

Lecture Notes in Physics

Edited by J. Ehlers, München, K. Hepp, Zürich,
H. A. Weidenmüller, Heidelberg, and J. Zittartz, Köln
Managing Editor: W. Beiglböck, Heidelberg

42

H II Regions and Related Topics

Proceedings of a Symposium Held at
Mittelberg, Kleinwalsertal, Austria
January 13–17, 1975

Edited by T. L. Wilson and D. Downes



Springer-Verlag
Berlin · Heidelberg · New York 1975

Editors

Dr. T. L. Wilson

Dr. D. Downes

Max-Planck-Institut für Radioastronomie

Auf dem Hügel 69

53 Bonn 1/BRD

Library of Congress Cataloging in Publication Data

Symposium on H II Regions and Related Topics, Mittelberg, Austria (Bregenz), 1975.

Proceedings of a symposium on H II regions and related topics.

(Lecture notes in physics ; 42)

Sponsored by the Deutsche Forschungsgemeinschaft, the Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V., and the European Physical Society.

Bibliography: p.

Includes index.

1. Interstellar hydrogen--Congresses. 2. Stars--Evolution--Congresses. 3. Radio sources (Astronomy)--Congresses. 4. Interstellar matter--Congresses. I. Wilson, Thomas L. II. Downes, D. III. Deutsche Forschungsgemeinschaft (Founded 1949). IV. Max-Planck-Gesellschaft zur Förderung der Wissenschaften. V. European Physical Society. VI. Title. VII. Series.

QB791.5.S9 1975 523.1'12 75-30666

ISBN 3-540-07409-0 Springer-Verlag Berlin · Heidelberg · New York

ISBN 0-387-07409-0 Springer-Verlag New York · Heidelberg · Berlin

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically those of translation, reprinting, re-use of illustrations, broadcasting, reproduction by photocopying machine or similar means, and storage in data banks.

Under § 54 of the German Copyright Law where copies are made for other than private use, a fee is payable to the publisher, the amount of the fee to be determined by agreement with the publisher.

© by Springer-Verlag Berlin · Heidelberg 1975.

Printed in Germany.

Offsetdruck: Julius Beltz, Hemsbach/Bergstr.

TABLE OF CONTENTS

Introduction IX
List of participants XI

Part I: MOLECULAR CLOUDS AND DUST CLOUDS

Chairman: J. Lequeux

Formation of molecules and dust 1
E.E. Salpeter

Radio observations of molecular clouds
P. Thaddeus *

Interpretation of the carbon recombination line 17
C.M. Walmsley

The stellar population of dark clouds 30
G.L. Grasdalen

Observations of the H and C recombination line 39
toward NGC 2024.....
T.L. Wilson

The ionization of carbon in dusty H I regions 42
D.A. Cesarsky and J. Lepine

Recent interstellar molecular line work 47
G. Winnewisser

Part II: FORMATION OF STARS AND H II REGIONS

Chairman: E.E. Salpeter

A review of star formation 53
S. von Hoerner

IV

Recent theoretical work on star formation	79
R. Kippenhahn and W. Tscharnuter	
Cocoon stars	107
F.D. Kahn	
The early stages of H II regions	110
E. Krügel	
Model calculations of dusty Strömgren spheres	123
T. de Jong, F.P. Israel, A.G.G.M. Tielens	
Part III: IR-SOURCES, MASERS AND COMPACT H II REGIONS	
Chairman: F.D. Kahn	
IR observations of H II regions at $\lambda < 40\mu$	134
C.G. Wynn-Williams	
IR observations at $\lambda > 40\mu$ of compact H II regions	137
R.E. Jennings	
Compact H II regions, mainly radio observations	156
H.J. Habing	
Selective absorption by dust in H II regions	175
L.F. Smith	
Optical studies of galactic nebulae and their exciting stars.....	183
M.C. Lortet	
Molecular masers in H II regions	188
B.F. Burke	
Masers associated with galactic H II regions	195
V.V. Burdjuzha, T.V. Ruzmaikina and D.A. Varshalovich	
On the nature of the SiO maser in the Kleinmann-Low nebula	205
H.J. Habing, F.M. Olmon, P.J. Bedijn, T. de Jong	

