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PREFACE

This volume treats the numerical solution of radiative transfer problems in optically thick, radiating atmospheres. The volume addresses two topics: the solution of line and continuum transfer problems by fast and efficient methods, and the transfer of polarized radiation.

In 1973 Cannon proposed a novel method for solving radiative transfer equations subject to constraints such as radiative or statistical equilibrium. His method was based on the perturbation of the exact equations with an approximate but numerically simpler and more convenient operator. Even linear equations that could be solved directly were instead solved iteratively, but with the potential of a significant advantage in computation time. It was not appreciated then that this was the beginning of a new era in computational radiative transfer. Powerful general methods for solving transfer problems had been developed during the 1960's and 70's. The most widely employed among them was Auer and Mihalas' complete linearization method for the solution of non-linear equations. But cost in computer time and memory limited its use, particularly in time-dependent applications. It seemed only a matter of time, however, until a new generation of computers would permit an attack on problems still beyond reach. Cannon's approach revealed a new vista, but it took nearly a decade to realize its promise. This was accomplished by Scharmer who formulated a line transfer problem in terms of integral equations, writing the exact equation as a perturbation series with an approximate integral operator. His equations were efficient, saving time both in the construction of the operators and in the solution of the resulting system of equations. And the solution was obtained in much less time than with conventional direct differential or integral methods.

Cannon's and Scharmer's method opened a new approach and, what may be even more important, a new way of looking at radiative transfer. It has spawned a host of methods that are built on the same general principles. This development is still in progress, as is well documented by the present book which contains several new numerical methods, on operator perturbation as well as on polarized radiative transfer, that are described here for the first time. This volume will achieve its purpose if it stimulates further research on these topics.

The book is conceived as a manual of modern numerical methods for solving radiative transfer problems. Both sections, on operator perturbation and on polarized radiation, open with introductory articles, and the introduction to the entire book give synopses and cross references for all articles. While their focus is on astrophysical plasmas, the methods are easily adapted to applications involving other media where self-absorption of radiation is important. Stratification in plane-parallel layers is generally assumed but most methods can be extended to other geometries. Although the book is intended primarily for graduate students and workers in the field of radiative transfer, the level of presentation is designed to make it accessible also to advanced undergraduates.

A book such as this needs the diligent work and willingness of all its authors to conform to an overall plan. I take this opportunity to express my gratitude to my collaborators for their efforts. In particular I extend my warmest thanks to Bengt Gustafsson, president of the Commission of the International Astronomical Union on Stellar Atmospheres at the time of its meeting in 1985 in New Delhi, India, for having invited me to organize a session on radiative transfer, where reports on some of the research included here were first given.

Cambridge, Massachusetts W.K.
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