

Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

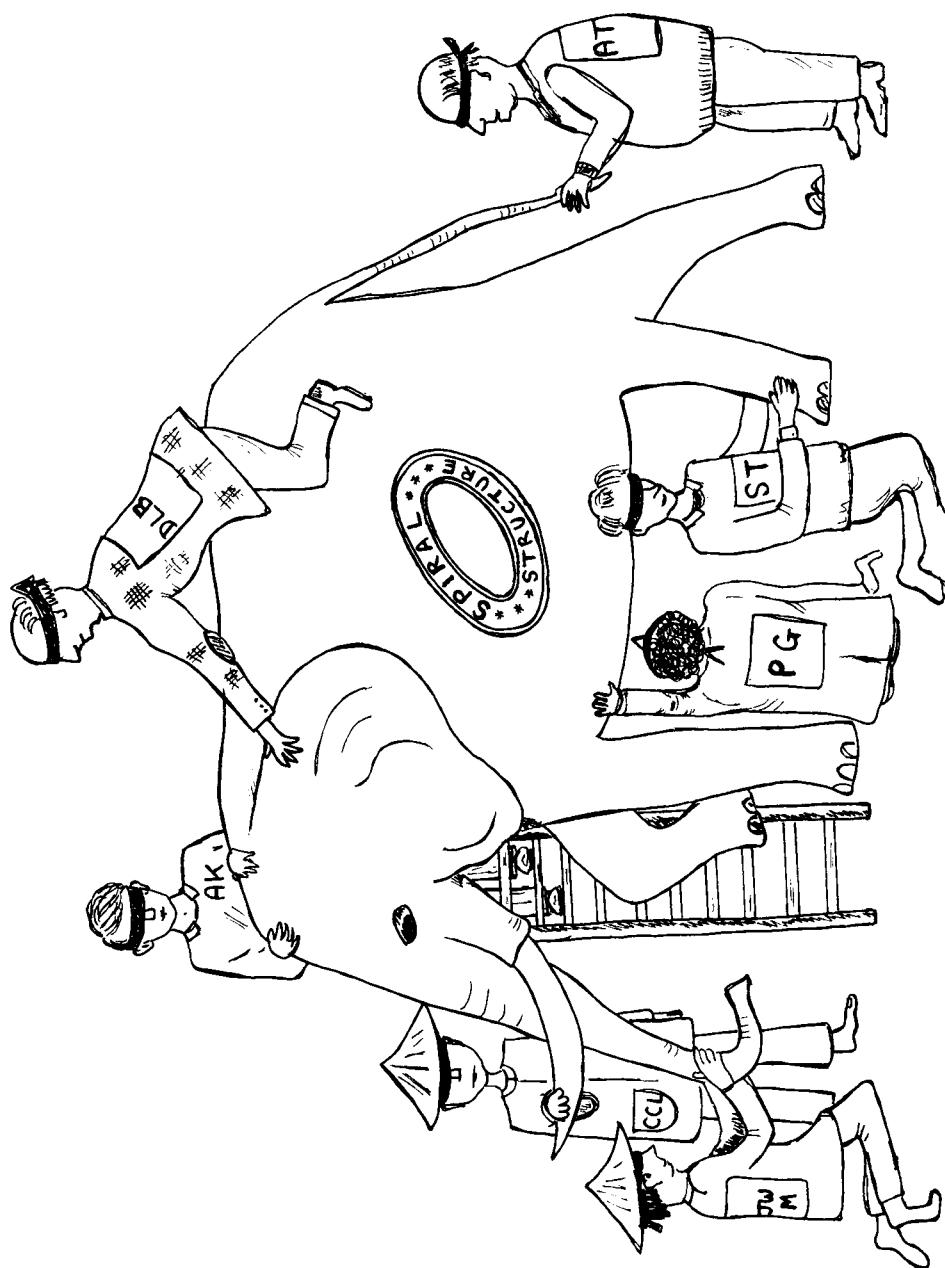
[More information](#)

Dynamics of Astrophysical Discs

Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

[More information](#)

Cartoon, drawn by Janet Sellwood in 1984, based on Toomre's assessment of the state of spiral structure theory in 1980. Apart from a few extra blindfolded individuals, this still seems appropriate today.

Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

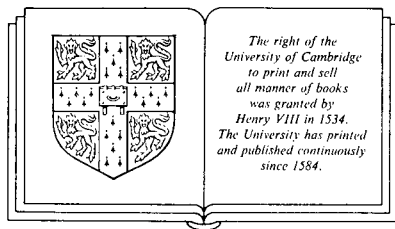
[More information](#)

Dynamics of Astrophysical Discs

The proceedings of a conference
at the Department of Astronomy,
University of Manchester,
13 - 16 December 1988.

Edited by

J. A. SELLWOOD



CAMBRIDGE UNIVERSITY PRESS

Cambridge

New York Port Chester

Melbourne Sydney

Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

[More information](#)

PUBLISHED BY THE PRESS SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE
The Pitt Building, Trumpington Street, Cambridge, United Kingdom

CAMBRIDGE UNIVERSITY PRESS
The Edinburgh Building, Cambridge CB2 2RU, UK
40 West 20th Street, New York NY 10011-4211, USA
477 Williamstown Road, Port Melbourne, VIC 3207, Australia
Ruiz de Alarcón 13, 28014 Madrid, Spain
Dock House, The Waterfront, Cape Town 8001, South Africa

<http://www.cambridge.org>

© Cambridge University Press 1989

This book is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without
the written permission of Cambridge University Press.

First published 1989
First paperback edition 2003

A catalogue record for this book is available from the British Library

ISBN 0 521 37485 5 hardback
ISBN 0 521 54814 4 paperback

Table of contents

Titles of invited papers are highlighted. Names of co-authors who did not attend the conference are given in smaller type.

Preface		ix
Names and addresses of participants		xi
Conference photograph		xvi
Spiral waves in Saturn's rings	<i>Jack J. Lissauer</i>	1
Structure of the Uranian rings	<i>C. D. Murray & R. P. Thompson</i>	17
Planetary rings: theory	<i>Nicole Borderies</i>	19
Simulations of light scattering in planetary rings	<i>L. Dones, M. R. Showalter & J. N. Cuzzi</i>	25
Accretion discs around young stellar objects and the proto-Sun	<i>D. N. C. Lin</i>	27
The β Pictoris disc: a planetary rather than a protoplanetary one	<i>Pawel Artymowicz</i>	43
Optical polarimetry and thermal imaging of the disc around β Pictoris	<i>R. D. Wolstencroft, S. M. Scarrott, R. F. Warren-Smith, C. M. Telesco, R. Decher & E. E. Becklin</i>	45
Observations of discs around protostars and young stars	<i>Ronald L. Snell</i>	49
VLA observations of ammonia toward molecular outflow sources	<i>José M. Torrelles, Paul T. P. Ho, Luis F. Rodríguez, Jorge Cantó & Lourdes Verdes-Montenegro</i>	61
Derivation of the physical properties of molecular discs by an MEM method	<i>John Richer & Rachael Padman</i>	65
Masers associated with discs around young stars	<i>Geneviève Brebner</i>	67
The nature of polarisation discs around young stars	<i>S. M. Scarrott</i>	69
The correlation between the main parameters of the interstellar gas (including Salpeter's spectrum of masses) as a result of the development of turbulent Rossby waves	<i>V. V. Dolotin & A. M. Fridman</i>	71
Discs in cataclysmic variables and X-ray binaries	<i>A. R. King</i>	73
A disc instability model for soft X-ray transients containing black holes	<i>Shin Mineshige & J. Craig Wheeler</i>	79
X-ray variability from the accretion disc of NGC 5548	<i>J. S. Kaastra</i>	81

