - 246 2690.5	40	Sol + Plan. Inter.

La constante de la energía, dada por $C = -\frac{1}{a}$, fue evaluada en once puntos diferentes. Esto permitió detectar cambios de signo en el valor de la constante en dos épocas equidistantes al pasaje por el perihelio. Se pensó en un posible acercamiento a Júpiter o a Saturno. Se calculó entonces la esfera de actividad de ambos planetas para esas fechas, encontrándose que la distancia (Δ) del cometa a los mismos era mucho mayor que el radio (ρ) de dichas esferas (Tablas II y III).

Por último, se calculó la diferencia de energía antes del pasaje por el perihelio (U_b) y después de haber pasado (U_a). Se procedió de igual manera para la fecha osculadora, (U'_b) y (U'_a).

$$U_b = \Delta \left(\frac{1}{a} \right)_b = \left(\frac{1}{a} \right)_p - \left(\frac{1}{a} \right)_{or}$$

$$U_a = \Delta \left(\frac{1}{a} \right)_a = \left(\frac{1}{a} \right)_{fut.} - \left(\frac{1}{a} \right)_p$$

Estas diferencias de energía fueron evaluadas, independientemente, con los dos grupos de datos. Pero no se observaron diferencias apreciables en los resultados.

El cambio total de energía está dado por $U = U_b + U_a$. Los valores obtenidos para ambas fechas se presentan en la Tabla IV.

TABLA II
Valor de $C = -1/a$

Día Juliano	Grupo A	Grupo B
242 1400.5 (orig.)	.0001750301	.0001743060
244 1400.5	-.0001715902	-.0001723137
1800.5	+.0000009529	+.0000002298
2020.5	.0001339214	.0001389235
2044.5 (perih.)	.0001346089	.0001338864
2070.5	.0001412985	.0001405766
2290.5	.0000892475	.0000885269
2690.5	-.0000427657	-.0000434722
246 2690.5 (fut.)	+.0006975030	+.0006967985

Grupo A : datos de Hurukawa. Grupo B : Datos de Marsden

TABLA III
Esferas de Actividad de Radio $\rho = R_p \sqrt{\frac{5}{2} m'^2}$; $m' = \frac{m_p}{M_\odot}$

Día Juliano	R_c (UA)	R_p (UA)	Plan.	ρ (UA)	Δ (UA)
244 1400.5	8.06895	9.05783	Saturno	0.30138	8.99697
1800.5	4.16370	5.12591	Júpiter	0.27639	9.13094
2070.5	4.17603	4.98651	Júpiter	0.26888	7.59546
2290.5	8.07720	9.24582	Saturno	0.30763	6.69895

TABLA IV
Valores de U_b , U_a , U , en Unidades de 10^{-6} UA^{-1}

	U_b	U_a	U	U'_b	U'_a	U'
Grupo A	-41.7	562.9	521.2	-175.4	696.6	521.2
Grupo B	-41.9	563.0	521.1	-175.5	696.6	521.1

De nuestros resultados se dedujo que el cometa Kohoutek 1973f evoluciona como la mayoría de los cometas de largo período, ya que ganó energía total antes de pasar por el perihelio ($U_b < 0$) y perdió energía después de haberlo pasado ($U_a > 0$). Su órbita original es elíptica [$(1/a)_{or} > 0$], confirmando la hipótesis de Oort.

La fig. 1 pertenece al trabajo de Everhart y Raghavan (1970); en ella se muestra la distribución de los valores $-U_b$ y $+U_a$, para 392 cometas de largo período. Los valores obtenidos para el Kohoutek 1973f, nos permiten ubicarlo en la zona más conspicua de dicha curva.

