

ASTROPHYSICS AND SPACE SCIENCE LIBRARY

---

# ACTIVITY IN RED-DWARF STARS

Edited by Patrick B. Byrne and Marcello Rodonò

---

VOLUME 102

PROCEEDINGS

D. REIDEL PUBLISHING COMPANY

DORDRECHT / BOSTON / LANCASTER

5.479  
1 61  
0

# ACTIVITY IN RED-DWARF STARS

PROCEEDINGS OF THE 71st COLLOQUIUM  
OF THE INTERNATIONAL ASTRONOMICAL UNION  
HELD IN CATANIA, ITALY, AUGUST 10–13, 1982

Edited by

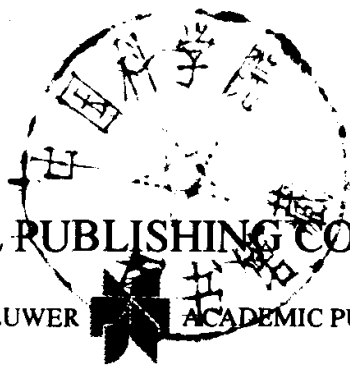
PATRICK B. BYRNE

*Armagh Observatory, Northern Ireland*

and

MARCELLO RODONÒ

*Astrophysical Observatory and University of Catania, Italy*



D. REIDEL PUBLISHING COMPANY

A MEMBER OF THE KLUWER  ACADEMIC PUBLISHERS GROUP

DORDRECHT / BOSTON / LANCASTER

844278

Library of Congress Cataloging in Publication Data

**CIP**

IAU Colloquium (71st : 1982 : Catania, Italy)  
Activity in red-dwarf stars.

(Astrophysics and space science library ; 102)

Includes index.

1. Red dwarfs--Congresses. I. Byrne, Patrick, B., 1947-  
II. Rodonò, Marcello, 1941- . III. Title. IV. Series.  
QB843.R4I27 1982 523.8 83-8698  
ISBN 90-277-1601-3

---

Published by D. Reidel Publishing Company,  
P.O. Box 17, 3300 AA Dordrecht, Holland.

Sold and distributed in the U.S.A. and Canada  
by Kluwer Academic Publishers,  
190 Old Derby Street, Hingham, MA 02043, U.S.A.

In all other countries, sold and distributed  
by Kluwer Academic Publishers Group,  
P.O. Box 322, 3300 AH Dordrecht, Holland.

All Rights Reserved

Copyright © 1983 by D. Reidel Publishing Company, Dordrecht, Holland  
No part of the material protected by this copyright notice may be reproduced or  
utilized in any form or by any means, electronic or mechanical  
including photocopying, recording or by any informational storage and  
retrieval system, without written permission from the copyright owner

Printed in The Netherlands

## ACTIVITY IN RED-DWARF STARS

# ASTROPHYSICS AND SPACE SCIENCE LIBRARY

A SERIES OF BOOKS ON THE RECENT DEVELOPMENTS  
OF SPACE SCIENCE AND OF GENERAL GEOPHYSICS AND ASTROPHYSICS  
PUBLISHED IN CONNECTION WITH THE JOURNAL  
SPACE SCIENCE REVIEWS