V

Part IV: EVOLVED H II REGIONS AND OB-STARS

Chairman: R. Kippenhahn

Observed parameters of O-type stars	207
P.S. Conti	
Recent optical observations of some evolved H II regions	222
J. Meaburn	
Evolved H II regions	245
E. Churchwell	
Radio continuum spectra	260
M.J. Seaton	
Some recent calculations and computer programs	266
M. Salem	

Part V: LARGE-SCALE DISTRIBUTION OF H II REGIONS

Chairman: B.F. Burke

Survey of the galactic plane at 5 GHz	271
W. J. Altenhoff	
The galactic distribution of molecules (a CO survey)	272
N.Z. Scoville	
Radio observations of H II regions in external galaxies	288
F.P. Israel	
Optical observations of H II regions in external galaxies	304
E.M. Burbidge and G.R. Burbidge	
Ionized gas in NGC 4151	319
K.J. Fricke	
On the ionization conditions in the interarm gas of M 33	322
P. Benvenuti and S. D'Ordorico	

VI

Observations of the excited hydrogen radio line H 56 α in several H II regions	329
J.J. Berulis, G.T. Smirnov and R.L. Sorochenko	
Far infrared observations of H II regions	343
D.A. Harper	
Large scale features of galactic and extragalactic H II regions. G. Courtès*	
Interstellar isotopic ratios, stellar mass losses and galactic evolution	356
J. Audouze and J. Lequeux	

Part VI: SELECTED GALACTIC H II REGIONS

Chairman: M.J. Seaton

"Review" of Orion A and B	360
B. Zuckerman	
A new radio map of the core of Orion A	369
S.F. Gull and A.H.M. Martin	
M 17	372
D. Lemke	
DR 21 and associated sources - a review	393
S. Harris	
The giant H II region W 3.....	408
P.G. Mezger and J.E. Wink	
The W 49 region	424
T.L. Wilson	
The W 51 source complex	443
J. Bieging	
CO/dust ratio in the ρ Ophiuchi complex	463
P. Encrenaz, E. Falgarone and R. Lucas	
40-350 micron emission from dust in NGC 2023.....	466
J.P. Emerson, I. Furniss and R.E. Jennings	

VII

Part VII: H II REGIONS ASSOCIATED WITH NUCLEI OF GALAXIES

Chairman: P.G. Mezger

The center of our Galaxy	467
D. Downes	
The molecular cloud associated with Sgr B2.....	469
A.H.M. Martin	
High resolution maps of the galactic center at 2.2 and 10 μ	471
E.E. Becklin and G. Neugebauer	
H II regions in the nuclei of external galaxies	472
M.H. Ulrich	
The distribution of H II regions in the Large Magellanic Cloud	484
Th. Schmidt-Kaler	

* These manuscripts were not received.

INTRODUCTION

The Symposium on H II Regions and Related Topics was held at Mittelberg, Kleinwalsertal, Austria, during January 13-17, 1975. This meeting dealt with recent radio, infrared and optical observations of H II regions and associated molecular clouds and maser sources, as well as the interpretation of these observations.

Separate sessions were devoted to current ideas on star formation and radio and optical observations of external galaxies. Our understanding of these topics has greatly advanced during the past decade and the current generation of large radio telescopes in Europe has provided a new impetus to the research field. This meeting brought together an international group of scientists involved in nearly all areas related to H II regions.

