Preface

The transport of radiant energy plays an important role in physics and engineering. However, it is of paramount importance in astronomy: the development of theories of radiative transfer (RT) since the beginning of the last century has made possible our present knowledge of the basic physics working in the observable Universe. A. Schuster and K. Schwartzschild can be considered the founding fathers of modern radiative transfer. With his seminal paper *Radiation through a Foggy Atmosphere*, published in 1905, the former set the cornerstone of a theory that the former developed in the following years. In his paper *On the Equilibrium of the Sun's Atmosphere* (1906), Schwartzschild, by studying the problem of the temperature distribution in the solar atmosphere, reached the conclusion that the latter is in radiative equilibrium and derived a formula for the observed phenomenon of limb darkening. Later in 1914, Schwartzschild published another fundamental paper, *Diffusion and Absorption in the Sun's Atmosphere*, in which he derived the basic equations of RT and gave their formal solution in terms of an integral equation that Milne and Hopf developed later on. Moreover, this paper paved the way to what was later called local thermodynamic equilibrium. (The aforementioned three papers can be found in D. H. Menzel's *Selected Papers on the Transfer of Radiation*, published by Dover in 1966.) The situation in the 1930s and 1950s was given authoritative reviews by E. A. Milne in his *Thermodynamics of the Stars* (1930, *Handbuch der Astrophysik*, Vol. 3) and by D. Barbier in his *Théorie Générale des Atmosphères Stellaires* (1958, *Handbuch der Astrophysik*, Vol. 50).

The availability of large computers for the numerical solution of the RT equation and the computation of stellar atmosphere models marked a turn in the 1960s. Since then, effective numerical techniques for both aims have been steadily developed with impressive results. Nowadays the amazing performance of modern computers makes it possible to compute "all-singing, all-dancing" stellar atmosphere models that include many physical processes and consider time variability and three-dimensional (3D) geometry. However, during the conference *Stellar Atmosphere beyond Classical Models*, held in Trieste in 1990, V. V. Ivanov made a keen distinction between the industry of radiative transfer, based merely on numerical technology, and ART (analytical radiative transfer). Behind his joke there was the concern that the ever-wider application of overwhelming numerical simulations may hide the underlying physics. Twenty-seven years later, at a moment when radiative transfer is living a transition from old to new fields of application and a dramatic improvement both in observational and computational facilities is on the horizon, the fear that the new practitioners of radiative transfer may lack the necessary physical and mathematical background motivated the choice of devoting the XXIX IAC Winter School to the applications of radiative transfer to stellar and planetary atmospheres.

The present volume is the outcome of the School, and it has been the main aim of the editors that the book should preserve its spirit and purpose. Hence their ambitious aim to publish not just the compilation of the lectures delivered during the School, but a useful reference text for beginners in the theory and practice of stellar atmospheres. The material is organized in two parts. The first is intended as introductory to the second and presents the basis, both physical and mathematical, of radiative transfer. The authors of the first three contributions (L. Crivellari, A. Herrero and O. Atanaković) worked in close collaboration in order to complement homogeneously the content of their chapters. The first one addresses the physics of RT from a general point of view, while the second deals with specific issues of RT in stellar atmospheres and spectral line formation. Chapter 3 contains an exhaustive review of numerical methods for the solution of the RT equation, including the standard ones widely in use since the 1960s and their progressive improvements as well as novel algorithms, probably less well known until now. A review by M. Carlsson on the stellar atmosphere codes nowadays available concludes the first part. In the second, J. Puls, M. Bergemman and M. S. Marley discuss the phenomenology and physics of early-type stars, late-type stars and ultracool dwarfs and extrasolar planets. The purpose of the second part is to present a comprehensive although necessarily brief overview of the state of the art and future outlook vis-à-vis the next release of the Gaia mission data, which will provide precise information on distances, proper motion and spectral distribution for more than a billion Galaxy stars as well as radial velocities for many millions of the brightest stars, and the launch of the NASA James Webb Space Telescope.

The PowerPoint files with the original content of the lectures delivered can be found on the website of the School (www.iac.es/winterschool/2017).

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