## *Editorial Board*

J. E. BLAMONT, *Laboratoire d'Aeronomie, Verrières, France*

R. L. F. BOYD, *University College, London, England*

L. GOLDBERG, *Kitt Peak National Observatory, Tucson, Ariz., U.S.A.*

C. DE JAGER, *University of Utrecht, The Netherlands*

Z. KOPAL, *University of Manchester, England*

G. H. LUDWIG, *NOAA, Environmental Research Laboratories, Boulder, CO, U.S.A.*

R. LÜST, *President Max-Planck-Gesellschaft zur Förderung der Wissenschaften, München, F.R.G.*

B. M. McCORMAC, *Lockheed Palo Alto Research Laboratory, Palo Alto, Calif., U.S.A.*

H. E. NEWELL, *Alexandria, Va., U.S.A.*

L. I. SEDOV, *Academy of Sciences of the U.S.S.R., Moscow, U.S.S.R.*

Z. ŠVESTKA, *University of Utrecht, The Netherlands*

VOLUME 102

PROCEEDINGS

## PREFACE

IAU Colloquium No. 71 had its immediate origins in a small gathering of people interested in the optical and UV study of flare stars which took place during the 1979 Montreal General Assembly. We recognized that a fundamental change was taking place in the study of these objects. Space-borne instruments (especially IUE and Einstein) and a new generation of ground-based equipment were having a profound effect on the range of investigations it was possible to make. To extract maximum benefit from these new possibilities it would be necessary as never before to have good communication with colleagues in other disciplines, for instance, with atomic and solar physicists. Similarly, studies of phenomena associated with the outer atmospheres of the late-type stars could now hope to give significant insights into certain aspects of solar activity. So, in view of the wide range of backgrounds of those participating, the meeting had an unusually high proportion of invited reviews while most of the contributed papers were presented as posters. It is gratifying that in the short time since the meeting a good deal of correspondence has been received from participants remarking on the success of this format.

Once the decision had been taken in principle to hold the meeting, a very considerable amount of work fell on the two organizing committees, viz. the Scientific and Local Organizing Committees. The Scientific Organizing Committee was chaired by D.J. Mullan and consisted of A.D. Andrews, B.W. Bopp, A.K. Dupree, R.E. Gershberg, G. Godoli, J.L. Linsky, M. Rodonò, O.B. Slee and G.S. Vaiana. The Local Organizing Committee comprised M. Rodonò (chairman), C. Blanco, S. Catalano, E. Marilli, L. Paternò and S. Serio.

We would like to gratefully acknowledge the cooperation of the IAU and in particular the General Secretary, P.A. Wayman, and Assistant General Secretary, R.M. West, at all stages of preparing for the Colloquium. The Colloquium was sponsored by IAU Commission No. 27 and co-sponsored by Commissions No. 10, 29, 40, 42, 44.

The following chaired the sessions: A.K. Dupree, C. Jordan, J.L. Linsky, D.J. Mullan, D.M. Popper, M. Rodonò, R. Rosner, Y. Uchida, G.S. Vaiana and N.O. Weiss.

There are a number of people we would like to thank whose names do not appear in any of the Committees. Sterling work was done by Fabia

Foggi in the months before and both during and since the meeting. A. Calì, S. Del Popolo, G. Gentile, E. Martinetti, M.G. Minaldi, M. Miraglia, M.L. Rapisarda, S. Sardone, M.C. Scuderi, C. Sorge, and V. Stancanelli also assisted tirelessly in various capacities during the meeting. Their faces, if not their individual names, will be known to all who attended. Last, but far from least, our thanks go to Mrs. Eleonora Rodonò, who acted as interpreter, guide, social secretary and even personal confidant on a number of occasions!

Vital financial support was provided by the National Research Council of Italy, the Astrophysical Observatory and the University of Catania, the Astronomical Observatory of the University of Palermo, the Ministero della Pubblica Istruzione, the Regione Siciliana, the Comune di Catania and the Amministrazione Provinciale di Catania. Social entertainments were provided by Azienda Autonoma delle Terme di Acireale, Comune di Acicastello, Camera di Commercio di Catania, Ente Provinciale per il Turismo di Catania, and Azienda di Soggiorno e Cura di Acireale.

This preface would not be complete without commenting on a very special aspect of IAU Colloquium No. 71. Scientific intercourse was made doubly easy by the very successful social programme which accompanied the scientific meeting. Perhaps in this context we should thank one final chairman, viz. Dave Gibson, who presided during the closing dinner.

It has been our task as Editors to bring this large and diverse collection of material to a wider audience. Within each session the invited papers are followed by the related contributed ones. The order is not strictly that in which they were presented. Rather we have grouped the papers according to subject matter.

Discussions which took place after the orally presented papers were recorded on magnetic tape. We have transcribed these and they follow the text of the appropriate paper. There are inevitable gaps due to loss of recording for various reasons. Generally the discussion was transcribed word-for-word but to improve readability repetitions, excessive use of colloquialisms, etc were removed. We are confident that no unacceptable charge of emphasis resulted.

An index follows the text at the end of the book. In preparing it we were conscious of two dangers. The first was that of producing too sparse an index which would make the exercise a trivial one. The second lies in the direction of "safety first", including all references one could possibly imagine. We have tried to take a middle road, bearing in mind the likely use of the book. For instance, in the case of star names, we have not referenced every one appearing in the book but rather those which are discussed at some length.