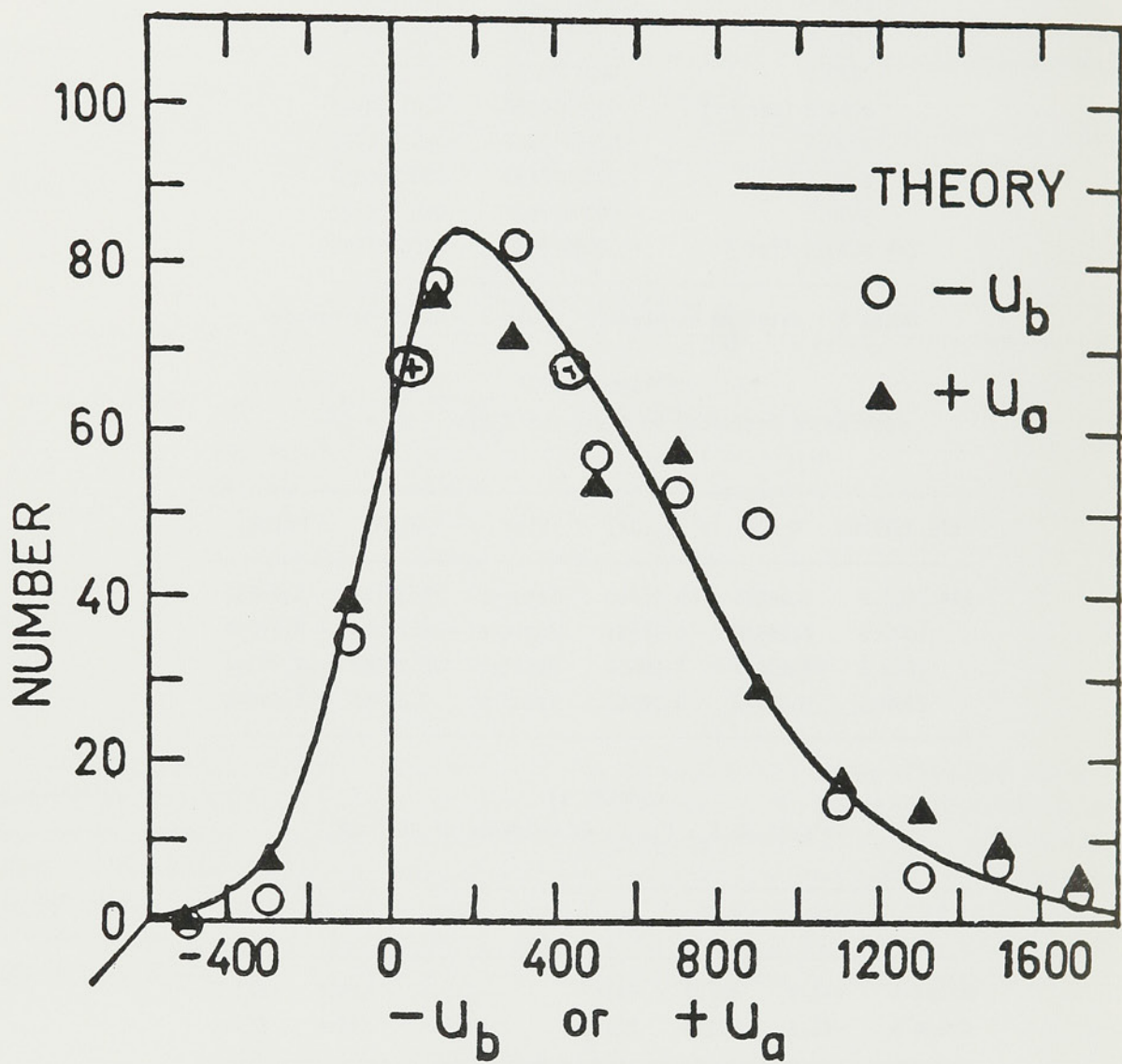


Fig. 1.

AGRADECIMIENTOS: Deseo expresar mi agradecimiento a la Dra. Elsa G. de Rodríguez Pardina, bajo cuya dirección se realizó este trabajo.

REFERENCIAS

- Bilo, E.H., Hulst, H.C. van de, 1960, *Bull. Astron. Inst. Neth.* 15, 119.
Everhart, E., Raghavan, N., 1970, *A. J.* 75, 258.
Schubart, J., Stumpff, P., 1966, *Veröffentlichungen des Astron. Rechen-Inst.* N°18.
Sekanina, Z., 1966, *Acta Carolinae Math. et Phys.* 3, (N°2).

DISCUSION

ALTAVISTA.- ¿Qué método se usó para integrar las ecuaciones diferenciales del movimiento?

FERNANDEZ.- El programa de N-cuerpos de Schubert y Stumpff no utiliza ninguno de los métodos clásicos de perturbaciones especiales (Cowell, Encke), sino que integra simultáneamente las ecuaciones correspondientes a los planetas y a los cuerpos estudiados. La integración del sistema de ecuaciones diferenciales ordinarias de 2° orden, se realiza mediante el método numérico de Adams-Störmer.

ALTAVISTA.- ¿Se hicieron estudios sobre propagación de errores por truncamiento en las integraciones numéricas?

FERNANDEZ.- No se hicieron estudios sobre propagación de errores, pero se compararon, para distintas fechas, las coordenadas de los planetas obtenidas con el programa con las de las efemérides ($\epsilon \sim 10^{-6}$ U.A.).

RESULTADOS PRELIMINARES DE OBSERVACIONES DE URANO
CON EL ASTROLABIO DANJON DE SANTIAGO

F. Noël

Observatorio Astronómico Nacional, Cerro Calán
Departamento de Astronomía
Universidad de Chile

RESUMEN

Se dan los resultados preliminares obtenidos en la determinación de las coordenadas ecuatoriales de Urano durante tres años de observaciones con el Astrolabio Danjon de Santiago. Se comparan las coordenadas obtenidas con el Astrolabio, referidas al sistema del FK4, con las efemérides del planeta dadas por el American Ephemeris y con los resultados obtenidos con el Círculo Meridiano del Observatorio Naval de Washington.

Se describe brevemente el programa de observación de planetas del Astrolabio de Santiago.

ABSTRACT

Preliminary results obtained in the determination of the equatorial coordinates of Uranus, during three years of observations, with the Danjon Astrolabe of Santiago, are given. The coordinates obtained with the Astrolabe, which are referred to the system of the FK4, are compared with the ephemeris of the planet given by the American Ephemeris and with the results obtained with the Meridian Circle of the U.S. Naval Observatory.

A short description is given of the program of planet observations with the Astrolabe at Santiago.

DISCUSION

BLAAUW.- You showed the results of a few months of observations; is it now planned to make this a continued programme for the future?

NOËL.- Sí, hasta ahora hemos observado solamente Urano en forma sistemática ya que es el único planeta cuya declinación actual lo permite. Continuaremos estas observaciones en el futuro

hasta cuando la declinación de Urano sea apropiada. Además esperamos observar cualquier otro planeta que esté en posición favorable y que sea observable con el astrolabio.

PENNA.- ¿Los resultados $\Delta\alpha$ y $\Delta\delta$ obtenidos en las observaciones de Júpiter tienen la misma precisión que los resultados de Urano?

NOËL.- Júpiter fue observado solamente durante 1974, obteniéndose únicamente cuatro tránsitos dobles, lo cual no hace posible efectuar una comparación de la precisión de esos resultados de Júpiter con los resultados obtenidos hasta ahora para Urano.

HIGH SPEED SPECTROGRAMS OF SHORT BURSTS FROM
JUPITER AT 32 MHz

Jorge May

Observatorio Radioastronómico, Maipú
Departamento de Astronomía
Universidad de Chile

Michael D. Desch and Richard S. Flagg

Department of Physics and Astronomy
University of Florida
Gainesville, Florida, U.S.A.

