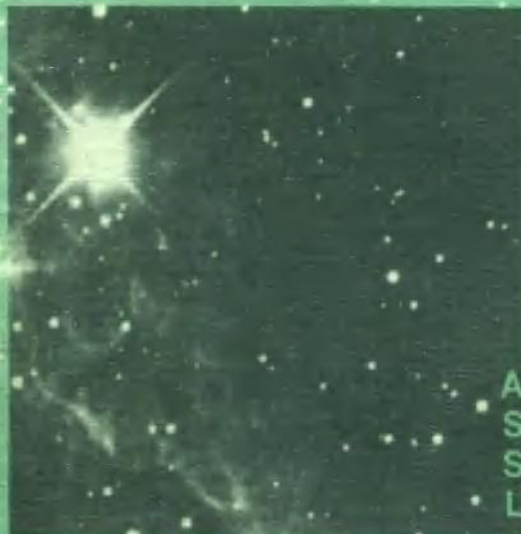


The Symbiotic Phenomenon

Joanna Mikolajewska
Michael Friedjung
Scott J. Kenyon
Roberto Viotti
(editors)



Astrophysics
Space
Science
Library

Kluwer Academic Publishers

THE SYMBIOTIC PHENOMENON

PROCEEDINGS OF THE 103RD COLLOQUIUM OF THE
INTERNATIONAL ASTRONOMICAL UNION,
HELD IN TORUN, POLAND, AUGUST 18-20, 1987

Edited by

JOANNA MIKOLAJEWSKA

*Institute of Astronomy,
Nicolaus Copernicus University, Torun, Poland*

MICHAEL FRIEDJUNG

Institut d'Astrophysique (CNRS), Paris, France

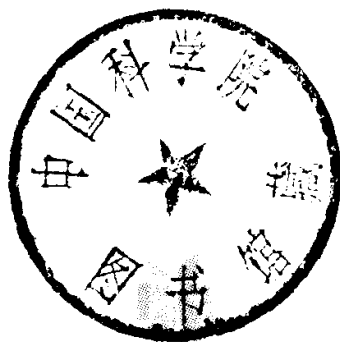
SCOTT J. KENYON

*Harvard-Smithsonian Center for Astrophysics,
Cambridge, Massachusetts, U.S.A.*

and

ROBERTO VIOTTI

Istituto Astrofisica Spaziale (CNR), Frascati, Italy



KLUWER ACADEMIC PUBLISHERS

DORDRECHT / BOSTON / LONDON

893552

Library of Congress Cataloging in Publication Data

CIP

International Astronomical Union. Colloquium (103rd : 1987 : Toruń, Poland)

The symbiotic phenomenon : proceedings of the 103rd Colloquium of the International Astronomical Union, held in Toruń, Poland, August 18-20, 1987 / edited by Joanna Mikolajewska ... [et al.].

p. cm. -- (Astrophysics and space science library ; v. 145)

Includes index.

ISBN 9027727236

I. Stars, Symbiotic--Congresses. I. Mikolajewska, Joanna.

II. Title. III. Series.

QB843.S96I58 1987

523.8'41--dc19

88-4392

CIP

ISBN 90-277-2723-6

Published by Kluwer Academic Publishers,
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

Kluwer Academic Publishers incorporates
the publishing programmes of
D. Reidel, Martinus Nijhoff, Dr W. Junk and MTP Press.

Sold and distributed in the U.S.A. and Canada
by Kluwer Academic Publishers,
101 Philip Drive, Norwell, MA 02061, U.S.A.

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

All Rights Reserved

© 1988 by Kluwer Academic Publishers

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 information storage and
retrieval system, without written permission from the copyright owner.

Printed in The Netherlands

PREFACE

Symbiotic stars were identified spectroscopically as M giants with a very strong He II 4686 emission line. After five decades of study by many astronomers, the first international meetings devoted to symbiotics were held at the University of Colorado (Boulder) and at the Haute Provence Observatory during the Summer of 1981. These conferences emphasized exciting new results obtained by modern satellite (EINSTEIN, IUE) and ground-based observatories. Although the vast majority of the participants were already fairly sure that symbiotics are almost certainly interacting binary systems, and not extremely peculiar single stars, it was not clear exactly which types of physical processes were needed to be invoked to explain their observed behaviour. Many were even worried that it might not be possible to clearly define a class of "symbiotic stars", and thus establish a unique model applicable to any system.

