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Valentina Zharkova
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Preface

Charged particles, electrons, protons, ions and neutral atoms are invisible but very powerful participants in all processes in plasmas of the Sun, stars, magnetospheres, interplanetary space and laboratory experiments. Their presence in theoretical research is very often masked behind macro descriptions of the plasma status by means of temperature, density, electric and magnetic fields and so on.

All of these are defined by some sort of ensembles of particles whose various properties (e.g. velocities, charges, masses, numbers or excitation-state status) define the macro parameters which are good descriptors of a plasma’s status in equilibrium. However, in many events on the Sun or stars or in interplanetary space, the atmospheres are well beyond equilibrium. The subject of this book is the investigation of processes of non-equilibrium in flaring atmospheres with a consideration of particle kinetics, dynamics and radiative processes.

The author’s PhD thesis, titled “Radiative transfer in solar quiescent prominences with filamentary structure”, investigated non-equilibrium radiative processes in cool, steady atmospheres and their effects on hydrogen lines and continuous emission. The research was done under the supervision of the late Prof. Nina Morozhenko (Solar Division, Main Astronomical Observatory, Ukraine), a researcher of the highest caliber, who taught well how to properly conduct research and test hypotheses with theoretical predictions. After completing her PhD, the author applied the approach used and knowledge gained during the writing of her thesis to the development of physical concepts in such dynamic events as solar flares.

The research in particle kinetics was initiated at the Astronomy Unit, State Kiev University, by the prominent plasma physicist Prof. Nikolaj Kotsarenko (1941–1993), former head of the Space Physics and Astronomy division in the Physics Department, National University of Kiev, Ukraine. This work was also kindly supported by the theoretical group Theory and Diagnostics of Physical Processes in Solar Flares, led by Prof. Boris Somov of Moscow Sternberg Astronomical Institution, Moscow State University, Russia, and the researchers comprising the group who now carry out their research at various institutions around the world. During annual gatherings of this group, the researchers had many fruitful talks and discussions, which helped the author to make significant progress in her knowledge
and understanding of the complex physical processes of particle acceleration and precipitation in solar flares.

My acquaintance with Prof. John Brown, Astronomer Royal for Scotland, University of Glasgow, Scotland, and his famous group, which consisted of Prof. Gordon Emslie, Drs. D. Alexander, A. MacKinnon and other researchers, gave the present author a better understanding of particle kinetics and dynamics developed by various groups in Russia, the United Kingdom and the United States. Very frequently our research seminars and talks sparked extensive debates which motivated further research to clarify the argued points. Such discussions helped the author to build, brick by brick, her knowledge and understanding of such complex phenomena as the physical processes in solar flares, for which the author is enormously grateful.

The idea of this book was conceived at one of the RHESSI workshops frequently devoted to particle acceleration and precipitation in flaring atmospheres on the Sun and their diagnostics from multi-wavelength observations. Particle kinetics is a rather complex topic which needs to be taught to younger scientists so that they may continue the research begun four decades ago with the pioneering works of Prof. Sergey Syrovatsky (Moscow Physical-Technical Institution, Russia), Prof. John Brown (Glasgow University, UK) and Dr. Olga Shmeleva (IZMIRAN, Russia).

The author is also very grateful to her PhD students, who were engaged in the study of various aspects of particle kinetics: Dr. Victor Kobylinskij V.A. (funded by Kiev University, 1989–1993), Dr. Dmitry Syniavskij (Kiev University, Ukraine) (funded by Kiev University, Ukraine, 1990–1994) and Dr. Mykola Gordovskyy (Bradford University, UK), whose study was funded by the Engineering and Physical Sciences Research Council (2002–2005). The students’ dedication to and thorough knowledge of their topics significantly advanced the subject to new levels of understanding, and their knowledge of the topic is reflected in the current book.

The research carried out with her students helped the author to produce a strong synergy between research in kinetics and the dynamics of solar flares and the helioseismology of the solar interior behind these events. The author wishes to acknowledge a very fruitful collaboration with Dr. Alexander Kosovichev (Stanford University, USA), which led to the discovery of sunquakes. These are seismic responses of the solar interior to processes occurring in solar flares. They were reported in a paper in Nature on 27 May 1998 and gained worldwide media coverage on 28 May 1998 by all major TV and radio stations and newspapers.

The author is very grateful to her younger collaborators: Dr. Taras Siversky, my former post-doctoral research assistant employed on a research grant funded by the Science, Technology and Facilities Council (2007–2009); Dr. Sergey Zharkov (son), employed on the European Framework 5 Grant EGSO (2002–2005), currently a Research Fellow at Mullard Space Science Laboratory (MSSL), University College London (UCL), UK; and Dr. Sarah Matthews, a Reader at MSSL, UCL, who helped the author to significantly advance the topics of particle acceleration and precipitation in flaring atmospheres, the generation of seismic responses (sunquakes) associated with solar flares, and the determination of the connection of these processes with the phenomenon of solar flares covering atmospheric heights from the corona to the solar interior.
The author also wishes to acknowledge the Russian collaborators from the Institute of Solar-Terrestrial Physics, Irkutsk, Russia (Prof. A. Altyntsev, Drs. L. Kashapova and N. Meshalkina), whose contribution to our joint research within the Royal Society Joint International Grant (2009–2011) made a reality of recent papers comparing our kinetic and dynamic simulations with multi-wavelength observations, which ultimately became an important part of this book.

And last but not least, the author appreciates the support of her family and partner which allowed her to stay focused on this project and complete the book.

The author hopes that this book will help researchers who are just beginning their study of the physical phenomena of flaring atmospheres on the Sun.

Bradford, January 2012

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