STELLAR NUCLEOSYNTHESIS

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

VOLUME 109

PROCEEDINGS

STELLAR NUCLEOSYNTHESIS

PROCEEDINGS OF THE THIRD WORKSHOP OF THE
ADVANCED SCHOOL OF ASTRONOMY OF THE ETTORE MAJORANA CENTRE
FOR SCIENTIFIC CULTURE, ERICE, ITALY, MAY 11–21, 1983

Edited by

CESARE CHIOSI
Institute of Astronomy, University of Padova, Italy

and

ALVIO RENZINI
Department of Astronomy, University of Bologna, Italy

D. REIDEL PUBLISHING COMPANY
A MEMBER OF THE KLUWER ACADEMIC PUBLISHERS GROUP
DORDRECHT / BOSTON / LANCASTER

Library of Congress Cataloging in Publication Data

CIP

Main entry under title:

Stellar nucleosynthesis.

(Astrophysics and space science library ; v. 109)
Includes index.
1. Nucleosynthesis–Congresses. 2. Stars–Congresses.
I. Chiosi, C. (Cesare) II. Renzini, Alvio. III. Ettore Majorana International Centre for Scientific Culture. Advanced School of Astronomy.
IV. Series.
QB450.S74 1984 523.01'9723 84-1962
ISBN-13: 978-94-009-6350-4 e-ISBN-13: 978-94-009-6348-1
DOI: 10.1007/978-94-009-6348-1

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.

TABLE OF CONTENTS

Preface

The synthesis of elements in stellar interiors, their ejection into the interstellar medium and the consequent chemical enrichment of galaxies are among the most exciting issues of Modern Astrophysics.
Progress in this field has been steady over the past 30 years, passing from the early identification of the basic processes of Nuclear Astrophysics to the present stage when specific stellar environments for the production of the various elements and isotopes are being identified, and detailed quantitative predictions are being attempted. More specifically, current work in this field is aimed at answering two strictly related questions: i) what is the amount of the various elements (isotopes) which are synthetized and ejected by stars of any given initial mass and chemical composition, and ii) which are all the possible nucleosynthetic environments for any given element (isotope), and which is their relative importance.
The comparison with the whole pattern of abundances in the solar system, nearby stars, HII regions, interstellar medium and galaxies indicates that theoretical models are encouragingly succesful, even if many facets of the problem are still far from being completely understood. Moreover, the recent advances in understanding the history of star formation in our own galaxy and in nearby galaxies, combined with the current results of stellar nucleosynthesis, are allowing a more detailed approach to the problem of the chemical evolution of galaxies.
The aim of this meeting was therefore to bring together both observers and theoreticians working on stellar nucleosynthesis and related fields, so as to discuss the most recent results, review facts and reasonably well established conclusions, and help the formulation of sharper questions for what remains to be understood.
The workshop was held in Erice (Sicily), at the "Ettore Majorana Centre for Scientific Culture", from May 11 through 21, 1983, and was organized

about a sequence of review lectures, each followed by contributed talks and discussions.

The opening session was devoted to reviewing the most recent results concerning the determination of chemical abundances in particularly interesting objects providing direct evidence for stellar nucleosynthesis (like planetary nebulae, supernovae and supernova remnants).

In Session 2 recent results on some relevant nuclear reaction rates have been presented.

Session 3 grouped the contributions concerning the quasi-static evolution of normal stars, its relevance for the nucleosynthesis of the various elements and isotopes, and the comparison of the evolutionary models with the observations.

Session 4 addressed the important questions of identifying the precursors of both Type I and Type II supernovae, and of determining the detailed composition of the ejecta by explosive nucleosynthesis associated with these events.

Finally, Session 5 was devoted to a presentation of recent calculations of the evolution of hypothetical pre-galactic very massive objects (including their potential role in pre-galactic nucleosynthesis), and to reviewing the progress that has been made in understanding the chemical evolution of galaxies.

The discussion during and after talks was spirited and contributed significantly to the succes of the workshop. We regrett for not having been able of reporting it "in toto" in the proceedings. Nevertheless, we hope that what has been recorded may still give to the reader at least part of the excitement we have experienced during the ten days of the workshop.

We would like to express here our best appreciation to Drs. M. L. Quarta, L. Sanz Fernandez de Cordoba and M. Tosi for having untiringly recorded and collected the contributions to the discussion.

The European Physical Society, the Italian National Council of Research (CNR) and the "Ettore Majorana Centre for Scientific Culture" are gratefully acknowledge for having provided generous finantial assistance to several participants, thus allowing them to attend this meeting.