Jovian short-bursts activity was recorded at Maipú on 8 August 1976 from 1100 to 1104 UT at a frequency of 32 MHz. The receiving equipment consisted of an E-W linearly polarized, 15-full-wavelength dipole array, a 500-kHz bandwidth receiver, and a high-speed instrumentation tape recorder. Subsequent data processing using the University of Florida high speed spectrograph yielded frequency and time resolution of 3.2 kHz and 300 μ sec across the 500 kHz band.

It was found that each burst drifts in a negative sense, from high to low frequency, exhibiting a general uniformity in the overall structure. From the measurement of 312 bursts a mean drift rate of $-29.6 \text{ MHz sec}^{-1}$ was detected, being, in fact, among the largest of any recorded at lower frequencies. We propose then that the particles may have been accelerated initially in the Jovian ionosphere at the Io flux tube foot and not at Io itself as has been previously suggested.

STUDIES OF THE SPECTRAL MORPHOLOGY OF JUPITER'S
DECAMETRIC RADIO SOURCES

Jorge May

Observatorio Radioastronómico, Maipú
Departamento de Astronomía
Universidad de Chile

James R. Thieman and Alex G. Smith
Department of Physics and Astronomy
University of Florida
Gainesville, Florida, U.S.A.

The analysis of over 140 000 hours of merged observations of the Jupiter radio sources made during the last two decades at Florida, Chile, Texas and India, has allowed comparison of the spectral dependences of the sources over a broader frequency range (5 to 30 MHz) and with a higher resolution (2° in System III longitude or the position of Io from superior geocentric conjunction) than has previously been possible. The random errors in the occurrence statistics have been reduced to a very low level due to the large volume of data and long span of years used. The distinction between chronological and spectral changes in source structure has been considered, because the probabilities, and often the positions, of the sources do vary with time. The longitude histograms clearly show a real shift in the source A and source B positions between 15 and 10 MHz suggesting a merging of the sources at the lower frequency. The Io phase histograms that isolate the dependence of each source on the position of Io, illustrate changes with frequency in the structures and sizes of the main probability maxima and in the positions of surrounding secondary peaks. Some of these histograms reveal new phenomena, such as a bridge of radiation through source B longitudes connecting sources A and C at 15 MHz, and spectral modification of positions of the Io-related source B peak. The identification of these new detailed features will be of importance to any theory of the emission process.

DISCUSSION

WAMSTEKER.- The 12 year periodicity in the strength of the sources is not associated with solar activity, since the shock front separating the solar environment from the interstellar medium seems to be crossing the Jupiter orbit depending on the solar activity.

MAY.- We have investigated already the possibility that the solar activity would be responsible for this effect. However the work done a couple of years ago showed very clearly that this effect was related more to the apparent jovicentric declination of the earth than to the solar cycle.

CAMPUSANO.- ¿Existe evidencia en otras frecuencias del período de aproximadamente 12 años observado en la actividad del espectro decamétrico de Júpiter?

MAY.- Se consideraron las frecuencias más confiables, es decir 18, 20 y 22 MHz para visualizar la evolución temporal de las radiofuentes. Con todas las frecuencias el efecto es el mismo.

EL PROBLEMA DE LAS SERIES SEMICONVERGENTES EN MECANICA
CELESTE Y LAS SOLUCIONES PERIODICAS DE POINCARÉ

Carlos A. Altavista

Observatorio Astronómico, Universidad Nacional de La Plata

RESUMEN: La convergencia de las soluciones de las ecuaciones diferenciales de la Dinámica es un problema fundamental. Algunos han centrado la cuestión en la anulación del Hessiano formado con el Hamiltoniano no perturbado del problema. Sin embargo, en caso de ecuaciones diferenciales lineales, se pueden encontrar ejemplos muy simples en que es posible obtener soluciones periódicas, aun cuando se anule el Hessiano construido con el Hamiltoniano no perturbado - respecto a las coordenadas - del sistema dado de ecuaciones diferenciales.

ABSTRACT: Convergence of solutions of differential equations in Dynamics is a fundamental problem. Several authors have emphasized that semiconvergence of series is closely connected with the problem of the vanishing of the Hessian formed with the undisturbed Hamiltonian of a particular dynamical problem. However, in case of linear differential equations, we can find very simple examples in which periodic solutions are obtained, despite the vanishing of the Hessian formed with the undisturbed Hamiltonian of the given system of differential equations.

El objeto de este trabajo es señalar algunas características que permitan encuadrar y definir la naturaleza de la función conocida por "Tercera Integral" del movimiento y que fuera obtenida hace casi dos décadas por G. Contopoulos. Consideraremos aquí sistemas de ecuaciones diferenciales canónicos cuyo Hamiltoniano sea cuadrático en las coordenadas y componentes de la velocidad de un problema dinámico particular dado. En el caso tratado por G. Contopoulos, este autor parte de las ecuaciones:

$$\frac{d^2\xi}{dt^2} = -P\xi + bz^2, \quad \frac{d^2z}{dt^2} = -Qz + 2b\xi z, \quad (1)$$

donde se toma como función potencial:

$$ZW = -\frac{C^2}{r^2} - P\xi^2 - Qz^2 + 2b\xi z^2; \quad (2)$$

se supone que la razón P/Q es irracional. En forma canónica estas ecuaciones se escriben:

$$\frac{d\xi}{dt} = \frac{\partial F}{\partial R}; \quad \frac{dR}{dt} = -\frac{\partial F}{\partial \xi}; \quad \frac{dz}{dt} = \frac{\partial F}{\partial Z}; \quad \frac{dZ}{dt} = -\frac{\partial F}{\partial Z}, \quad (3)$$