Since the publication of the Haute-Provence proceedings, our understanding of the physical processes occurring in symbiotic stars (and in related objects such as cataclysmic variables and compact planetary nebulae) has greatly improved. We now speak confidently of a "symbiotic phenomenon", in which an evolved red giant and a hot companion object (usually thought to be an accreting main sequence star or a luminous white dwarf star) happily coexist. Given this basic advance in our field, it seemed appropriate to bring together symbiotic aficionados from around the world to summarize our basic understanding of these binaries, to delineate the physical problems we have yet to solve, and thus to plan new observational and theoretical attacks on this important group of interacting binary system.

Our apparently improved understanding of symbiotic objects motivated a presentation that was significantly different from those of Boulder and Haute Provence. Rather than describe observations in distinct wavelength regions or discuss physical peculiarities of individual objects, the organization of this colloquium emphasized a multifrequency approach to our study of symbiotic stars and a description of the basic physical components (and their interaction). Thus, the meeting began with introduction to the observations and the working models constructed for symbiotic stars, continued with discussions of techniques designed to probe the physical structure of a symbiotic binary (e.g., orbital solutions, IR photometry and spectroscopy of the cool mass-losing component, radio/optical imagery, and polarization), and then turned to a description of physical models developed to interpret the multifrequency observations. With this physical background in mind, we then confronted cherished ideas with observational reality to

test our grasp of the symbiotic phenomenon. We hoped that this interaction would lead to a better understanding of our successes and failures, which could be used on the final day of the conference to place our field in the context of binary stellar evolution, to identify aspects of the symbiotic phenomenon in other stellar objects, and to discuss projects that remain to be accomplished.

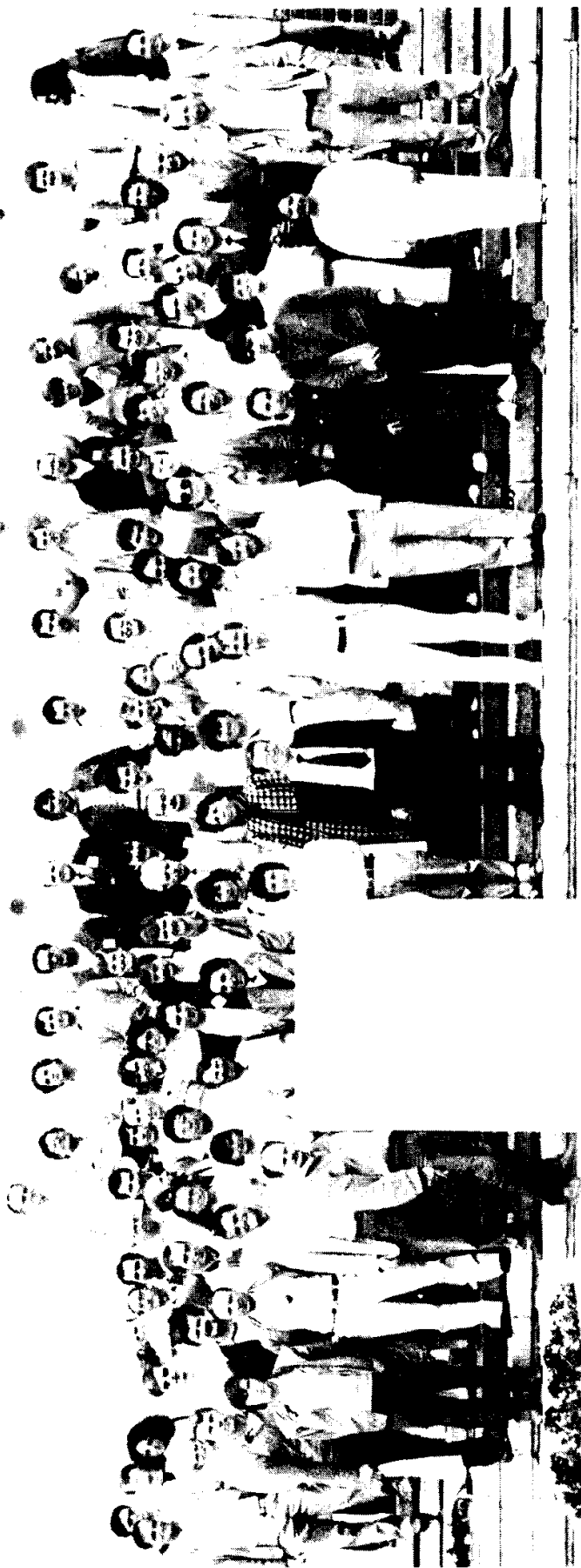
The large attendance of this colloquium (91 participants from 23 countries) speaks highly of the growth of our field since Haute Provence. For this reason alone, we may consider the meeting successful, because many researchers entered the lively discussions and exchanged ideas. It was not possible to reproduce the full discussion in this volume, but summaries of the three general discussions are included. We are happy to see that many young scientists have begun to study the symbiotic phenomenon, so we can expect an exciting crop of new results and revolutionary ideas for the next symbiotic colloquium !