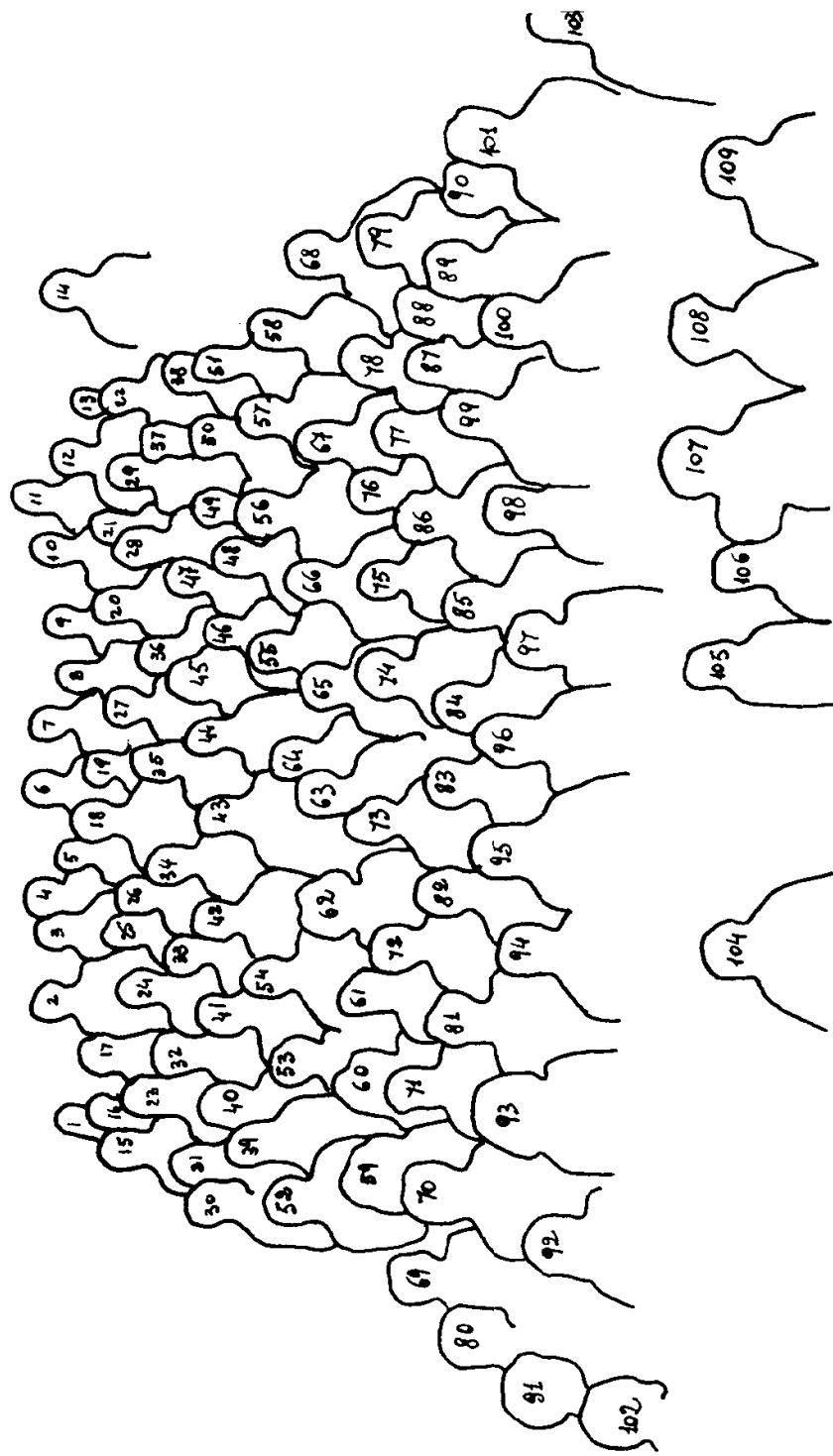
Finally we would like to thank all of those authors who brought their manuscripts in camera-ready form at the beginning of the meeting as requested, making our editorial duties much easier. Our thanks go to D.Reidel Publ.Co. in the person of Mrs. Pols v.d.Heijden for their excellent cooperation.

