1 Preface

Solar and stellar atmospheres, magnetospheres of planets or coronae of magnetars are in the state of plasma. Even dust particles in the cosmic space can be charged, thus forming a plasma. Therefore, plasma astrophysics is a vast field which is impossible to cover in one book, especially owing to its fast development given by new observations made by ground-based and satellite instruments.

The amount of information we have concerning astrophysical plasmas decreases roughly with increasing distance from the observer. Thus, the Sun as our nearest star can be considered as the laboratory for plasma astrophysics. Therefore, in this textbook, although universal plasma processes are presented, examples of observations are taken from solar physics.

However, information about processes in the solar atmosphere are only provided via electromagnetic waves, particle beams, and coronal mass ejections. This limits studied areas of plasma physics, in difference to those connected with in-situ measurements, e.g., in the Earth magnetosphere or in laboratory devices.

Our research group has been working in the field of solar flares for many years, where plasma astrophysics plays a very important role.

Based on these facts, in this textbook a selection of topics was made. The main emphasis is given to a primary-energy release process in solar flares – the magnetic field reconnection and its "visualization" through the accelerated electrons generating the radio and X-ray emissions. Namely, the radio emission, generated by the plasma emission mechanism, carries a direct information about these plasma processes. Moreover, magnetic reconnection and effects of particle beams are universal processes applicable in many eruptive processes in the universe. Examples of numerical simulations of these processes, presented in this textbook, were mainly taken from simulations made at Astronomical Institute AS CR at Ondřejov. Other topics, like magnetic structures, magnetohydrodynamic waves, and helicity are also very important, but here they only support the main topics.

Except a description of acceleration processes, where formulas from the special relativity theory are needed, this textbook presents classical plasma astrophysics.

In whole the textbook the *SI* system of units is used unless another set is explicitly announced (dimension-less units or, exceptionally, *CGS* system).

This textbook is based on my experience in research studies of solar flares and teaching courses on plasma astrophysics at Faculty of Mathematics and Physics, Charles University in Prague.

This textbook is intended as an introduction to plasma astrophysics and plasma physics of solar flares. It is addressed to graduate and doctoral students. It can be of interest of students in theoretical physics, space plasma physics and laboratory plasma physics.

No separate book can summarize all aspects of plasma astrophysics. Therefore, for earnest students in this field I recommend several excellent books about plasma astrophysics, e.g., Chen (1974), Melrose (1980), Priest (1982), Kirk et al. (1994) and Aschwanden (2004), which were for me a source of information and inspiration for writing this textbook.

In Ondřejov, June 30, 2014 Marian Karlický