It was a happy circumstance that the Colloquium was held in the beautiful old town of Torun which actually was the birthplace of Nicolas Copernicus the founder of Modern Astronomy. The first director of the Torun Astronomical Observatory at Piwnice, the late W. Dziwulski was very active in the field of variable stars, and a postumus work is included in these proceedings.

We are grateful to the other members of the scientific organizing committee, D. Allen, A. Boyarchuk, E. Brandi, M. Hack, S. Kwok, B. Paczynski, R. Stencel, and A. Woszczyk, for their assistance in preparing the scientific program. We especially acknowledge D. Allen, H. Nussbaumer and R. Stencel for their extra efforts, particularly in planning the conference agenda. Light curves supplied by J. Mattei of the AAVSO highlighted the long-term behaviour of symbiotic stars, and emphasized the vital role that amateur astronomers play in our attempts to understand these objects. We finally thank the presidents of IAU Commissions 27, 29, 42 and 44 for sponsoring the Colloquium.

We extend our heartfelt thanks to the local organizing committee, R. Biernikowicz, C. Iwaniszewska, M. Mikolajewski, B. Ridak, A. Woszczyk, and J. Ziolkowski. We are especially grateful to the chairman of this committee, Prof. A. Woszczyk, for his careful attention to the many fine details and extracurricular activities that made this meeting so enjoyable. Additional thanks are due to many anonymous people for taking care of the day activities of a scientific meeting.

