

IAU COLLOQUIUM 145

**Supernovae and
Supernova Remnants**

**EDITED BY RICHARD MCCRAY
and ZHENRU WANG**

Dramatic advances in ground-based and space astronomy, together with observations of the serendipitous supernova 1987A, have led to the study of supernovae and supernova remnants becoming one of the most active and rewarding fields in today's astrophysics. To take stock of these exciting developments and to give focus to future research, the International Astronomical Union held a colloquium in Xian, China, for the world's leading experts and this volume gathers together their articles.

The articles summarise our knowledge of supernova 1987A and give the first results on supernova 1993J. They not only demonstrate the latest techniques for interpreting spectra and light curves of supernovae, but show how they can be applied to measuring the cosmic distance scale. They also cover recent advances in theories for type I and type II supernovae, and observations and interpretations of supernova remnants. Two appendices provide a unique reference of newly discovered supernovae and supernova remnants.

Together these forty review articles provide an up-to-date and wide-ranging review of our understanding of supernovae and supernova remnants for graduate students and researchers.

**Supernovae
and Supernova Remnants**

Supernovae and Supernova Remnants

Proceedings International Astronomical Union
Colloquium 145,
held in Xian, China
May 24–29, 1993

Edited by
RICHARD McCRAY
JILA, University of Colorado, Boulder

ZHENRU WANG
Center for Astrophysics, Nanjing University



Published by the Press Syndicate of the University of Cambridge
The Pitt Building, Trumpington Street, Cambridge CB2 1RP
40 West 20th Street, New York, NY 10011- 4211, USA
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

© Cambridge University Press 1996

First published 1996

Printed in Great Britain at the University Press, Cambridge

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

Library of Congress cataloguing in publication data available

ISBN 0 521 46080 8 hardback

Contents

<i>Participants</i>	xii
<i>Preface</i>	xv
<i>Acknowledgements</i>	xvii

Observations of Supernovae and the Cosmic Distance Scale

Supernova Rates

<i>S. van den Bergh</i>	1
-----------------------------------	---

Light Curves of Supernovae

<i>B. Leibundgut</i>	11
--------------------------------	----

Supernovae and the Cosmic Distance Scale

<i>R. P. Kirshner</i>	19
---------------------------------	----

Individual Light Curve Fits of SN Ia and H_0

<i>P. A. Höflich, E. Müller, and A. Khoklov</i>	29
---	----

Towards the Cosmic Distance Scale through Nebular SNe Ia

<i>P. Ruiz-Lapuente and A. V. Filippenko</i>	33
--	----

Type Ia Supernovae

Observations of Type Ia Supernovae

<i>N. B. Suntzeff</i>	41
---------------------------------	----

Type Ia Supernovae: Mechanisms and Nucleosynthesis

<i>K. Nomoto, H. Yamaoka, T. Shigeyama, and K. Iwamoto</i>	49
--	----

SNIa Diversity: Theory and Diagnostics

<i>R. Canal and P. Ruiz-Lapuente</i>	69
--	----

Searching for Type Ia Supernova Progenitors

<i>A. Renzini</i>	77
-----------------------------	----

2D Simulations of Deflagrations in White Dwarfs

<i>E. Livne</i>	87
---------------------------	----

2D Simulations of Supernovae

<i>D. Arnett</i>	91
----------------------------	----

Type Ib and Type II Supernovae

Recent Advances in Supernova Theory

<i>A. Burrows</i>	99
-----------------------------	----

Dynamics of Type-II Supernovae

<i>H.-Th. Janka and E. M. Müller</i>	109
--	-----

Hydrodynamics and Theoretical Light Curves of SNe II

<i>V. S. Imshennik and S. I. Blinnikov</i>	119
--	-----

Instabilities and Mixing in Type II-P and II-b Supernovae

<i>T. Shigeyama, K. Iwamoto, I. Hachisu, K. Nomoto, and H. Saio</i>	129
---	-----

Progenitors and Hydrodynamics of Type II and Ib Supernovae <i>S. E. Woosley, T. A. Weaver, and R. G. Eastman</i>	137
Statistical Analysis of Supernovae and Progenitors of SN Ib and SN Ic <i>Z.-W. Li</i>	149
Supernova Nucleosynthesis in Massive Stars <i>M. Hashimoto, K. Nomoto, T. Tsujimoto, and F.-K. Thielemann</i>	157
Nuclear Weak Processes in Presupernova Stars <i>A. Ray, T. Kar, S. Sarkar, and S. Chakravarti</i>	165
SN 1987A, SN 1993J, and Other Supernovae	
X-Rays and γ -Rays from SN 1987A <i>S. Kumagai</i>	173
Spectrophotometry of SN 1987A from the Kuiper Airborne Observatory <i>D. H. Wooden</i>	183
Infrared Spectroscopy of SN 1987A <i>J. Spyromilio</i>	193
SN 1987A: Observations at Later Phases <i>P. Bouchet, I. J. Danziger, C. Gouiffes, M. Della Valle, and A. Monetti</i>	201
Freeze out, IR-Catastrophes, and Non-thermal Emission in SNe <i>C. Fransson, J. Houck, and C. Kozma</i>	211
Understanding the Nebular Spectrum of SN 1987A <i>R. McCray</i>	223
The Oxygen 1.13 μm Fluorescence Line of SN 1987A: a Diagnostic for the Ejecta of Hydrogen-Rich Supernovae <i>E. Oliva</i>	235
Review of Contributions to the Workshop on SN 1993J <i>J. C. Wheeler and A. V. Filippenko</i>	241
A Determination of the Properties of the Peculiar SNIa 1991T through Models of its Early-time Spectra <i>P. A. Mazzali and I. J. Danziger</i>	277
Supernovae and Circumstellar Matter	
Radio Supernovae <i>K. W. Weiler, S. D. Van Dyk, R. A. Sramek, and N. Panagia</i>	283
The SN 1987A Environment <i>L. Wang and E. J. Wampler</i>	299
Radio Emission from SN 1987A <i>L. Staveley-Smith, R. N. Manchester, A. K. Tzioumis, J. E. Reynolds, and D. S. Briggs</i>	309
Interaction of Supernova Ejecta with Circumstellar Matter and X-Ray Emission: SN 1987A & SN 1993J <i>T. Suzuki, K. Nomoto, T. Shigeyama, and S. Kumagai</i>	317

Supernova Remnants

Historical Supernovae and Supernova Remnants <i>Z.-R. Wang</i>	323
Radio Emission from Supernova Remnants <i>R. G. Strom</i>	333
The Distribution of Supernova Remnants in the Galaxy <i>D. A. Green</i>	341
Supernova Remnants in Nearby Spiral Galaxies <i>K. S. Long</i>	349
X-Ray Spectroscopy of Supernova Remnants <i>R. Petre</i>	345
ASCA Observation of Supernova Remnants <i>H. Tsunemi</i>	357
Optical and UV Observations of Supernova Remnants <i>R. A. Fesen</i>	381
Far-Ultraviolet Observations of Supernova Remnants <i>W. P. Blair</i>	391
Compact Objects in Supernova Remnants <i>R. A. Chevalier</i>	399

Catalogues

A List of Supernovae Discovered between 1989 January 1 and 1993 April 1 <i>S. van den Bergh</i>	407
A Catalogue of Galactic Supernova Remnants <i>D. A. Green</i>	419
List of Contributed Papers	425