30th October 1982

P.B. Byrne and M. Rodonò







1. Agrawal, 2. Linnell, 3. Bopp, 4. La Fauci, 5. Wing Jr., 6. Wing, 7. Bodo, 8. Rodonò, 9. Kameswara Rao, 10. Fischerstrom, 11. Weiss, 12. Scaltriti, 13. Mrs. Scaltriti, 14. Das, 15. Doyle, 16. Gokhale, 17. Goldberg, 18. Pallavicini, 19. Simon, 20. Pirronello, 21. Olah, 22. Bruca, 23. Gimenez, 24. Herrero, 25. Sarma, 26. Lang, 27. Magazzù, 28. Andersen, 29. Pidotella, 30. Butler, 31. Elliott, 32. Tanaka, 33. Paternò, 34. Belvedere, 35. Oskanian, 36. Bohn, 37. Haisch, 38. Giampapa, 39. Walter, 40. Brown, 41. Feldman, 42. Linsky, 43. Charles, 44. Venugopal, 45. Torres, 46. Van Leeuwen, 47. Reglero Velasco, 48. Golub, 49. Cutispoto, 50. Worden, 51. Stencel, 52. Basri, 53. Mrs. Catalano, 54. Catalano, 55. Stern, 56. Sakurai, 57. Kuypers, 58. Kodaira, 59. Angelico, 60. Calvet, 61. Ducati, 62. Baliunas, 63. Priest, 64. Hidayat, 65. Serio, 66. Dupree, 67. non participant, 68. Rucinski, 69. Byrne, 70. Budding, 71. Popper, 72. Peres, 73. Bookmeyer, 74. Mrs. Vaiana, 75. Mrs. Serio, 76. Uchida, 77. Alphenaar, 78. Melikyan, 79. Chugainov, 80. Blanco, 81. Rosner, 82. Mullan, 83. Andrews, 84. Maggio, 85. Vaiana, 86. Sciortino, 87. Ni, 88. Mattig, 89. Gibson, 90. Jordan, 91. De La Reza, 92. Pazzani, 93. Zuccarello, 94. Rapisarda (LOC), 95. Godoli, 96. Del Popolo (LOC), 97. Mrs. Rodonò, 98. Micela, 99. Simnett, 100. Tsai, 101. Pettersen, 102. Collier, 103. Collura, 104. Strazzulla, 105. Minaldi (LOC), 106. Scuderi (LOC), 107. Cali (LOC), 108. Foggi (LOC), 109. Nha.

## LIST OF PARTICIPANTS

- Agrawal P.C., Tata Institute of Fundamental Research, Homi  
Bhabha Road, Bombay 400 005, India
- Alphenaar P., Sterrewacht Leiden, Huygens Laboratorium,  
Wassenaarseweg 78, Leiden 2300RA, The Netherlands
- Andersen B.N., Institute of Theoretical Astrophysics,  
University of Oslo, P.B.1029, Blindern, Oslo 3, Norway
- Andrews A.D., Armagh Observatory, College Hill, Armagh  
BT61 9DG, Northern Ireland, UK
- Angelico G., Osservatorio Astrofisico, Città Universitaria,  
95125 Catania, Italy
- Anile M.A., Seminario Matematico, Città Universitaria,  
95125 Catania, Italy
- Baliunas S.L., Center for Astrophysics, 60 Garden Street,  
Cambridge, MA 02138, USA
- Basri G., Department of Astronomy, University of California,  
Berkeley, CA 94720, USA
- Belvedere G., Istituto di Astronomia, Città Universitaria,  
95125 Catania, Italy
- Blanco C., Osservatorio Astrofisico, Città Universitaria,  
95125 Catania, Italy
- Bodo G., Osservatorio Astronomico, 10025 Pino Torinese,  
Italy
- Bohn H.U., Institute of Astronomy and Astrophysics, Am  
Hubland, D-8700 Wurzburg, Germany FR
- Bookmyer B.B., University of Maryland, European Division,  
Im Bosseldorn 30, 6900 Heidelberg, Germany FR
- Bopp B.W., Department of Physics and Astronomy, University  
of Toledo, Toledo, OH 43606, USA
- Bromage G.E., Building R25, Rutherford-Appleton Laboratory,  
Chilton, Didcot, Oxon OX11 0QX, UK
- Brown A., Department of Physics, Queen Mary College, Mile  
End Road, London E1 4NS, UK