donde:

$$R = \frac{d\xi}{dt}, \quad Z = \frac{dz}{dt},$$

$$F = \frac{1}{2} (R^2 + Z^2 + P\xi^2 + Qz^2 - 2b\xi z^2),$$

$$F_0 = \frac{1}{2} (R^2 + Z^2 + P\xi^2 + Qz^2); \quad F = F_0 + bF_1,$$

con

$$F_1 = -\xi z^2;$$

b es un parámetro pequeño. Para resolver el problema se introducen las coordenadas:

$$\begin{aligned} \xi &= \left(\frac{2x_1}{\sqrt{P}} \right)^{1/2} \cos y_1, & R &= P^{1/4} (2x_1)^{1/2} \sin y_1, \\ z &= \left(\frac{2x_2}{\sqrt{Q}} \right)^{1/2} \cos y_2, & Z &= Q^{1/4} (2x_1)^{1/2} \sin y_2. \end{aligned} \quad (4)$$

Con esta transformación, la parte no perturbada del Hamiltoniano original queda expresada así:

$$F_0 = P^{1/2} x_1 + Q^{1/2} x_2. \quad (5)$$

En estas condiciones el célebre teorema de Poincaré relativo a la no existencia de nuevas integrales uniformes no se puede aplicar, pues una de las condiciones para su validez es que el Hessianiano de F_0 respecto de las coordenadas no se anule, lo que en el caso particular que estamos tratando no se cumple. Sin embargo, cabe consignar que el teorema fue demostrado por Poincaré para el caso en que las variables utilizadas fueran los elementos keplerianos (problema de los dos cuerpos). La investigación sobre la naturaleza de la función introducida por G. Contopoulos se realiza a partir de la condición involutoria:

$$(F, \Phi) = 0$$

en donde F y Φ (Φ función a determinar) se suponen desarrollables en series de potencias del parámetro b . La función Φ obtenida de este modo particular, tiene una estructura tal que conduce a encuadrarla dentro de la categoría de series semiconvergentes, según las definiciones dadas por el mismo Poincaré. No podemos aquí, en la brevedad de esta exposición, entrar en los detalles de la cuestión.

Una situación similar se ha de presentar en todos aquellos casos en que el Hamiltoniano tenga una estructura similar al caso investigado por G. Contopoulos, luego de ser sometido a transformaciones del tipo de las expresiones (4).

Por ser de interés describiremos brevemente una técnica general que se puede aplicar a ecuaciones diferenciales de la forma:

$$\frac{d^2x}{dt^2} = f(x,t) \quad , \quad (6)$$

para ser llevadas a la forma canónica. Si $f(x,t)$, como siempre ocurre, se puede considerar como la derivada respecto a x de una función $\phi(x,t)$, de modo que tengamos:

$$f = \frac{\partial \phi}{\partial x} \quad ,$$

y si ahora ponemos:

$$x = x_1 \quad , \quad \frac{dx}{dt} = y_1 \quad , \quad t = y_2 \quad , \quad (7)$$

$$F = \frac{y_1^2}{2} - \phi(x_1, y_2) - x_2 \quad ,$$

la ecuación (6) se puede reemplazar por el sistema:

$$\frac{dx_1}{dt} = \frac{\partial F}{\partial y_1} \quad , \quad \frac{dx_2}{dt} = \frac{\partial F}{\partial y_2} \quad ; \quad \frac{dy_1}{dt} = - \frac{\partial F}{\partial x_1} \quad , \quad \frac{dy_2}{dt} = - \frac{\partial F}{\partial x_2} \quad .$$

Recordemos ahora, para volver al problema que nos preocupa, que Gylden, en su teoría planetaria, encontró ecuaciones de la forma:

$$\frac{d^2y}{dx^2} + n^2y = \mu \phi'(y, x) \quad , \quad (7a)$$

donde ϕ' es una función desarrollable en potencias de y , y periódica en x . Mediante cambios adecuados de variables, Poincaré ha demostrado que la ecuación (7a) se puede llevar a forma canónica, en variables x_i, y_i :

$$\frac{dx_i}{dt} = \frac{\partial F}{\partial y_i} \quad , \quad \frac{dy_i}{dt} = - \frac{\partial F}{\partial x_i} \quad , \quad (i = 1, 2) \quad ,$$

en donde ahora se tiene:

$$-F = nx_1 + x_2 - \mu \phi' \left(\frac{2x_1}{n} \sin y_1, y_2 \right) \quad (8)$$

Poniendo $\mu = 0$ queda:

$$F_0 = -nx_1 - x_2$$

y, por lo tanto, hemos llegado a una completa analogía con el caso planteado por G. Contopoulos en un problema particular de Dinámica. Las soluciones (en serie) de la ecuación (7a) son, como lo ha demostrado el mismo Poincaré, de un carácter puramente formal.