vi	<i>Table of contents</i>	
Viscously heated coronae and winds around accretion discs	<i>M. Czerny & A. R. King</i>	83
Optical emission line profiles of symbiotic stars	<i>K. Robinson, M. F. Bode, J. Meaburn & M. J. Whitehead</i>	85
The effect of formation of FeII in winds confined to discs for luminous stars	<i>M. Friedjung & G. Muratorio</i>	87
Observational evidence for accretion discs in active galactic nuclei	<i>Matthew Malkan</i>	89
The fuelling of active galactic nuclei by non-axisymmetric instabilities	<i>I. Shlosman, J. Frank & M. C. Begelman</i>	99
The circum-nuclear disc in the Galactic centre	<i>Wolfgang J. Duschl</i>	101
Non-axisymmetric instabilities in thin self-gravitating differentially rotating gaseous discs	<i>J. C. B. Papaloizou & G. J. Savonije</i>	103
Non-linear evolution of non-axisymmetric perturbations in thin self-gravitating gaseous discs	<i>G. J. Savonije & J. C. B. Papaloizou</i>	115
Eccentric gravitational instabilities in nearly Keplerian discs	<i>Steven P. Ruden, Fred C. Adams & Frank H. Shu</i>	119
Gravity mode instabilities in accretion tori	<i>W. Glatzel</i>	121
The stability of viscous supersonic shear flows – critical Reynolds numbers and their implications for accretion discs	<i>W. Glatzel</i>	123
Asymptotic analysis of overstable convective modes of uniformly rotating stars	<i>Umin Lee</i>	125
Polytropic models in very rapid rotation	<i>Vassilis S. Geroyannis</i>	127
Distribution and kinematics of gas in galaxy discs	<i>R. Sancisi</i>	129
Are the smallest galaxies optically invisible?	<i>Claude Carignan</i>	133
Can we understand the constancy of rotation curves?	<i>Daniel Pfenniger</i>	135
How well do we know the surface density of the Galactic disc?	<i>Thomas S. Statler</i>	137
On the heating of the Galactic disc	<i>P. te Lintel Hekkert & Herwig Dejonghe</i>	139
The bulge-disc interaction in galactic centres	<i>Mark E. Bailey & Althea Wilkinson</i>	141
Dynamics of the large-scale disc in NGC 1068	<i>J. Bland & G. N. Cecil</i>	143
The flow of gas in barred galaxies	<i>E. Athanassoula</i>	145
The warped dust lane in A1029-459	<i>L. S. Sparke & S. Casertano</i>	147
Structure and evolution of dissipative non-planar galactic discs	<i>T. Y. Steiman-Cameron & R. H. Durisen</i>	149

<i>Table of contents</i>	vii
Non-axisymmetric magnetic fields in turbulent gas discs <i>K. J. Donner & A. Brandenburg</i>	151
Non-axisymmetric disturbances in galactic discs <i>Alar Toomre</i>	153
Spiral instabilities in <i>N</i>-body simulations <i>J. A. Sellwood</i>	155
Long-lived spiral waves in <i>N</i> -body simulations <i>Neil F. Comins & Michael C. Schroeder</i>	173
Overstable modes in stellar disc systems <i>P. L. Palmer, J. C. B. Papaloizou & A. J. Allen</i>	175
Galactic seismological approach to the spiral galaxy NGC 3198 <i>M. Noguchi, T. Hasegawa & M. Iye</i>	177
Characteristics of bars from 3-D simulations <i>D. Friedli & D. Pfenniger</i>	179
Spirals and bars in linear theory <i>J. F. Sygnet, M. Tagger & R. Pellat</i>	181
Stellar hydrodynamical solutions for Eddington discs <i>N. W. Evans</i>	183
Theory of gradient instabilities of the gaseous Galactic disc and rotating shallow water <i>A. M. Fridman</i>	185
Stability criteria for gravitating discs <i>Valerij L. Polyachenko</i>	199
Stability of two-component galactic discs <i>Alessandro B. Romeo</i>	209
The smoothed particle hydrodynamics of galactic discs <i>Pawel Artymowicz & Stephen H. Lubow</i>	211
Tidal triggering of active disc galaxies by rich clusters <i>Gene G. Byrd & Mauri Valtonen</i>	213
The formation of spiral arms in early stages of galaxy interaction <i>Maria Sundin</i>	215
Formation of leading spiral arms in retrograde galaxy encounters <i>M. Thomasson, K. J. Donner, B. Sundelius, G. G. Byrd, T.-Y. Huang & M. J. Valtonen</i>	217
The influence of galaxy interactions on stellar bars <i>M. Gerin, F. Combes & E. Athanassoula</i>	219
Disc galaxies – work in progress in Gothenburg <i>Stefan Engström, Björn Sundelius & Magnus Thomasson</i>	221
Motion of a satellite in a disc potential <i>B. Zafiroopoulos</i>	223
Observer's summary <i>R. J. Cohen</i>	225
Common processes and problems in disc dynamics <i>Scott Tremaine</i>	231
Citation index	239
Index of authors	253
Subject index	255