- Bruca L., S.I.S.S.A., International Center for Theoretical  
Physics, Miramare, 34100 Trieste, Italy
- Budding E., Department of Astronomy, University of Manchester,  
Manchester M13 9PL, UK
- Butler C.J., Armagh Observatory, College Hill, Armagh BT61  
9DG, Northern Ireland, UK
- Byrne P.B., Armagh Observatory, College Hill, Armagh BT61 9DG,  
Northern Ireland, UK
- Calvet N., C.I.D.A., Apartado 264, Merida 5101-A, Venezuela
- Castellani V., Istituto Astrofisica Spaziale, Casella  
Postale 67, 00044 Frascati, Italy
- Catalano F.A., Osservatorio Astrofisico, Città Universitaria,  
95125 Catania, Italy
- Catalano S., Istituto di Astronomia, Città Universitaria,  
95125 Catania, Italy
- Cellino A., Osservatorio Astronomico, 10025 Pino Torinese,  
Italy
- Charles P.A., Department of Astrophysics, South Parks Road,  
Oxford OX1 3RQ, UK
- Chugainov P.F., Crimean Astrophysical Observatory, P.O.  
Nauchny, 334413 Crimea, USSR
- Collier A.C., Physics Department, University of Canterbury,  
Christchurch, New Zealand
- Collura A., Osservatorio Astronomico, Palazzo dei Normanni,  
90134 Palermo, Italy
- Cutispoto G., Osservatorio Astrofisico, Città Universitaria,  
95125 Catania, Italy
- Das M.K., Department of Physics and Astrophysics, S.V.  
College, Delhi University, Dhaula Kuan, New Delhi 110 021,  
India
- De La Reza R., CNPQ Observatorio Nacional, Rua General Bruce  
586, 20921 Rio De Janeiro, Brazil
- Doyle J.G., Armagh Observatory, College Hill, Armagh BT61  
9DG, Northern Ireland, UK
- Ducati J.R., Centre de Données Stellaires, Observatoire de  
Strasbourg, 11 rue de l'Université, 6700 Strasbourg, France

## LIST OF PARTICIPANTS

xxi

- Dupree A.K., Center for Astrophysics, 60 Garden Street,  
Cambridge, MA 02138, USA
- Elliott I., Dunsink Observatory, Castleknock, Co.Dublin,  
Ireland
- Evans D.S., Department of Astronomy, University of Texas,  
Austin, TX 78712, USA
- Feldman P.A., Herzberg Institute of Astrophysics, National  
Research Council of Canada, Ottawa K1A 0R6, Canada
- Fischerstrom C., Stockholms Observatorium, S-13300  
Saltsjobaden, Sweden
- Gahm G., Stockholms Observatorium, S-13300 Saltsjobaden,  
Sweden
- Gershberg R.E., Crimean Astrophysical Observatory, P.O.  
Nauchny, 334413 Crimea, USSR
- Giampapa M.S., Center for Astrophysics, 60 Garden Street,  
Cambridge, MA 02138, USA
- Gibson D.M., Physics and Astronomy Department, New Mexico  
Tech., Socorro, NM 87801, USA
- Gimenez A., Departamento de Astrofisica, Facultad de  
Fisicas, Universidad Complutense, Madrid 3, Spain
- Giuricin G., Osservatorio Astronomico, Via G.B.Tiepolo 11,  
34131 Trieste, Italy
- Godoli G., Cattedra di Fisica Solare, Università degli  
Studi, Largo E.Fermi 5, 50125 Firenze, Italy
- Gokhale M.H., Indian Institute of Astrophysics, Bangalore  
560 034, India
- Goldberg L., Kitt Peak National Observatory, P.O.Box 26732,  
Tucson, AZ 85726, USA
- Golub L., Center for Astrophysics, 60 Garden Street,  
Cambridge, MA 02138, USA
- Haisch B.M., Div.52-54, Bldg 201, Lockheed Palo Alto Research  
Laboratory, 3251 Hanover St., Palo Alto, CA 94304, USA
- Hartmann L., Center for Astrophysics, 60 Garden Street,  
Cambridge, MA 02138, USA
- Herrero A., Instituto de Astrofisica de Canarias, Univer-  
sidad De La Laguna, Tenerife, Spain