En esta breve reseña queremos mencionar también el caso de las denominadas integrales adélficas de Whittaker. En el caso simple de dos grados de libertad debemos considerar las ecuaciones en coordenadas generalizadas:

$$\frac{dq_i}{dt} = \frac{\partial H}{\partial p_i} ; \quad \frac{dp_i}{dt} = - \frac{\partial H}{\partial q_i} \quad (9)$$

Ahora bien: Whittaker ha demostrado que en el problema de los tres cuerpos el Hamiltoniano original del problema se puede expandir de tal forma que su primer término sea H_2 , en donde H_2 es una función cuadrática homogénea de las coordenadas del problema. Una transformación de coordenadas como la siguiente:

$$p_r = (2s_r q_r')^{1/2} \sin p_r' ; \quad q_r = (2q_r')^{1/2} s_r^{-1/2} \cos p_r' \quad (10)$$

donde las s_r son ciertas constantes, hace que el Hamiltoniano quede en la forma:

$$H = s_1 q_1 + s_2 q_2 + H_3 + H_4 + \dots$$

en donde H_r es un término de orden r . En el nuevo Hamiltoniano tenemos evidentemente:

$$H_0 = s_1 q_1 + s_2 q_2$$

Como bien se sabe, existen tres tipos de integrales adélficas que corresponden a tres casos particulares de la solución de la ecuación:

$$(H, \phi) = 0$$

que no se puede, en general, representar por una única expresión analítica. Esto se debe al hecho, demostrado por Poincaré, que si tales integrales (adélficas) tienen expresiones en serie de forma trigonométrica, que convergen, no pueden converger uniformemente para todos los valores de la variable independiente t y, en particular, para todos los valores de las constantes cuyos valores están comprendidos entre ciertos límites.

Dentro de las limitaciones impuestas a este trabajo, haremos referencia a la ecuación lineal,

$$\frac{d^2 x}{dt^2} + (q^2 - q_1 \cos 2t) x = 0 \quad (11)$$

que, de acuerdo a lo visto anteriormente, se puede llevar a forma Hamiltoniana, si se eligen las nuevas variables:

$$x = \left(\frac{2x_1}{q} \right)^{1/2} \sin y_1, \quad \frac{dx}{dt} = (2qx_1)^{1/2} \cos y_1,$$

y en donde el Hamiltoniano, según lo ha demostrado Poincaré, tiene la forma:

$$F = -qx_1 - x_2 + \mu x_1 \sin^2 y_1 \cos 2y_2, \quad (11')$$

con:

$$F_0 = -qx_1 - x_2$$

La ecuación (11') admite soluciones periódicas y ha sido estudiada (Poincaré, *Méthodes Nouvelles*, Cap. XVII) en detalle por varios autores. El interés de estas soluciones radica en el hecho que cuando la ecuación deja de ser lineal y se escribe en la forma:

$$\frac{d^2x}{dt^2} + (q^2 - q_1 \cos 2t) x = \phi(t),$$

en que $\phi(t)$ es una función conocida de t , las soluciones de esta nueva ecuación con segundo miembro, en general, dejan de ser periódicas.

Otro problema que afecta a la convergencia de las soluciones de las ecuaciones diferenciales de la Dinámica, es la presencia de ciertos divisores que, en determinadas circunstancias, pueden tomar valores pequeños. Poincaré y Bohlin han dado procedimientos para evitar la presencia de tales divisores; pero el primero de esos autores ha demostrado que las nuevas series obtenidas tampoco convergen. Finalmente, veamos brevemente qué posible conexión puede existir entre las soluciones periódicas que estudió el mismo Poincaré y los casos mencionados anteriormente. Veamos un ejemplo dado por él mismo. Consideremos el sistema canónico:

$$\frac{dx_i}{dt} = \frac{\partial R_2}{\partial y_i}, \quad \frac{dy_i}{dt} = -\frac{\partial R_2}{\partial x_i} \quad (i = 1, 2, 3, 4), \quad (12)$$

donde:

$$R_2 = A_1(\sigma_1^2 + \tau_1^2) + A_2(\sigma_2^2 + \tau_2^2) + A_3(\sigma_3^2 + \tau_3^2) + A_4(\sigma_4^2 + \tau_4^2). \quad (13)$$

Los coeficientes A_i dependen de los semiejes mayores. Las σ_i y τ_i son funciones de los elementos orbitales. Las transformaciones de coordenadas:

$$\tau_i = \sqrt{2\phi_i} \cos \omega_i, \quad \sigma_i = \sqrt{2\phi_i} \sin \omega_i, \quad (14)$$

llevan a R_2 a la forma:

$$R_2 = 2A_1\phi_1 + 2A_2\phi_2 + 2A_3\phi_3 + 2A_4\phi_4. \quad (15)$$

Como $F = \text{constante}$ es una integral, podemos escribir, siendo μ un pequeño parámetro,

$$F = F_0 + \mu F_1 + \mu^2 F_2 + \dots ; \quad \text{constante} = C = C_0 + \mu C_1 + \mu^2 C_2 + \dots \quad (16)$$

Y ahora Poincaré demuestra que si Λ, Λ' son variables conjugadas de las variables de Delaunay λ y λ' , y V una función que depende linealmente de las mismas, es posible resolver en primera aproximación el sistema de ecuaciones diferenciales original, mediante el cálculo de una función determinante S dada por:

$$S = S_0 + \mu S_1 + \mu^2 S_2 + \dots \quad (17)$$

con:

$$S_0 = \Lambda_0 \lambda_2 + \Lambda'_0 \lambda'_2 + V_1^0 v_1 + V_2^0 v_2$$

Aquí V_1^0, V_2^0 son constantes y se definen a través de:

$$V_1 = \frac{\partial S}{\partial v_1}, \quad V_2 = \frac{\partial S}{\partial v_2}$$

Si ahora se escribe:

$$F(\Lambda, \Lambda', \lambda_2, \lambda'_2, V_1, V_2, v_1, v_2) = C \quad (18)$$

poniendo en ésta:

$$\frac{\partial S}{\partial v_1} = 0, \quad \frac{\partial S}{\partial v_2} = 0 \quad (19)$$

el primer miembro de (18) no depende de v_1 y v_2 . La ecuación que resulta se integra de inmediato, y las series resultantes son convergentes, pues F sólo depende de la diferencia $\lambda_2 - \lambda'_2$. En general Poincaré considera que esta integral particular no conduce a soluciones simples en el problema de los tres cuerpos.

