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T. P. Ray S. V. W. Beckwith (Eds.)

# Star Formation and Techniques in Infrared and mm-Wave Astronomy



Lectures Held at the Predoctoral  
Astrophysics School V

Organized by the European Astrophysics Doctoral Network  
(EADN) in Berlin, Germany, 21 September - 2 October 1992

**Springer-Verlag**

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Hong Kong Barcelona  
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ISBN 3-540-58196-0 Springer-Verlag Berlin Heidelberg New York  
ISBN 0-387-58196-0 Springer-Verlag New York Berlin Heidelberg

CIP data applied for

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Printed in Germany

This book was processed using the T<sub>E</sub>X/L<sup>A</sup>T<sub>E</sub>X macro packages from Springer-Verlag.  
SPIN: 10080361 55/3140-543210 - Printed on acid-free paper

## Preface

The European Astrophysics Doctoral Network (EADN) is an affiliation of 27 universities whose aim is to encourage the mobility of astrophysics students within Europe. This it does through mobility grants funded by the EU ERASMUS programme.

In addition the EADN organizes a summer school aimed at students in either the first or second year of their doctoral studies. The first such school was held in Les Houches (France) in September 1988 and subsequent schools have been held in Ponte de Lima, Dublin and Graz. As a rule, each school proposes two closely related themes: one being astrophysical and the other more methodological, e.g. in the field of technology or in numerical studies. The content of the lectures, although advanced, is aimed at a broad audience. The presentations should, in general, be understandable to students who are still beginners in their field.

The past decade has seen an enormous growth in our understanding of star formation due largely to developments in infrared and mm technology. The choice of themes for the Fifth EADN Summer School in Berlin, i.e. Star Formation and Techniques in Infrared and mm-Wave Astronomy, was therefore an easy one. The School itself was held at the Technische Universität Berlin from 21st September to October 2nd 1992.

In Part I of this volume, sites of star formation, i.e. molecular clouds, the characteristics of low and high mass young stellar objects (YSOs) and their interaction with their environment, are amongst the topics considered in depth. One of the most important findings in recent years has been the discovery that stellar birth is associated not only with the accretion of matter but with the outflow of material as well. These outflows in turn seem to be related to another ubiquitous phenomenon amongst young stars, namely the presence of disks. Both disks and outflows are examined in Part I.

Because stars form in the dusty environments of molecular clouds, our understanding of the processes governing their formation, particularly at the earliest stages, has relied heavily on infrared and mm observing techniques. Far-infrared astronomy has to be carried out from space (for example in the past by satellites like IRAS and in the future by ESA missions like ISO) but it is possible to observe from the ground at sub-millimeter and millimeter wavelengths. Observing methods in the far-infrared and sub-mm are explored in Part II. The widespread availability of infrared arrays has revolutionized the field of infrared astronomy. Such arrays have rapidly replaced traditional detectors and these are discussed in Part II along with other techniques for studying star formation at near-infrared wavelengths. Part II ends with a detailed review of the rapidly developing field of high resolution infrared studies including a discussion of adaptive optics. The only lecture course given at the Berlin School but not included in this volume was on Molecular Line Emission. An important part of the EADN school programme, is that students present their

research to their fellow students. Abstracts of the student presentations at the Berlin School are given in Part III.

As in previous years, participants had time off to enjoy their surroundings and it must be said that in this respect Berlin was not found wanting! Organized events included a welcoming reception by the Technische Universität Berlin who hosted the School and a visit to the Potsdam Observatory.

Seven lecturers from various parts of Europe, delivered approximately seventy lectures over the ten working days of the School. The Scientific Directors would like to thank them for their hard work which was appreciated not only by us but quite clearly by the students themselves. We would also like to express our sincere gratitude to the Technische Universität Berlin and to the local organizers, Dr. J.P. Kaufmann and Prof. Dr. E. Sedlmayr, not only for their help but for their hospitality as well. Finally thanks are also due to the School secretaries, A. Grace and I. Birambaux, who made sure that the administrative “wheels” of the School ran very smoothly.

Dublin/Heidelberg  
April 1994

T.P. Ray  
S.V.W. Beckwith

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