- Hidayat B., Bosscha Observatory, Lembang, Java, Indonesia
- Johnson H.M., Dept. 52-12, Bldg. 255, Lockheed Missiles  
and Space Co., 3251 Hanover Street, Palo Alto, CA  
94304, USA
- Jordan C., Department of Theoretical Physics, University  
of Oxford, 1 Keble Road, Oxford OX1 3NP, UK
- Kameswara Rao N., Indian Institut of Astrophysics,  
Bangalore 560034, India
- Kodaira K., Department of Astronomy, Faculty of Science,  
University of Tokyo, Bunkyo-ku, Tokyo 113, Japan
- Kuijpers J., Astronomical Institute, Zonnenburg 2, 3512  
Utrecht, The Netherlands
- La Fauci G., Osservatorio Astrofisico, Città Universitaria,  
95125 Catania, Italy
- Lang K.R., Department of Physics, Robinson Hall, Tufts  
University, Medford, MA 02155, USA
- Linnell A.P., Department of Physics and Astronomy,  
Michigan State University, E.Lansing, MI 48824, USA
- Linsky J.L., Joint Institute for Laboratory Astrophysics, Univer-  
sity of Colorado, Boulder, CO 80309, USA
- Magazzù A., S.I.S.S.A., Inter.Center Theor.Physics,  
Miramare, 34100 Trieste, Italy
- Maggio A., Osservatorio Astronomico, Palazzo dei Normanni,  
90134 Palermo, Italy
- Marilli E., Osservatorio Astrofisico, Città Universitaria,  
95125 Catania, Italy
- Mattig W., Kiepenheuer Institut, Schoneckstr. 6, 7800  
Freiburg, Germany FR
- Melikyan N.D., Byurakan Astrophysical Observatory, Erevan,  
378433 Armenia, USSR
- Micela G., Osservatorio Astronomico, Palazzo dei Normanni,  
90134 Palermo, Italy
- Milone E.F., Physics Department, University of Calgary,  
Calgary, Alberta T2N 1N4, Canada
- Monsignori Fossi B., Osservatorio Astrofisico di Arcetri,  
Largo E.Fermi 5, 50125 Firenze, Italy

- Mullan D.J., Bartol Research Foundation, University of Delaware, Newark, DE 19711, USA
- Nha Il-S., Department of Astronomy and Meteorology, Yonsei University, Seoul (Private Bag), Korea
- Ni W.T., Department of Physics, National Tsing Hua University Hsinchu, Taiwan, Republic of China
- Nordlund A., University Observatory, Oster Voldgate 3, 1350 Copenhagen K, Denmark
- Olah K., Konkoly Observatory, P.O.Box 67, 1525 Budapest, Hungary
- Oskanian V.A., Byurakan Astrophysical Observatory, Erevan, 378433 Armenia, USSR
- Pallavicini R., Osservatorio Astrofisico di Arcetri, Largo E.Fermi 5, 50125 Firenze, Italy
- Paternò L., Osservatorio Astrofisico, Città Universitaria, 95125 Catania, Italy
- Pazzani V., Osservatorio Astrofisico, Città Universitaria, 95125 Catania, Italy
- Peres G., Osservatorio Astronomico, Palazzo dei Normanni, 90134 Palermo, Italy
- Pettersen B.R., Institute of Mathematical and Physical Sciences, University of Tromsø, O.O.Box 953, N-9001 Tromsø, Norway
- Pidatella R.M., Osservatorio Astrofisico, Città Universitaria, 95125 Catania, Italy
- Pirronello V., Osservatorio Astrofisico, Città Universitaria, 95125 Catania, Italy
- Popper D.M., Department of Astronomy, University of California, Los Angeles, CA 90024, USA
- Priest E.R., St.Andrews University, St.Andrews, Fife KY16 9SS, Scotland, UK
- Reglero Velasco V., Universidad de Valencia, Facultad de Matematica, Departamento de Mecanica y Astronomia, Valencia, Spain
- Rodonò M., Osservatorio Astrofisico, Città Universitaria, 95125 Catania, Italy