The Editors



LIST OF THE PARTICIPANTS

D. A. ALLEN, Anglo-Australian Observatory, Epping, Australia
 A. ALTAMORE, Universita La Sapienza, Rome, Italy
 B. G. ANANDARAO, Physical Research Laboratory, Ahmedabad, India
 N. E. ANDERSON, Princeton University Observatory, Princeton, USA
 T. BELYAKINA, Crimean Astronomical Observatory, Nauchny, USSR
 S. BENSAMMAR, Observatoire de Paris, Meudon, France
 R. BIERNIKOWICZ, Nicolaus Copernicus University, Torun, Poland
 M. F. BODE, Lancashire Polytechnic, Preston, United Kingdom
 Yu. V. BORISOV, Institute of Astrophysics TSSR Acad. of Sciences, Dushanbe, USSR
 E. W. BRUGEL, University of Colorado, Boulder, USA
 A. CASSATELLA, European Space Agency, Madrid, Spain
 D. CHOCHOL, Astronomical Institute, Tatranska Lomnica, Czechoslovakia
 J. P. DE GREVE, Vrije Universiteit Brussel, Brussel, Belgium
 E. DROBYSHEVSKY, A.F. Ioffe Institute of Physics and Technology, Leningrad, USSR
 W. J. DUSCHL, M.P.I. fur Physik und Astrophysik, Garching, FRG
 J. E. EATON, Indiana University, Bloomington, USA
 T. FERNANDEZ-CASTRO, Planetario de Madrid, Madrid, Spain
 J. FRANTSMAN, R.A.O. A.N. L.S.S.R., Riga, USSR
 M. FRIEDJUNG, Institute d'Astrophysique, Paris, France
 M. GARCIA, Smithsonian Astrophysical Observatory, Cambridge, USA
 K. GESICKI, N. Copernicus Astronomical Center, Torun, Poland
 A. GIMENEZ, Instituto de Astrofisica de Andalucia, Granada, Spain
 L. HRIC, Astronomical Institute, Tatranska Lomnica, Czechoslovakia
 CHANG-CHUN HUANG, Purple Mountain Observatory, Nanking, China
 A.P. IPATOV, Astrosoviet, Moscow, USSR
 C. IWANISZEWSKA, Nicolaus Copernicus University, Torun, Poland
 I. V. Il'in, Crimean Astrophysical Observatory, Nauchny, USSR
 E. JANASZAK, Planetarium and Astronomical Observatory, Olsztyn, Poland
 SHI-YANG JIANG, Beijing Astronomical Observatory, Beijing, China
 A. JORISSEN, Universite Libre de Bruxelles, Brussel, Belgium
 J. KALUZYNY, Warsaw University, Warsaw, Poland
 S. J. KENYON, Smithsonian Astrophysical Observatory, Cambridge, USA
 T. KHUDYAKOVA, Astronomical Observatory, Leningrad, USSR
 S. KRAWCZYK, Nicolaus Copernicus University, Torun, Poland
 J. KRELOWSKI, Nicolaus Copernicus University, Torun, Poland
 M.I. KUMSIASHVILI, Abastumani Astrophysical Observatory, Abastumani, USSR
 S. KWOK, University of Calgary, Calgary, Canada
 P. G. LASKARIDES, University of Athens, Athens, Greece
 E. M. LEIBOWITZ, Tel Aviv University, Tel Aviv, Israel
 M. LIVIO, University of Illinois, Urbana, USA
 R. LUTHARDT, Zentralinstitut fur Astrophysik der Adw. DDR, Sonneberg, DDR
 J. LUTZ, Washington State University, Pullman, USA
 L.S. LUUD, I.A.F. A. / A.N. E.S.S.R., Tartu, USSR
 A. M. MAGALHAES, Instituto Astronomico e Geofisico USP, Sao Paulo, Brasil
 O.Yu. MALKOV, Astrosoviet, Moscow, USSR