Preface

Discs occurring in a wide diversity of astronomical objects prompt similar questions about their dynamical behaviour. Astrophysicists working on problems related to just one type of disc may find that a similar problem has already been addressed in a different context. This is especially true of the dynamical behaviour: the dispersion relation for spiral density waves was originally derived for galaxies but has been applied, with more success even, to Saturn's rings, the formalism of a global mode treatment for gaseous accretion discs has some similarity to that for the collisionless stellar discs of galaxies, aspects of the dynamics of planet formation around a young stellar object are reflected in the response of a galaxy disc to a co-orbiting giant molecular cloud complex, *etc.*

In order to encourage thinking along these lines, the Department of Astronomy in the University of Manchester organised a four day conference in December 1988 to bring together experts on discs in a number of contexts. In rough order of increasing physical size, these are: planetary ring systems, accretion discs in cataclysmic binary stars and active galactic nuclei, protoplanetary and protostellar discs and disc galaxies.

The aim of the conference, and of these proceedings, was to present those aspects of the behaviour of each type of disc that could be of relevance to other types. To emphasise this theme, the sequence of talks was deliberately arranged so as to ensure that many different disc types were discussed on any one day. Though this worked very successfully at the meeting, it is less appropriate for a reference volume; the sequence of papers in these proceedings has therefore been rearranged so that those concerning each particular disc type are grouped together.

Of the papers presented at the meeting, this volume contains articles by all ten review speakers, reports of 15 out of the 17 contributed papers, 33 out of the 34 poster papers and summary talks of both the observational data and theoretical work. The editor is particularly grateful to the overwhelming majority of these authors for transmitting their manuscripts to him in machine-readable form and for not exceeding the requested lengths. Two of the papers by authors from the Soviet Academy of Sciences were given considerably more space than other contributed papers as their work is less widely available in the West.

Full postal addresses of all the participants are listed at the front of the book – the affiliations only of the authors are given in each paper. The abbreviations used for the main astronomical journals are those recommended in *Astronomy and Astrophysics Abstracts*. I have included a citation index of all papers referenced in the book which is followed by an index of authors. I hope that together these will provide more useful information than the customary names index, which has no obvious advantage (aside from boosting the egos of those most frequently cited!).

The enthusiasm of the ninety-five participants, who came from sixteen different countries, and the generally high standard of their presentations ensured the success of the meeting. The conference could not have taken place, however, without the willing help of a very able group of Manchester locals.

The invaluable and constant guidance of Professor Franz Kahn, in matters both scientific and organisational, is greatly appreciated. The local and financial arrangements for the meeting were almost exclusively, and ably handled by Mrs Ellen Carling, assisted

Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

[More information](#)

x

Preface

by Miss Melanie Thomas. Mrs Carling also typed most of the manuscripts not received in machine readable form. Mrs Yvonne Cain printed the conference programmes *etc.* and an especially well presented book of *Abstracts* for participants. Mr John Turner assisted with slides, videos and other aids during the sessions. The conference photograph was taken and printed by Mr Ian Callaghan.

The text of this volume was prepared using T_EX on the Manchester Starlink facilities. I hope it will serve both as an accurate record of the meeting and a useful reference work in years to come.

JERRY SELLWOOD

June 1989

Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

[More information](#)

Names and addresses of participants

Peter Allan	Department of Astronomy, The University, Manchester M13 9PL
Moray Anderson	Department of Astronomy, The University, Glasgow G12 8QW
Pawel Artymowicz	Space Telescope Science Institute, 3700 San Martin Drive, Baltimore MD 21218, USA
Lia Athanassoula	Observatoire de Marseille, 2 Place le Verrier, 13248 Marseille Cedex 04, France
Mark Bailey	Department of Astronomy, The University, Manchester M13 9PL
Joss Bland	Department of Astronomy & Space Physics, Rice University, Houston TX 77251, USA
Mike Bode	School of Physics & Astronomy, Lancashire Polytechnic, Corporation Street, Preston PR1 2TQ
Nicole Borderies	Jet Propulsion Laboratory 301-150, 4800 Oak Grove Drive, Pasadena CA 91109, USA
Genevieve Brebner	School of Physics & Astronomy, Lancashire Polytechnic, Corporation Street, Preston PR1 2TQ
Adrian Brooks	Department of Astronomy, The University, Manchester M13 9PL
Gene Byrd	Department of Physics & Astronomy, University of Alabama, Box 1921, Tuscaloosa AL 35487, USA
Massimo Calvani	International School for Advanced Studies, Strada Costiera 11, 34014 Trieste, Italy
Claude Carignan	Département de Physique, Université de Montréal, CP 6128 Succ "A", Montréal, Quebec, Canada
Jim Cohen	Nuffield Radio Astronomy Laboratories, Jodrell Bank, Macclesfield, SK11 9DL
Neil Comins	Department of Physics and Astronomy, University of Maine, Bennett Hall, Orono ME 04469, USA
Michal Czerny	Astronomical Observatory, Warsaw University, Al. Ujazdowskie 4, 00- 478 Warszawa, Poland
J Robert Davies	Department of Physics, University of Wales, P O Box 913, Cardiff CF1 3TH
Fernando de Felice	Istituto di Fisica Matematica 'J.-Louis Lagrange', Via Carlo Alberto 10, 10123 Torino, Italy

Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

[More information](#)

xii

List of participants

Herwig Dejonghe	Astronomical Observatory, Krijgslaan 281, B-9000 Gent, Belgium
Marc de Vries	Sterrenkundig Instituut, Postbus 80000, Utrecht, The Netherlands
Luke Dones	Mail Stop 245-3, NASA Ames Research Center, Moffet Field CA 94035, USA
Karl Donner	Observatory and Astrophysics Laboratory, Tähtiforinmäki, SF-00130 Helsinki, Finland
Mark Dubal	Department of Astronomy, University of Leicester, University Road, Leicester LE1 7RH
Bérengère Dubrulle	Observatoire du Pic du Midi et de Toulouse, 14 Avenue Edouard Belin, 31400 Toulouse, France
Wolfgang Duschl	Institut für Theoretische Astrophysik, Universität Heidelberg, Im Neuenheimer Feld 561, D-6900 Heidelberg 1, Federal Republic of Germany
John Dyson	Department of Astronomy, The University, Manchester M13 9PL
George Efstathiou	Department of Astrophysics, 1 Keble Road, Oxford OX1 3NP
Stefan Engström	Department of Astronomy/Astrophysics, Chalmers University of Technology, S-41296 Göteborg, Sweden
N Wyn Evans	Astronomy Unit, School of Mathematics, Queen Mary College, Mile End Road, London E1 4NS
Juhan Frank	Max-Planck-Institut für Astrophysik, Karl-Schwarzschild Straße 1, 8046 Garching bei München, Federal Republic Germany
Alexei Fridman	Astronomical Council, USSR Academy of Sciences, Pyatnitskaya St 48, 109017 Moscow, USSR
Michael Friedjung	Institut D'Astrophysique, 98 bis, Boulevard Arago, 75014 Paris, France
Daniel Friedli	Observatoire de Genève, Chemin des Maillettes 51, CH-1290 Sauverny, Switzerland
Maryvonne Gerin	Radioastronomie Millimétrique, Laboratoire de Physique de l'ENS, 24 Rue Lhomond, F75231 Paris Cedex 05, France
Vasilios Geroyannis	Astronomy Laboratory, Department of Physics, University of Patras, 26110 Patras, Greece
Jamshid Ghanbari	Department of Astronomy, The University, Manchester M13 9PL
Wolfgang Glatzel	Max-Planck-Institut für Astrophysik, Karl-Schwarzschild Straße 1, 8046 Garching bei München, Federal Republic Germany
Richard James	Department of Astronomy, The University, Manchester M13 9PL

Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

[More information](#)*List of participants*

xiii

Jelle Kaastra	Laboratory for Space Research, P O Box 9504, 2300 RA Leiden, The Netherlands
Franz Kahn	Department of Astronomy, The University, Manchester M13 9PL
Simon Kemp	Department of Astronomy, The University, Manchester M13 9PL
Andrew King	Department of Astronomy, University of Leicester, University Road, Leicester LE1 7RH
Christopher Kitchin	The Hatfield Polytechnic Observatory, Bayfordbury, Near Hertford SG13 8LD
Basil Laspas	Department of Astronomy, The University, Manchester M13 9PL
Umin Lee	Department of Astronomy, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan
Doug Lin	Lick Observatory, University of California, Santa Cruz CA 95064, USA
Peter te Lintel Hekkert	Sterrewacht, Postbus 9513, 2300 RA Leiden, The Netherlands
Jack Lissauer	Earth and Space Science Department, State University of New York, Stony Brook NY 11794, USA
Simon Litchfield	Department of Astronomy, University of Leicester, University Road, Leicester LE1 7RH
Huw Lloyd	Department of Astronomy, The University, Manchester M13 9PL
Stephen Lubow	Space Telescope Science Institute, 3700 San Martin Drive, Baltimore MD 21218, USA
Matt Malkan	Department of Astronomy, University of California, Math-Science Building, Los Angeles CA 90024, USA
Leon Mestel	Astronomy Centre, University of Sussex, Falmer, Brighton BN1 9QN
Shin Mineshige	Astronomy Department, University of Texas, RLM 15.308, Austin, TX 78712-1083, USA
Gerard Matorio	Observatoire de Marseille, 2 Place le Verrier, 13248 Marseille Cedex 04, France
Carl Murray	Astronomy Unit, School of Mathematical Sciences, Queen Mary College, Mile End Road, London E1 4NS
Luciano Nobili	Dipartimento di Fisica, Universita di Padova, Via F Marzolo 8, 35131 Padova, Italy
Masafumi Noguchi	National Astronomical Observatory, Mitaka, Tokyo 181, Japan

Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

[More information](#)

xiv

List of participants

Mark O'Reilly	Department of Astronomy, University of Leicester, University Road, Leicester LE1 7RH
Rachael Padman	Mullard Radio Astronomy Observatory, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE
Philip Palmer	Astronomy Unit, School of Mathematical Sciences, Queen Mary College, Mile End Road, London E1 4NS
John Papaloizou	Astronomy Unit, Department of Mathematics, Queen Mary College, Mile End Road, London E1 4NS
Alan Pedlar	Nuffield Radio Astronomy Laboratories, Jodrell Bank, Macclesfield SK11 9DL
Daniel Pfenniger	Observatoire de Genève, Chemin des Maillettes 51, CH-1290 Sauverny, Switzerland
Valerij Polyachenko	Astronomical Council, USSR Academy of Sciences, Pyatnitskaya St 48, 109017 Moscow, USSR
Neil Raha	Department of Astronomy, The University, Manchester M13 9PL
N Ramamani	181A Huntingdon Road, Cambridge CB3 0DJ
John Richer	Mullard Radio Astronomy Observatory, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE
Keith Robinson	School of Physics & Astronomy, Lancashire Polytechnic, Corporation Street, Preston PR1 2TQ
Alessandro Romeo	Scuola Internazionale Superiore di Studi Avanzati, Strada Costiera 11, 34014 Trieste, Italy
Steven Ruden	Astronomy Department, 601 Campbell Hall, University of California, Berkeley CA 94720, USA
Renzo Sancisi	Kapteyn Laboratory, Postbus 800, 9700 AV Groningen, The Netherlands
Gertjan Savonije	Sterrenkundig Instituut, Universiteit van Amsterdam, Roeters Straat 15, 1018 WB Amsterdam, The Netherlands
Mike Scarrott	Department of Physics, University of Durham, South Road, Durham DH1 3LE
Jerry Sellwood	Department of Astronomy, The University, Manchester M13 9PL
Ron Snell	Five College Radio Observatory, University of Massachusetts, Graduate Research Center, Tower B, Amherst MA 01003, USA
Linda Sparke	Washburn Observatory, University of Wisconsin, 475 N Charter Street, Madison WI 53706, USA

Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

[More information](#)*List of participants*

xv

Ralph Spencer	Nuffield Radio Astronomy Laboratories, Jodrell Bank, Macclesfield SK11 9DL
Tom Statler	Joint Institute for Laboratory Astrophysics, University of Colorado, Boulder CO 80309-0440, USA
Tom Steiman-Cameron	Mail Stop 245-3, NASA Ames Research Center, Moffett Field CA 94035, USA
Björn Sundelius	Department of Astronomy/Astrophysics, Chalmers University of Technology, S-41296 Göteborg, Sweden
Maria Sundin	Department of Astronomy/Astrophysics, Chalmers University of Technology, S-41296 Göteborg, Sweden
Jean Sygnet	Institut d'Astrophysique de Paris, 98 bis, Boulevard Arago, 75014 Paris, France
Magnus Thomasson	Onsala Space Observatory, S-43900 Onsala, Sweden
Robert Thompson	Astronomy Unit, School of Mathematics, Queen Mary College, Mile End Road, London E1 4NS
Alar Toomre	Department of Mathematics, Room 2-371, MIT, Cambridge MA 02139, USA
José Torrelles	Instituto de Astrofísica de Andalucía, Ap Correos 2144, Granada 18080, Spain
Scott Tremaine	Director CITA, McLennan Labs, University of Toronto, Toronto ON M5S 1A1, Canada
Roberto Turolla	Dipartimento di Fisica, Università di Padova, Via F Marzolo 8, 35131 Padova, Italy
Esko Valtaoja	Department of Physical Sciences, University of Turku, SF-20500 Turku, Finland
Leena Valtaoja	Turku University Observatory, Tuorla, SF-21500 Piikkiö, Finland
Tony Weeks	Department of Astronomy, The University, Manchester M13 9PL
Althea Wilkinson	Department of Astronomy, The University, Manchester M13 9PL
Ray Wolstencroft	Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ
Basil Zafiroopoulos	Department of Astronomy, The University, Manchester M13 9PL