- Rosner R. , Center for Astrophysics, 60 Garden Street,  
Cambridge, MA 02138, USA
- Rucinski S. , Max Planck Institut for Astrophysics,  
K.Schwarzschild Str.1, 8042 Garching bei Munchen,  
Germany FR
- Russo G. , Osservatorio Astronomico di Capodimonte, via  
Moiarello 16, 80131 Napoli, Italy
- Sakurai T. , Department of Astronomy, University of Tokyo,  
Bunkyo-ku, Tokyo 113, Japan
- Sarma M.B.K. , Department of Astronomy, Osmania University,  
Hyderabad 500 007, Andhra Pradesh, India
- Saxner M. , Astronomiska Observatoriet, Box 515, 751 20  
Uppsala, Sweden
- Scaltriti F. , Osservatorio Astronomico, 10025 Pino Torinese,  
Italy
- Sciortino S. , Osservatorio Astronomico, Palazzo dei Normanni,  
90134 Palermo, Italy
- Serio S. , Osservatorio Astronomico, Palazzo dei Normanni,  
90134 Palermo, Italy
- Simnett G.M. , Department of Space Research, P.O.Box 363,  
University of Birmingham, Birmingham B15 2TT, UK
- Simon T. , Institute of Astronomy, University of Hawaii,  
2680 Woodlawn Dr., Honolulu, HI 96822, USA
- Soderblom D.R. , Center for Astrophysics, 60 Garden Street,  
Cambridge, MA 02138, USA
- Sole M. , Department of Astronomy and Astrophysics, Charles  
University, Svedska 8, 150 00 Praha 5, Czechoslovakia
- Spadaro D. , Osservatorio Astrofisico, Città Universitaria,  
95125 Catania, Italy
- Spicer D.S. , Institute of Astronomy, ETH-Zentrum, 8092  
Zurich, Switzerland
- Stencel R.E. , Joint Institute Laboratory Astrophysics,  
University of Colorado, Boulder, CO 80309, USA
- Stern R.A. , M.S. 169-327, Jet Propulsion Laboratory, 4800  
Dak Grove Dr., Pasadena, CA 91109, USA



- Strazzulla G., Osservatorio Astrofisico, Città Universitaria,  
95125 Catania, Italy
- Tanaka K., Tokyo Astronomical Observatory, Mitaka, Tokyo,  
Japan
- Ternullo M., Osservatorio Astrofisico, Città Universitaria,  
95125 Catania, Italy
- Tornambè A., Istituto di Astrofisica Spaziale, Casella  
Postale 67, 00044 Frascati, Italy
- Torres C.A.P.C.O., CNPQ/ON, Observatorio Astrofisico Bra-  
sileiro, Caixa Postal 21, 37500 Itajuba MG, Brazil
- Tsai C.H., Taipei Observatory, Yuan Shan, Taipei 104,  
Taiwan, Republic of China
- Uchida Y., Tokyo Astronomical Observatory, University of  
Tokyo, Mitaka 181, Tokyo, Japan
- Vaiana G.S., Osservatorio Astronomico, Palazzo dei Normanni,  
90134 Palermo, Italy
- Van Leeuwen F., Royal Greenwich Observatory, Herstmonceux  
Castle, Hailsham, East Sussex BN27 1RP, UK
- Vazquez M., Instituto de Astrofisica de Canarias, Universidad  
De La Laguna, Tenerife, Spain
- Vennerstrom S., Astronomisk Observatorium, Oster Voldgade 3,  
1350 Copenhagen, Denmark
- Venugopal V.R., Radio Astronomy Centre, Tata Institute of  
Fundamental Research, P.O.Box 8, Ootacamund 643 001, India
- Vogt S.S., Lick Observatory, University of California,  
Santa Cruz, CA 95064, USA
- Vrba F.J., U.S.Naval Observatory, Flagstaff Station,  
P.O.Box 1149, Flagstaff, AZ 86002, USA
- Walter F.M., Joint Institut Laboratory Astrophysics, Boulder,  
CO 80309, USA
- Weiss N.O., Department of Applied Mathematics and Theoretical  
Physics, Silver Street, Cambridge CB3 9EW, UK
- Wing R.F., Astronomy Department, The Ohio State University,  
174 West 18th Avenue, Columbus, OH 43210, USA
- Wood F.B., Department of Astronomy, University of Florida,  
Gainesville, Florida 32611, USA