E.V. MENCHENKOVA, Odessa Astronomical Observatory, Odessa, USSR
 A. MICHALITSIANOS, NASA-Goddard Space Flight Center, Greenbelt, USA
 J. MIKOLAJEWSKA, Nicolaus Copernicus University, Torun, Poland
 M. MIKOLAJEWSKI, Nicolaus Copernicus University, Torun, Poland
 M. MUCIEK, Nicolaus Copernicus University, Torun, Poland
 H. NUSSBAUMER, Institute of Astronomy ETH Zentrum, Zurich, Switzerland
 M. ORIO, Technion-Israel Institute of Technology, Haifa, Israel
 J. PAPAŁ, Nicolaus Copernicus University, Torun, Poland
 H. PAUL, Zentral Institut fuer Astrophysik der Adw. DDR, Sonneberg, DDR
 E.N. POPOVA, Astrosviet, Moscow, USSR
 A.F. PUGACH, Main Astronomical Observatory, Kiev, USSR
 D. RAIKOVA, Dept. of Astronomy of the Bulgarian Acad. of Sci., Sofia, Bulgaria
 O. REGEV, Technion-Israel Institute of Technology, Haifa, Israel
 M. H. RODRIGUEZ, Main Astronomical Observatory, Kiev, USSR
 B. RUDAK, N. Copernicus Astronomical Center, Torun, Poland
 Yu.S. RUSTAMOV, Institute of Physics, Baku, USSR
 H. M. SCHMID, Institute of Astronomy ETH Zentrum, Zurich, Switzerland
 H. E. SCHWARZ, European Southern Observatory, Santiago, Chile
 PARAG SEAL, Indian Institute of Astrophysics, Bangalore, India
 E. R. SEQUIST, University of Toronto, Toronto, Canada
 P. L. SELVELLI, Osservatorio Astronomico di Trieste, Trieste, Italy
 N.M. SHAKHOVSKOY, Crimean Astronomical Observatory, Nauchny, USSR
 A. SKOPAL, Astronomical Institute, Tatranska Lomnica, Czechoslovakia
 M. H. SLOVAK, University of Wisconsin, Madison, USA
 J. SMOLINSKI, N. Copernicus Astronomical Center, Torun, Poland
 J. SOLF, Max-Planck-Institute fuer Astronomie, Heidelberg, FRG
 R. E. STENCEL, University of Colorado, Boulder, USA
 A. STROBEL, Nicolaus Copernicus University, Torun, Poland
 R. SZCZERBA, N. Copernicus Astronomical Center, Torun, Poland
 SHIN'ICHI TAMURA, Tohoku University, Sendai, Japan
 O. G. TARANOVA, Sternberg Astronomical Institute, Moscow, USSR
 A. TARASOV, Crimean Astrophysical Observatory, Nauchny, USSR
 A. R. TAYLOR, Nuffield Radio Astronomy Laboratories, Jodrell Bank, United Kingdom
 T. TOMOV, National Astron. Observatory Rozhen, Smoljan, Bulgaria
 R. TYLEND, N. Copernicus Astronomical Center, Torun, Poland
 V.A. URPIN, A. F. Ioffe Institute of Physics and Technology, Leningrad, USSR
 R. VIOTTI, CNR/Istituto di Astrofisica Spaziale, Frascati, Italy
 M. VOGEL, Institute of Astronomy ETH Zentrum, Zurich, Switzerland
 R. E. WEBBINK, University of Illinois, Urbana, USA
 P. A. WHITELOCK, South African Astron. Observatory, Cape, South Africa
 A. WOSZCZYK, Nicolaus Copernicus University, Torun, Poland
 B. F. YUDIN, Sternberg Astronomical Institute, Moscow, USSR
 L.R. YUNGELSON, Astrosviet, Mosco, USSR
 D. ZAREMBA, Nicolaus Copernicus University, Torun, Poland
 J. ZIOLKOWSKI, N. Copernicus Astronomical Center, Warsaw, Poland
 S. ZOLA, Jagiellonian University, Cracow, Poland

TABLE OF CONTENTS

Preface	xi
Group Photograph	xiii
List of Participants	xv
 SESSION 1. THE BASIC DATA	 1
A Perspective on the Symbiotic Stars D. Allen	 3
Multifrequency Observations of Symbiotic Stars S.J. Kenyon	 11
V 641 Cas - A Symbiotic Candidate? T. Tomov, M. Mikolajewski	 23
Ultraviolet FeII Absorption Lines in HD 59643 J.E. Eaton	 25
Orbital Radial Velocity Curves of Symbiotic Stars M.R. Garcia, S.J. Kenyon	 27
Orbital Parameters of Three Symbiotic Stars E.M. Leibowitz, L. Formiggin	 33
Properties of Cool Stellar Components in S-Type Symbiotic Stars O.G. Taranova, B.F. Yudin	 37
Absolute Energy Distributions for Selected Quiescent Symbiotic Stars M.H. Slovak, A.D. Code	 43
Infrared Observations of Symbiotic Miras P.A. Whitelock	 47
The Environments of Cool Stars R.E. Stencel	 57

Dust Emission from Symbiotic Stars: Interpretation of IRAS Observations B.G. Anandarao, A.R. Taylor, S.R. Pottasch	65
Atmospheric Shocks in Mira Variables - MgII Emission E.W. Brugel, T.E. Beach, L.A. Willson, G.H. Bowen	67
The Radio Properties of Symbiotic Stars E.R. Seaquist	69
Radio Imaging of Symbiotic Stars A.R. Taylor	77
Observations of Bipolar Mass Flow from Symbiotic Stars J. Solf	85
Optical Polarimetry of Symbiotic Stars A.M. Magalhães	89
Polarimetry of Symbiotic Stars T.N. Khudyakova	101
The Present State of Symbiotic Polarimetry H.E. Schwarz, C. Aspin, A.M. Magalhães, R.E. Schulte - Ladbeck	103
SESSION 2. THE PHYSICS OF THE SYMBIOTIC PHENOMENON	105
Ionization Models of Symbiotic Stars H. Nussbaumer	107
Photoionization Models with Accretion Disks M. Vogel	119
Emission Line Ratio Classification of Symbiotic Stars H.E. Schwarz	123
Resonance Line Profiles from Radial Accretion Flows R. Tylenda	127
Colliding Winds in Symbiotic Systems S. Kwok	129
Accretion Disks in Symbiotic Stars W.J. Duschl	137
Accretion from Stellar Winds M. Livio	149