Con estas consideraciones sólo hemos dado un esbozo de las dificultades que ofrece el problema de la convergencia de las soluciones de las ecuaciones diferenciales de la Dinámica y de la Mecánica Celeste en general. Para un tratamiento más extenso y detallado del problema, se puede recurrir a la notable obra de G.E.O. Giacaglia: *Perturbation Methods in Non-Linear Systems*.

REFERENCIAS

- Contopoulos, G., 1960, *Zeits. für Astrophys.* 49, 273.
 Giacaglia, G.E.O., 1972, *Perturbation Methods in Non-Linear Systems, Applied Mathematical Sciences*, Volume 8. Springer-Verlag, New York-Heidelberg, Berlin.
 Poincaré, H., 1957, *Les Méthodes Nouvelles de la Mécanique Céleste*. Dover Pub. New York, Capítulos I, VIII, IX, X, XI, XIII, XIV y XV. Tomos I y II.

SOBRE LA POSIBILIDAD DE CONSTRUIR ORBITAS INTERMEDIARIAS EN
EL PROBLEMA DE LOS TRES CUERPOS

Carlos A. Altavista

Observatorio Astronómico, Universidad Nacional de La Plata

RESUMEN: La aplicación del método de la variación de los parámetros según una versión distinta de la tradicional, y que ha sido dada por el mismo Lagrange, permite, mediante un proceso de linealización, transformar las ecuaciones diferenciales del movimiento relativo de tres cuerpos en una ecuación diferencial aproximada, cuyo término lineal tiene como coeficiente una serie trigonométrica.

ABSTRACT: By means of the method of the variation of the parameters, according to a special procedure devised by Lagrange, it is possible to transform the set of differential equations of relative motion in the three-body problem into an approximate differential equation. This process involves as a second step, the linearization of the new equation, in which the linear term is multiplied by a trigonometric series.

1.- Para considerar el problema propuesto escribamos las ecuaciones diferenciales del movimiento relativo de un planeta alrededor del Sol, suponiendo que este movimiento está perturbado por un planeta de masa m' :

$$\frac{d^2x}{dt^2} + k^2(m_0 + m) \frac{x}{r^3} = \frac{\partial R}{\partial x} \quad , \quad (x = x, y, z) \quad , \quad (1)$$

donde los símbolos tienen un significado conocido; la terna de referencia se supone centrada en el Sol. Para resolver el sistema (1) podemos partir de la solución aproximada:

$$x = a \cdot P_x (\cos E - e) + b Q_x \sin E, \quad (x = x, y, z) \quad (2)$$

Los elementos orbitales son ahora variables. Para transformar las ecuaciones (1) mediante las ecuaciones (2), usaremos el método de la variación de los parámetros de acuerdo a las siguientes reglas dadas por Lagrange:

1) Las perturbaciones en el tiempo (o de cualquier variable angular explícitamente asociada al tiempo) se calcularán mediante la aplicación de un operador $D = d/dt$. Los elementos geométricos:

$$a, e, I, \Omega, \omega, e, \quad (3)$$

son constantes en este caso.

2) Las perturbaciones de los elementos geométricos se calcularán independiente, mediante la aplicación de un operador δ . En este caso las variables temporales permanecerán fijas.

Aquí nos ocuparemos solamente de las perturbaciones temporales. Para tener en cuenta estas perturbaciones, debemos derivar con respecto al tiempo las ecuaciones (2), manteniendo constantes a los elementos orbitales geométricos de la serie (3). Obtenemos:

$$\dot{x} = -a P_x \sin E \cdot \dot{E} + b Q_x \cos E \cdot \dot{E}, \quad (4)$$

$$\ddot{x} = (-a P_x \sin E + b Q_x \cos E) \ddot{E} + (-a P_x \cos E - b Q_x \sin E) \dot{E}^2 \quad (5)$$

Reemplazando las ecuaciones (2) y (5) en los primeros miembros de las ecuaciones (1) nos queda:

$$\begin{aligned} & (-a P_x \sin E + b Q_x \cos E) \ddot{E} + (-a P_x \cos E - b Q_x \sin E) \dot{E}^2 + \\ & + k^2 (m_0 + m) \frac{a P_x (\cos E - e) + b Q_x \sin E}{r^3} = \frac{\partial R}{\partial x} \end{aligned} \quad (6)$$

Multipliquemos estas ecuaciones por P_x, P_y, P_z , respectivamente, y sumemos:

$$- \sin E \cdot \ddot{E} - \cos E \cdot \dot{E}^2 + k^2 (m_0 + m) \frac{e_0 (\cos E - e)}{r^3} = \frac{1}{a} \left(P_x \frac{\partial R}{\partial x} + P_y \frac{\partial R}{\partial y} + P_z \frac{\partial R}{\partial z} \right) \quad (7)$$

Multipliquemos ahora las ecuaciones (6), respectivamente por Q_x, Q_y, Q_z y sumemos:

$$\cos E \cdot \ddot{E} - \sin E \cdot \dot{E}^2 + k^2 (m_0 + m) \frac{e_0 \sin E}{r^3} = \frac{1}{b} \left(Q_x \frac{\partial R}{\partial x} + Q_y \frac{\partial R}{\partial y} + Q_z \frac{\partial R}{\partial z} \right) \quad (8)$$

