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Preface

With the exception of a few objects that have been successfully identified as sources of highly energetic charged particles or of neutrinos, all our knowledge about the universe outside the inner solar system is based on the analysis of electromagnetic radiation. Some valuable information has been derived by measuring the flux, the time variations, or the polarization of astronomical radiation sources. By far the most important tool for investigating cosmic objects, however, has been the analysis of their energy distributions and of their line spectra. There are obvious reasons for this predominance of spectroscopic methods in modern astronomy. First, spectra contain a particularly large amount of physical information. If properly analyzed, spectra allow us to determine the chemical composition, local physical conditions, kinematics, and presence and strength of local physical fields. Second, apart from the cosmological redshift and the reduced observed total flux of faraway objects, spectra are independent of the distance, making spectroscopy a particularly valuable remote-sensing tool. Finally, there exists a well-developed theory of the formation of continua and line spectra.

The gathering of information on distant objects by means of spectral observations requires several steps. First, suitable instruments must be designed that allow us to measure the spectra of the faint astronomical sources. Then, these instruments must be employed to obtain spectra of optimal quality. Finally, the spectra must be analyzed and physical information on the observed objects must be extracted. In astronomy, the term *spectroscopy* is used for all these steps. Moreover, the theory of radiative transfer and line formation in stellar atmospheres is often included in the term *astronomical spectroscopy*. The content of this book is focused on the first two of these topics – that is, on the techniques and the practice of obtaining spectra of cosmic objects. Apart from space restrictions, there are several reasons for this emphasis on observational aspects. One obvious reason is the fact that this book belongs to a series of *observing handbooks*. Moreover, whereas astronomers observing different types of objects often use the same or similar instrumentation, the methods used for analyzing the spectra usually depend on the nature of the radiation sources. Because modern astronomy comprises many different types of objects, including stars, black holes, interstellar gas and dust, galaxies, and a variety of nonthermal emitters, the methods for analyzing astronomical spectra are correspondingly diversified. It would be difficult to treat them adequately in a single volume. Finally, there already are excellent books describing the analysis of astronomical spectra of different types. Examples of these books are cited in the second chapter of this volume.

Astronomical spectroscopy started in the nineteenth century in the optical spectral range. It later spread to all wavelengths at which astronomical observations are possible. In the early days, the observers typically built their own instruments and were specialists for a single wavelength regime. Today, much of the cutting-edge science is done at large ground-based and space-based observatories that are accessible to large observer communities, and present-day observers typically carry out observations at many different wavelengths. Therefore, this book tries to include all wavelengths at which astronomical spectroscopy is possible at present. It aims at providing all information that a researcher needs to plan and to execute astronomical spectroscopic observations with existing instrumentation. It provides the level of technical detail that is required for selecting the techniques and methods that are best suited for a given task. By describing the present-day technical state of the art, along with the limitations of present instruments, the book can furthermore be a good introduction to the topic for scientists and engineers who aim at improving present methods and on developing future, superior instrumentation. Finally, the book will, hopefully, help the reader to better understand and appreciate the opportunities of the vast amount of spectroscopic data that are available in astronomical data archives.

As this series is written for research astronomers, it is expected that the reader has some basic knowledge of astronomy and of elementary physics. Moreover, it will be assumed that the reader is familiar with the special notations and definitions that are frequently used in astronomy. Some of these notations and definitions have been changing with time. This book normally follows the notations currently defined by the International Astronomical Union (IAU) and specified on the IAU Web sites. For historic reasons, some technical terms are used with a different meaning in the astronomical literature. In these cases, I adopted the meaning that is preferred by a majority of the professional astronomers in the current scientific literature. Finally, topics that have been discussed in other volumes of this series of observing handbooks will not be treated here in detail, but references will be given in all such cases.

Present-day science depends on cooperation and teamwork. This book is no exception. It could not have been completed without the kind support of many different colleagues. Special thanks are due to Joachim Krautter, Walter Seifert, and Otmar Stahl, for critically reading parts of the manuscript. Moreover, I would like to thank Regina von Berlepsch, Luis Carrasco, Frank Eisenhauer, Edith Falgarone, Kay Justtanont, Norbert Kappelmann, Andreas Kaufer, Richard Kron, Olivier Le Fèvre, Holger Mandel, Michel Mayor, Karl Menten, Patrick Osmer, Jürgen Schmitt, Walter Seifert, Josef Solf, Otmar Stahl, Matthias Steinmetz, Stefan Wagner, Wenli Xu, and the Astrium GmbH for providing figures and/or for allowing me to use their figures in this book. Thanks are also due to the editors of *Astronomy and Astrophysics* (A & A) and to ESA, ESO, NASA, Fermilab, the H.E.S.S. consortium, and the Gemini Observatory for the kind permission to reprint illustrations.