Thermonuclear Runaway Models for Symbiotic Novae S.J. Kenyon	161
On the Outburst of Symbiotic Stars H. Nussbaumer, M. Vogel	169
Thermonuclear Runaways on Accreting Hot White Dwarfs D. Prialnik, O. Regev	171
The Decay Time after a Thermonuclear Flash M. Orio	173
General Discussion on the Physics of Symbiotic Stars S.J. Kenyon	177
SESSION 3. PHYSICS OF INDIVIDUAL OBJECTS	179
Z Andromedae: Quiescence and Activity A. Cassatella, T. Fernandez-Castro, N. Oliverson	181
CI Cygni - The Well Understood Symbiotic Binary? J. Mikolajewska, M. Mikolajewski	187
A P Cygni Profile for the He 10830 A Line of CI Cyg in Eclipse S. Bensammar, M. Friedjung, N. Letourneur, J.P. Maillard	193
Symbiotic Eclipsing Binary Star CI Cyg. The Cold Component Variability T.S. Belyakina	197
AG Dra a Symbiotic Star with an Uncommon Cool Component M. Friedjung	199
Spectral Variations of AG Dra between 1981 and 1985 C.C. Huang, Y.F. Chen, L. Chen	205
CH Cyg: Ten Years of Activity P.L. Selvelli	209
CH Cygni Half a Century Ago - Changing Activity of the Cool Component W. Dziewulski, M. Muciek, M. Mikolajewski	219

Spectroscopic Orbit of the Eclipsing Symbiotic Star CH Cyg M. Mikolajewski, R. Szczerba, T. Tomov	221
Slow and Rapid Changes of the Radial Velocities in the Symbiotic Binary CH Cygni A. Skopal	223
Radial Velocities of CH Cyg Just as the Jets Appeared E. Janaszak, M. Mikolajewski	225
The Spectrum of CH Cygni - A Search for Rapid Line Variations T. Tomov, D. Raikova	227
Polarization in CH Cygni during Quiet and Active Phases M.H. Rodriguez	229
Continued Radio Activity from CH Cygni A.R. Taylor, E.R. Seaquist, S.J. Kenyon	231
An "Accretor-Propeller" Model of CH Cygni M. Mikolajewski, J. Mikolajewska	233
A Review of the R Aquarii System A.G. Michalitsianos, M. Kafatos	235
The Ultraviolet Spectrum of RX Puppis M. Kafatos, A.G. Michalitsianos	245
A Model for RX Puppis D.A. Allen, A.E. Wright	249
Symbiotic Star AG Pegasi - Retrospect and Prospects D. Chochol	251
The Observations of AG Peg during 1985-1987 A.A. Boyarchuk, T.S. Belyakina, A.E. Tarasov, T. Tomov	257
The Photometric Period of AG Pegasi R. Luthardt	259
The Causes of the Light Variations in AG Peg B.F. Yudin	261
Ultraviolet Variability of the Symbiotic Star AG Peg D. Chochol, Z. Komarek, A. Vittone	263

