

Preface

The light coming from plasmas has always been one of the primary sources of knowledge on their properties. Be it multi-million-degree magnetic or inertial confinement plasmas, dazzling streamers of the solar corona, photoionized plasmas generated by powerful z-pinchs, or industrial plasmas for lithography, their spectra, from hard X-rays to infrared and beyond, can give us a great deal of information about diverse characteristics such as temperature and density, turbulent motions, ionization distributions, and electric and magnetic fields, to name a few. In most cases the measured plasma emission and absorption spectra are quite complex due to a large number of spectral lines with varying intensities and line shapes, as well as the presence of continuum photons. As a result, a reliable interpretation of spectroscopic experiments is mostly achieved with rather sophisticated methods capable of adequately describing the origin, propagation and possible destruction of plasma photons.

One of the most general approaches to calculation of plasma population kinetics and spectra is the collisional-radiative (CR) modeling. First introduced more than 50 years ago in a seminal paper by Bates, Kingston, and McWhirter, it addresses determination of state populations and ensuing spectra from a microscopic picture of interactions between emitters (i.e., atoms and ions in plasma) and other plasma particles. Thus it accounts for the most relevant collisional and radiative processes, hence the name. The variety of terrestrial and astrophysical plasmas results in a considerable diversity of possible interactions and environments, from simple electron-atom (ion) collisions in a stationary optically thin plasma to non-Maxwellian particle distribution functions to relatively weak forbidden radiative transitions to heavy-particle interactions to transient and/or optically thick plasmas, and so on. Unlike equilibrium descriptions of plasma population kinetics, for example, local thermodynamic equilibrium (LTE), a general CR approach calls for a fairly detailed (and of course reasonably accurate!) representation of relevant elementary interactions. This approach connects plasma modeling with the powerful apparatus of contemporary atomic physics, which may require utilization of very extensive sets of atomic data.

The idea for this book originated from invigorating discussions among the participants of the series of non-LTE code comparison workshops. The present collection of chapters is aimed at providing an overview of the modern methods employed in collisional-radiative modeling with emphasis on recent developments. Such a review seems to be long overdue, notwithstanding extensive applications of CR models to various plasmas as witnessed by hundreds, if not thousands, of articles on this subject.

The eight chapters presented here address both general topics, such as the balance between detail and completeness in CR models and self-consistent large-scale CR modeling, and more specific issues, such as simulations with different representations of atomic structure, applications in radiation hydrodynamics and interaction of monochromatic X-rays with matter, astrophysical applications, and validation and verification of CR models. This collection is not an introductory textbook and thus is intended for advanced students and young researchers who already have some knowledge in CR approach. We hope also that it will be useful for scientists and researchers working in general plasma spectroscopy.

When this book was in a final stage of preparation, one of the contributors, Prof. Vladimir G. Novikov of the Keldysh Institute of Applied Mathematics in Moscow, Russia, suddenly passed away. He was an excellent physicist with a wide range of interests and one of the leading specialists in quantum-statistical methods for high-temperature plasmas. We dedicate this book to his memory.

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