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K. W. Weiler (Ed.)

Supernovae and Gamma-Ray Bursters



Springer

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Cover picture: shows SN 1998bw/GRB 980425 in ESO 184-G82, by T.J. Galama, F.M. Freeswijk, E. Pian, F. Frontera, V. Doublie and J.-F. Gonzalez

Cataloging-in-Publication Data applied for

A catalog record for this book is available from the Library of Congress.

Bibliographic information published by Die Deutsche Bibliothek

Die Deutsche Bibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data is available in the Internet at <http://dnb.ddb.de>

ISSN 0075-8450

ISBN 3-540-44053-4 Springer-Verlag Berlin Heidelberg New York

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Springer-Verlag Berlin Heidelberg New York
a member of BertelsmannSpringer Science+Business Media GmbH

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Typesetting: Camera-ready by the authors/editor

Camera-data conversion by Steingraeber Satztechnik GmbH Heidelberg

Cover design: *design & production*, Heidelberg

Printed on acid-free paper

SPIN: 10880850 54/3141/du - 5 4 3 2 1 0

Preface

Since the dawn of mankind, observers of the sky have wondered at the sudden appearance of new stars on the seemingly unchanging heavens and, for at least 2000 years, have recorded these phenomena in their annals and archives. Even in more modern times, since the discovery of SN1885A in S Andromeda which figured in the important “island universe” discussions of the 1920’s, the puzzle of supernovae (SNe) has played an important role in astrophysics. Only with the seminal work of Fritz Zwicky and Walter Baade in the 1930’s did we begin to understand the differences between novae and SNe and the importance of SNe as the fonts of energy for the interstellar medium and as drivers of chemical evolution in galaxies. As recently as the 1940’s and 1950’s the early days of radio astronomy were heavily influenced by the familiar names of Cassiopeia A and Taurus A, two young supernova remnants, and two Nobel prizes have been awarded for discovery and study of a related phenomenon, pulsars.

In spite of the great age of the study of SNe, since at least the Chinese records of SN185 and probably earlier, the field is, in fact, very young having only attracted a large devoted following since the spectacular Type II SN1987A in the Large Magellanic Cloud, the first naked-eye SN in more than 400 years.

On a seemingly non-intersecting parallel path, γ -ray bursts (GRBs) discovered by the Air Force VELA satellites in the 1960’s presented a mystery to researchers for 30 years. Finally, the launch of the Italian/Dutch *BeppoSAX* satellite in 1996 provided sufficiently fast and accurate positional information to allow detection and study of their “afterglows” at other wavelengths. These results then provided evidence that, at least at some level, the fields of GRB and SN studies merge through the possible connection of Type Ib/c SNe, so that one of our most recent astronomical puzzles appears to be at least partially solved by reference to our ancient interest in SNe.

Although discovery, observation, and interpretation of new examples of SNe and GRBs continues, the end of the *Compton Gamma-Ray Observatory (CGRO)* era in 2000 and of the *BeppoSAX* operations in 2002 provides a significant break-point for trying to summarize the current status of these extremely active areas of study. Thus, experts from many areas of SN and GRB research have agreed to contribute chapters to this monograph to assemble a coherent picture.

Because the two areas of research have still only partially merged, and may never totally merge because of the possibility that some types of GRBs originate in other physical processes, we have chosen to roughly divide this work into two

parts – SN research and GRB research with bridging chapters to explore the known and likely relations between the two areas. We hope that this monograph contributes some small part to our ultimate understanding of these exciting phenomena.

Before proceeding further, however, I would like to thank all of the people and institutions which have contributed to the assembly of this volume. Foremost, I wish to thank all of the chapter authors who have contributed their knowledge, expertise, time, and effort to providing up-to-date descriptions of the many areas of supernova and GRB research and for working so willingly with me on the preparation and editing of this volume. Obviously, nothing could have been accomplished without the support of the Office of Naval Research (ONR), which provides the 6.1 funding for my research, and the Naval Research Laboratory (NRL) which provides me with the time and facilities necessary. Although too many individuals to list have been supportive of my effort, I must separately thank Dr. Lee J Rickard, who has been extremely tolerant of my disappearing for days at a time and who has shielded me from so many other demanding and time consuming tasks.

N.B.: Because the fields of supernova and GRB research tend to use somewhat different nomenclature for the same thing – radio supernova flux density light curves are often described by $S \propto \nu^{\pm\alpha} t^{\pm\beta}$ while GRB workers tend to use $F_\nu \propto \nu^{\pm\beta} t^{\pm\alpha}$ – I have attempted to standardize everywhere to the format $F_\nu \propto \nu^{+\alpha} t^{+\beta}$. I have also attempted to make all chapters consistent with using: α = spectral index, β = decline rate, F_ν = flux density, γ = gamma-rays, Γ = Lorentz factor, τ = optical depth, t = time, and T = temperature. Although I have tried to minimize it, there may be some remaining variation in notation between chapters.

Washington, DC, USA
January 2003

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