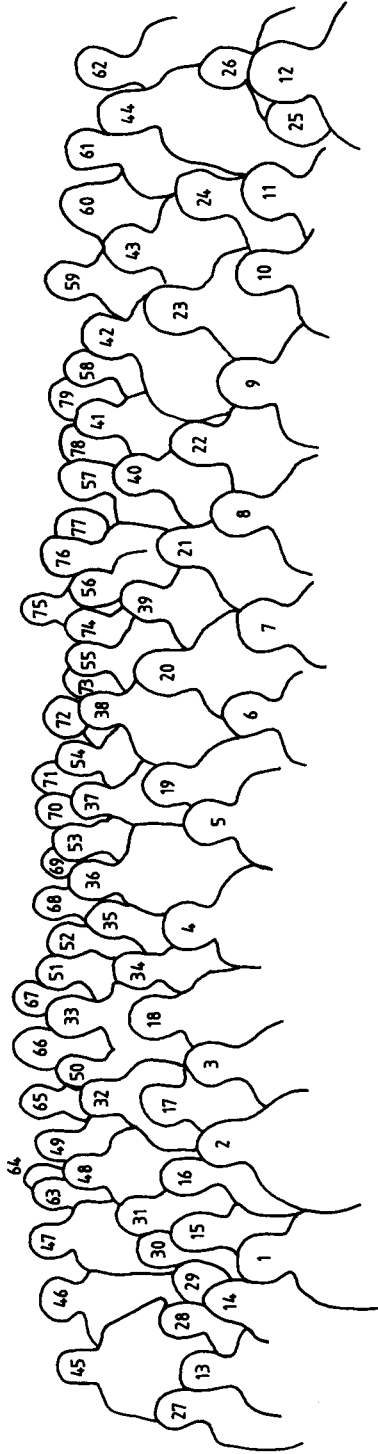
Cambridge University Press

0521548144 - Dynamics of Astrophysical Discs: The Proceedings of a Conference at the Department of Astronomy,
University of Manchester, 13-16 December 1988 - J. A. Sellwood

Frontmatter/Prelims

[More information](#)





1 Ramamani	11 Bailey	21 Cohen	31 Malkan	41 te Lintel	51 Statler	61 Friedli	71 E Valtaoja
2 Steiman-Cameron	12 Sellwood	22 Dyson	32 Carignan	42 Lubow	52 Sygnet	62 Polyachenko	72 Dones
3 Ward-Thompson	13 Sparke	23 Duschl	33 Lee	43 Mestel	53 Glatzel	63 Snell	73 Kaastra
4 Byrd	14 L. Valtaoja	24 de Vries	34 Athanassoula	44 Pfenniger	54 Turolla	64 Evans	74 Muratorio
5 Palmer	15 Torrelles	25 Borderies	35 Friedjung	45 Mr Turner	55 Dejonghe	65 Wolstencroft	75 Thomasson
6 Gerin	16 Engström	26 Brebner	36 Savonije	46 Papaloizou	56 Czerny	66 Toomre	76 Litchfield
7 Dubrulle	17 Efstathiou	27 Mrs Carling	37 Romeo	47 Tremaine	57 Comins	67 Sundelius	77 Lin
8 King	18 Robinson	28 Miss Thomas	38 de Felice	48 Noguchi	58 Richer	68 Donner	78 Frank
9 Kahn	19 Sancisi	29 Sundin	39 Calvani	49 Davies	59 James	69 Dubal	79 Scarrott
10 Lissauer	20 Pedlar	30 Artymowicz	40 Nobili	50 Mineshige	60 Padman	70 Ruden	