The Symposium was sponsored by the Deutsche Forschungsgemeinschaft, the Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V., and the European Physical Society. Financial support was given by the first two organizations. The idea of holding this meeting and the initial planning came from P.G. Mezger. The Scientific Program Committee consisted of F.D. Kahn, R. Kippenhahn, H.J. Habing, J. Lequeux, P.G. Mezger, E.E. Salpeter and M.J. Seaton. All of the work required to make this a smoothly running symposium was very capably handled by the Local Organizing Committee, R. Schwartz, H. Steppe and U. Wilson, with the help of E. Dietz and H. Höch.

The papers in this volume were prepared by the authors themselves, and we have included none of the discussion which followed the presentations. Textual changes were required for only a few manuscripts and R. Booth, R. Genzel and C.M. Walmsley helped with the editing.

LIST OF PARTICIPANTS

Aitken, D.K., London
Altenhoff, W.J., Bonn
Appenzeller, I., Heidelberg

Baars, J., Dwingeloo
Barlow, M.J., Sussex
Becklin, E.E., Pasadena
Bedijn, P.J., Leiden
Bieging, J., Bonn
Biermann, P., Bonn
Biermann, L., Munich
Booth, R.S., Jodrell Bank
Borgmann, J., Roden
Burke, B.F., Cambridge, Mass.
Burbidge, E.M., La Jolla
Burbidge, G.R., La Jolla

Cesarsky, D.A., Meudon
Churchwell, E., Bonn
Conti, P.S., Boulder
Courtès, G., Marseilles

Davies, R.D., Jodrell Bank
Deharveng, L., Marseilles
Downes, D., Bonn
Duinen, R.J. van, Groningen
D'Odorico, S., Asiago
Dyson, J.E., Manchester

Elsässer, H., Heidelberg
Emerson, J.P. London
Encrenaz, P., Meudon

Felli, M., Florence
Fricke, K.J., Bonn

Goldsworthy, F.A., Leeds
Grasdalen, G.L., Tucson
Grewing, M., Bonn
Gull, S.F., Cambridge, UK

Habing, H.J., Leiden
Harper, D.A., Chicago
Harris, S., Cambridge, UK
Harten, R.H., Leiden
Higgs, L.A., Ottawa
Hills, R.E., Cambridge, UK
Hoerner, S. von, Green Bank

Israel, F.P., Leiden
Jennings, R.E., London
Jong, T. de, Leiden
Jones, B., London

Kahn, F.D., Manchester
Kardashev, N.S., Moscow
Kegel, W.H., Heidelberg
Kesteven, M., Jodrell Bank
Kippenhahn, R., Munich
Krügel, E., Munich

Lee, T.J., Edinburgh
Lequeux, J., Meudon
Lemke, D., Heidelberg
Lortet, M.C., Meudon

Martin, A.H.M., Cambridge, UK
Matthews, H.E., Groningen
Meaburn, J., Manchester
Mezger, P.G., Bonn
Michel, K.W., Lindau

Olthof, H., Groningen

Panagia, N., Bologna
Pankonin, V., Bonn
Perinotto, M., Florence
Petrosian, V., Stanford
Pottasch, S.R., Groningen
Pauls, T.A., Bonn

Rowan-Robinson, M., London

Salem, M., London
Salpeter, E.E., Ithaca
Schmidt-Kaler, Th., Bochum
Scoville, N.Z., Amherst
Seaton, M.J., London
Setti, G., Bologna
Shaver, P.A., Groningen
Soifer, B.T., La Jolla
Sorochenko, R.L., Moscow
Smith, L.F., Bonn
Sume, A., Onsala

Ulrich, M.H., Austin
Vidal, J.L., Toulouse

Walmsley, C.M., Bonn
Weliachew, L., Meudon
Wehrse, R., Heidelberg
Weinberger, R., Heidelberg
Wendker, H.J., Hamburg
Werner, M., Pasadena
Wilson, T.L., Bonn
Wink, J.E., Bonn
Winnewisser, G., Bonn
Wynn-Williams, C.G., Cambridge, UK

Yorke, H.W., Munich

Zuckerman, B., Maryland