A New Absorption-Line Orbit for the Symbiotic Nova AG Pegasi M.H. Slovak, D.L. Lambert	265
The Symbiotic Novae R. Viotti	269
The Symbiotic Nova PU Vul (Kuwano-Honda Object): Some Results of Coordinated Investigations R.E. Gershberg, N.M. Shakhovskoj	279
The Spectroscopic Variations of the Symbiotic Nova PU Vul L. Hric, D. Chochol, B. Kovachev	283
Emission Line Analyses of HBV 475, V1016 Cyg and HM Sge S. Tamura	285
SESSION 4. CONTRIBUTIONS FOR OTHER INDIVIDUAL OBJECTS	287
Photometric and Spectroscopic Variations of the Symbiotic Star EG Andromedae A. Skopal, D. Chochol, A. Vittone, A. Mammano	289
The Search for the Elusive Companion of EG Andromedae J.E. Pesce, R.E. Stencel, N.A. Oliverson	291
The Symbiotic Star UV Aurigae P. Seal	293
The Third Galactic Carbon Symbiotic R.E. Schulte-Ladbeck, D.J. MacConnell, N. Zarate	295
BI Crucis A. Altamore, C. Rossi, R. Viotti	297
Effects of Eccentric Orbit of BF Cygni on IUE and Optical Spectra J. Mikolajewska, M. Mikolajewski	299
Ultraviolet to Near Infrared Observations of BF Cyg A. Cassatella, R. Gonzalez-Riestra, T. Fernandez-Castro, J. Fuensalida, A. Gimenez	301

Ultraviolet Variability of AX Persei J. Mikolajewska	303
IUE and Optical Observations of He 2-104 J.H. Lutz	305
Summary of Discussion on Individual Objects D. Allen	307
SESSION 5. SYMBIOTIC PHENOMENA AND STELLAR EVOLUTION. CONCLUSIONS.	309
The Formation and Evolution of Symbiotic Stars R.F. Webbink	311
Recurrent Novae M. Livio	323
Unravelling the Multiple Component Radio Emission of RS Oph in Outburst A.R. Taylor, M.F. Bode, R.J. Davis, R.W. Porcas	335
The 1987 Outburst of the Recurrent Nova U Sco K. Sekiguchi, M.W. Feast, P.A. Whitelock, M.D. Overbeek, W. Wargau, J. Spencer Jones	337
What Can We Learn from ζ Aur Binary Systems? K.P. Schröder	339
Summary of Final Discussion R.E. Stencel	347
Concluding Remarks M. Friedjung	349
Overheard in Torun	355
Subject Index	357
Object Index	363

SESSION 1. THE BASIC DATA

"Symbiotic stars are like platypus"

David Allen

A PERSPECTIVE ON THE SYMBIOTIC STARS

David Allen
Anglo-Australian Observatory
PO Box 296, Epping
NSW 2121
Australia

ABSTRACT. I give a very brief summary of the state of our knowledge of the symbiotic stars, together with some of my hopes for how the field will develop.

1. PREAMBLE

The task of the introductory speaker at a conference is a challenging one. The more so since the words one might choose for the verbal presentation differ from what the reader will seek in the final publication. So, I have decided to cheat: the text you are now considering reading is not what you would have heard if you attended the conference ... well, only partly so. I have taken the liberty of using different titles for the two presentations, to reflect their distinct emphases. But in one important way I have not cheated. This paper was written before the conference, and has not subsequently been modified. It may contain errors that are corrected by later papers; that is the risk I take. On the other hand, it is as fair a summary as I can give, as useful an introduction as I can conceive, to the view of symbiotic stars prevalent early in August 1987. I sincerely hope that the papers which follow will so overthrow the contents of this introduction that you will have no interest in reading it twice.

What I will present in the limited space available here cannot be regarded as a review, but only as a perspective. I eschew references (subsequent papers surely contain ample) save to draw attention to the proceedings of the 1981 conferences on the subject (Stencel 1981; Friedjung & Viotti 1982), and the only book published to date on these stars (Kenyon 1986).

Although not a review, it is appropriate to illustrate this paper with one optical spectrum of a classical symbiotic star, to show just what it is that characterises these objects. Because it is in the optical that they were first recognised, and still are classified, I have not broadened the waveband. Features to note in the spectrum, reproduced on the next page, include the TiO bands of the cool giant in the red; the Balmer jump in emission that shows the blue continuum to be gaseous rather than stellar; the high-excitation emission lines ($\lambda 4686$ of He II; $\lambda 6087$ of [Fe VII]); and the unidentified bands at 6830, 7088 Å, which are markedly broader than atomic emission lines of comparable intensity.