Finally, we would like to thank the local staff of the "Ettore Majorana

Centre for Scientific Culture", and in particular Ms. Pinola Savalli and Dr. Alberto Gabriele for their efficient organization of the logistic aspects of the meeting.

Last but not least, we like to express our gratitude to Prof. A. Zichichi, Director of the " Ettore Majorana Centre", for the warm hospitality.

While this preface was being written, the announcement came of the Nobel Price awarded to Drs. W. A. Fowler and S. Chandrasekhar for their invaluable contribution given to Astrophysics. Aware of expressing the sentiments of all participants, we like to dedicate these Proceedings to Drs. W. A. Fowler and S. Chandrasekhar as our modest sign of recognition and friendship. Without their pioneering work, a meeting on "Stellar Nucleosynthesis" could in fact have been hardly imagined at all !

Cesare Chiosi Alvio Renzini

List of Participants

R. BEDOGNI, Astronomy Department, Bologna, Italy
G. BERTELLI, Institute of Astronomy, Padova, Italy
J.R. BOND, Institute of Astronomy, Cambridge University, England
D. BRANCH, Dept. of Physics and Astronomy, University of Oklahoma, USA
R. BRAUN, Sterrewacht, Leiden, Holland

A. BRESSAN, SISSA, Trieste, Italy
M. CASSE', Commissariat à l'Energie Atomique, Gif-sur-Yvette Cedex, France
C. CHIOSI, Institute of Astronomy, Padova, Italy
A. CIANI, Institute of Astronomy, Padova, Italy
J.J. COWAN, Dept. of Physics and Astronomy, University of Oklahoma, USA

I.J. DANZIGER, ESO, Garching bei München, F. R. Germany
A. DIAZ, Royal Greenwich Observatory, Herstmonceux, England
C. DOOM, Astrofisisch Instituut, Vrije Universiteit, Brussel, Belgium
M.G. EDMUNDS, University College, Cardiff, England
C. FORIERI, SISSA, Trieste, Italy

C. FU-ZHEN, SISSA, Trieste, Italy
J.S. GALLAGHER III, Dept. of Astronomy, University of Illinois, USA
L. GREGGIO, Astronomy Department, Bologna, Italy
R.B.C. HENRY, Dept. of Physics, University of Delaware, USA
I. IBEN Jr., Dept. of Astronomy, University of Illinois, USA

M. JOHNSTON, Space Telescope Science Institute, Baltimore, USA
U.G. JØRGENSEN, University Observatory, Copenhagen, Denmark
H. KIRBIYIK, SISSA, Trieste, Italy
Z.W. LI, Dept. of Astronomy, University of Texas, Austin, USA
J.H. LUTZ, University College, London, England

A. MAEDER, Geneva Observatory, Switzerland
G. MATHEWS, L. Livermore Laboratory, University of California, USA
F. MATTEUCCI, Istituto Astrofisica Spaziale C.N.R., Frascati, Italy
R. MONTI, TESRE C.N.R., Bologna, Italy
K. NOMOTO, Dept. of Earth Science and Astronomy, Tokyo, Japan

W.W. OBER, Max Planck Institut für Astrophysik, Garching, F. R. Germany
M. PERSIC, SISSA, Trieste, Italy
A. PREITE-MARTINEZ, Istituto Astrofisica Spaziale C.N.R., Frascati, Italy
L. PULONE, Istituto Astrofisica Spaziale C.N.R., Frascati, Italy
M.L. QUARTA, Istituto Astrofisica Spaziale C.N.R., Frascati, Italy

M. RAYET, Phys. Nucl. Théorique, Université Libre de Bruxelles, Belgium
A. RENZINI, Astronomy Department, Bologna, Italy

P. SALVADOR DELBOURGO, Institut d'Astrophysique, Paris, France
L. SANZ FERNANDEZ DE CORDOBA, Inst. Nac. de Tec. Aerosp., Madrid, Spain
F.-K. THIELEMANN, Max Planck Inst. für Astrophysik, Garching, F.R. Germany
S. TORRES-PEIMBERT, Inst. Astronomia, Univ. Nac. Aut. Mexico, Mexico
A. TORNAMBE', Istituto Astrofisica Spaziale C.N.R., Frascati, Italy
M. TOSI, Astronomy Department, Bologna, Italy
H.-P. TRAUTVETTER, Inst. Für Kernphysik, Munster, R. R. Germany
S.E. WOOSLEY, Dept. of Astronomy, University of California Santa Cruz, USA

A. YAHIL, Astronomy Program, State Univ. of New York, Stony Brook, USA