Multipliquemos ahora la ecuación (7) por $-\sin E$, la (8) por $\cos E$ y sumemos; nos queda:

$$\ddot{E} + k^2 (m_0 + m) \frac{e_0 \sin E}{r^3} = m' f(x, y, z, x', y', z') \quad (9)$$

donde hemos explicitado el pequeño factor m' presente en R ; con $f(x, y, z, x', y', z')$ representa-

mos una función que puede desarrollarse en series infinitas convergentes de las formas:

$$\sum C \cos D, \quad \sum C' \cos D' \quad (10)$$

Los coeficientes C y C' son conocidos. Dependen, de acuerdo a las operaciones realizadas, de la relación de los semiejes mayores planetarios, de las excentricidades y de $\sin^2(J/2)$, donde J es la inclinación mutua de las órbitas. No es difícil demostrar que este ángulo puede ser reemplazado, por ejemplo, por las respectivas inclinaciones orbitales respecto al plano de la Eclíptica. En cuanto a los argumentos D y D' , teniendo en cuenta el desarrollo de la función perturbadora según Newcomb y las operaciones realizadas para obtener la función $f(x, y, z, x', y', z')$ tienen las respectivas formas generales:

$$D = pE + p'E' + j\tilde{\omega} + j'\tilde{\omega}' + k\Omega + k'\Omega' = pE + p'E' + q + q' \quad (11)$$

donde hemos indicado con q y q' , sumas de argumentos constantes, a saber, combinaciones lineales de las longitudes de los perihelios (respecto a una terna fija) y combinaciones lineales de las longitudes de los nodos respecto al plano de la Eclíptica. Consideremos ahora la ecuación diferencial del movimiento no perturbado:

$$\frac{d^2 E_0}{dt^2} + k^2(m_0 + m) \frac{e_0 \sin E_0}{r_0^3} = 0 \quad ; \quad (12)$$

restemos esta ecuación de la (9):

$$\frac{d^2 \Delta E}{dt^2} + k^2(m_0 + m) e_0 \left[\frac{\sin E}{r^3} - \frac{\sin E_0}{r_0^3} \right] = m' f(x, y, z, x', y', z') \quad (13)$$

donde hemos puesto $E - E_0 = \Delta E$; teniendo en cuenta además que el valor perturbado de r está dado por:

$$r = a_0 (1 - e_0 \cos E) \quad (14)$$

tenemos:

$$\frac{1}{r^3} = \frac{1}{r_0^3} (1 + 3e_0 \cos E + 6e_0^2 \cos^2 E_0 + \dots) \quad (15)$$

y análogamente para $1/r_0^3$.

2.- Corresponde ahora considerar el proceso de linealización de la ecuación diferencial (9). Comencemos por el primer miembro. Tenemos, por lo que hemos visto, que tomar en cuenta las diferencias de las clases:

$$\sin pE - \sin pE_0 \quad (16)$$

Escribiendo $E = E_0 + \Delta E$, es fácil ver que, en general, tendremos:

$$\sin p(E_0 + \Delta E) - \sin pE_0 = p \cos pE_0 \cdot \Delta E \quad (17)$$

Luego el primer miembro de la ecuación (9) toma la forma aproximada:

$$\frac{d^2 \Delta E}{dt^2} + k^2 (m_0 + m) \frac{e_0}{a_0^3} (\Sigma C \cos p E_0 \Delta E) \quad (18)$$

Corresponde tener en cuenta, entonces, la linealización de la función $f(x, y, z, x', y', z')$. Para ello debemos aplicar un criterio especial. En efecto, sabemos que las perturbaciones principales tienen lugar en el plano orbital, en longitud. En consecuencia, puede ocurrir que ciertos términos de esa función den lugar, al integrar las ecuaciones de perturbación (recordemos que hemos omitido hablar aquí de la correspondiente al planeta P' , que se trata de manera completamente similar), a desigualdades de largo período muy sensibles. Sean, por ejemplo, tales términos:

$$\cos(pE + p'E' + q'') \quad , \quad \sin(pE + p'E' + q''') \quad (19)$$

donde q'' y q''' son constantes, por lo que ya hemos visto; p y p' son enteros cualesquiera. Por supuesto en los casos que consideramos no toman valores nulos. Para linealizar esos términos, en los cuales E y E' son valores perturbados, consideremos las ecuaciones:

$$E = nt + c + e \sin E \quad ; \quad E' = n't + c' + e' \sin E' \quad (20)$$

Eliminemos t . Obtenemos:

$$E' = p_1 E + e' \sin E' - p_1 e \sin E + c' - p_1 c \quad ; \quad p_1 = \frac{n'}{n} \quad (21)$$

En primera aproximación, si e y e' son del orden de las masas planetarias, basta considerar:

$$E' = p_1 E - q_1 \quad ; \quad q_1 = \text{cte} \quad ; \quad (22)$$

si e y e' tienen valores moderados, digamos son del orden 0.05, en segunda aproximación, reemplazamos la ecuación (22) en el valor de $\sin E'$. Aquí resultarán naturalmente cálculos más elaborados. Pero tanto en uno como en el otro caso nuestros términos (19) toman una de las formas:

$$C_3 \sin(\nu E + q_1') \quad , \quad C_4 \sin(\nu' E + q_2') \quad ; \quad q_1', q_2', \text{ constantes} \quad , \quad (23)$$

donde C_3 y C_4 son constantes. ν y ν' no son números enteros en general. Estamos ahora en condiciones de linealizar la función $f(x, y, z, x', y', z')$, la cual, como hipótesis de trabajo, ha sido truncada en aquellos términos que han de producir desigualdades de largo período sensibles en las integraciones. Recordando los principios en que se basa la teoría de perturbaciones para integrar las ecuaciones diferenciales por aproximaciones sucesivas, debemos primeramente desarrollar $f(x, y, z, x', y', z')$ en serie de potencias de la masa perturbadora. Recordemos que en los términos seleccionados podemos escribir:

$$E = E_0 + \Delta E \quad , \quad (24)$$

de modo que por ser la diferencia $E-E_0$, función de las masas m y m' , para linealizar la función f , basta detenernos en el correspondiente desarrollo Tayloriano de $\sin[v(E_0+\Delta E)]$ en los términos lineales en ΔE ; análogo proceso será válido para $\cos[v(E_0+\Delta E)]$. En consecuencia tendremos finalmente en el segundo miembro (truncado) de la ecuación (9) términos de las formas:

$$(m' C_3' \sin vE_0) v\Delta E, \quad (m' C_4' \cos vE_0) v\Delta E, \quad (25)$$

que evidentemente se podrán combinar con el término obtenido al linealizar el primer miembro de dicha ecuación. Tendremos así en definitiva una ecuación diferencial aproximada de la forma:

$$\frac{d^2 \Delta E}{dt^2} + k^2 (m_0 + m') P(t) \Delta E = 0, \quad (26)$$

donde el coeficiente del término lineal es una serie trigonométrica, donde los términos que resultan de la contribución de truncar el segundo miembro de la ecuación (9) poseen funciones trigonométricas cuyos argumentos tienen coeficientes no enteros. El procedimiento que hemos seguido para la linealización del segundo miembro se debe a Gylén y ha sido estudiado con detalle por Poincaré.

REFERENCIAS

- Altavista C.A., 1963, *Boletín de la Asociación Argentina de Astronomía* N°6, 92.
- Brouwer, D., Clemence, G., 1961, *Methods of Celestial Mechanics*, Chapter XI. The Academic Press.
- Hill, C.W., 1905, *The Collected Mathematical Works*, Vol. I, 243.
- Lagrange, L., 1870, *Oeuvres*, Vol. V, 493.
- Newcomb, S., 1891, *Astronomical Papers*, Vol. III.
- Poincaré, H., 1893, *Les Méthodes Nouvelles de la Mécanique Céleste*, Vol. II, Capítulos XVI y XVII. Dover Pub., 1957.
- Smart, W.M., 1903, *Celestial Mechanics*, Chapter 3, 30.
- Tisserand, F., 1896, *Traité de Mécanique Céleste*, Vol. IV, Capítulo XXIII.

Palabras Finales

por el

Dr. Eugenio E. Mendoza V.

Instituto de Astronomía

Universidad Nacional Autónoma de México

Profesor Adrián Blaauw, presidente de la Unión Astronómica Internacional; profesor Claudio Anguita, presidente del Comité Científico Organizador; profesor Hugo Moreno, presidente del Comité Organizador Local, demás miembros de ambos comités; personal de la Universidad de Chile, señoras y caballeros traductores:

Todos los participantes les estamos muy agradecidos y los congratulamos por tan excelente primera Reunión Astronómica Regional Latinoamericana. A la vez nos es muy grato manifestar nuestro deseo y confianza para que estas reuniones se celebren periódicamente en los distintos países de nuestra querida América.

¡Muchas Gracias!

Indice de Autores - Index to Authors

Abraham, Z.	307	Cesco, C.U.	304
Actis, E.	299	Clariá, J.J.	146,150,151
Agüero, E.L.	61,73	Codina L., S.J.	247
Alcaíno, G.	153	Colomb, F.R.	175,183,195
Aldrovandi, S.M.V.	120,171		
Altavista, C.A.	309,321,327	Chaves, O.L.	217
Andrei, A.M.	287		
Aparici, J.	198	D'Avila, V.M.	287
Araujo, A.	105	Danks, A.C.	232
Arias, J.C.	105	de la Reza, R.	225
Arnal, E.M.	136,142	Desch, M.D.	310,318
Arnedo, M.M.V. de	269	Dubner, G.M.	175
		Ducati, J.R.	272
Bajaja, E.	64,183		
Blaauw, A.	133	Feinstein, A.	146
Blanco, B.	52	Fernández M., S.	311
Blanco, V.M.	52	Flagg, R.S.	318
Braz, M.A.	51	Franco, M.L.	136,188
		Freire, R.	228
Cabrera, A.L.	146		
Calderón, J.H.	55	Gallejo, M.	275
Campusano, L.E.	115	Gneiding, C.	247
Carestia, R.A.	275	Graham, J.A.	63
Carr, J.D.	310	Gutiérrez-Moreno, A.	257
Carranza, G.	53,73		
Carrasco, G.	279,289	Heiles, C.	195
Cerruti, M.A.	70	Houziaux, L.	232

Kunkel, W.E.	49	Pacheco, J.A. de F.	203,247
Lapasset, E.	244	Pedrerros, M.	115
Laporte, E.	247	Penna, J.L.	287
Lasker, B.M.	48	Pöppel, W.G.L.	188,195
Le Squeren, A.M.	180	Queiroz, M. de	287
Lépine, J.R.D.	180	Querci, F.	225
Levato, H.	241,271	Quintana, H.	75,126,212
Loyola, P.	289	Reyes, F.	198
MacConnell, D.J.	158	Sahade, J.	266
Magalhães, A.M.	247	Scalise Jr., E.	180
Malaroda, S.	241,271	Serafino, A.	299
Manrique, W.	299	Sérsic, J.L.	31,55,70,105
May, J.	198,310,318,319	Smith, A.G.	319
McCarthy, M.	52	Steiner, J.E.	268
Méndez, R.H.	167,169	Stock, J.	160,296
Mendoza V., E.E.	250,263	Strauss, F.M.	51,272,307
Milone, L.A.	242	Thieman, J.R.	319
Moreno, H.	257	Vieira, E.R.	188
Morras, R.	183	Vogt, N.	221
Mourão, R.R. de F.	217	Wamsteker, W.	256
Muzzio, J.C.	154	Wielebinski, R.	110
Natale, A.A.	120	Zaragoza, A.	275
Niemela, V.S.	169,211,266	Zorec, J.	211
Noël, F.	316		
Olano, C.A.	188		



