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（影印版）

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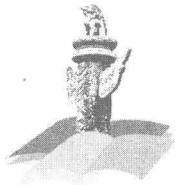

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序　言

物理学是研究物质、能量以及它们之间相互作用的科学。她不仅是化学、生命、材料、信息、能源和环境等相关学科的基础，同时还是许多新兴学科和交叉学科的前沿。在科技发展日新月异和国际竞争日趋激烈的今天，物理学不仅囿于基础科学和技术应用研究的范畴，而且在社会发展与人类进步的历史进程中发挥着越来越关键的作用。

我们欣喜地看到，改革开放三十多年来，随着中国政治、经济、教育、文化等领域各项事业的持续稳定发展，我国物理学取得了跨越式的进步，做出了很多为世界瞩目的研究成果。今日的中国物理正在经历一个历史上少有的黄金时代。

在我国物理学科快速发展的背景下，近年来物理学相关书籍也呈现百花齐放的良好态势，在知识传承、学术交流、人才培养等方面发挥着无可替代的作用。从另一方面看，尽管国内各出版社相继推出了一些质量很高的物理教材和图书，但系统总结物理学各门类知识和发展，深入浅出地介绍其与现代科学技术之间的渊源，并针对不同层次的读者提供有价值的教材和研究参考，仍是我国科学传播与出版界面临的一个极富挑战性的课题。

为有力推动我国物理学研究、加快相关学科的建设与发展，特别是展现近年来中国物理学者的研究水平和成果，北京大学出版社在国家出版基金的支持下推出了《中外物理学精品书系》，试图对以上难题进行大胆的尝试和探索。该书系编委会集结了数十位来自内地和香港顶尖高校及科研院所的知名专家学者。他们都是目前该领域十分活跃的专家，确保了整套丛书的权威性和前瞻性。

这套书系内容丰富，涵盖面广，可读性强，其中既有对我国传统物理学发展的梳理和总结，也有对正在蓬勃发展的物理学前沿的全面展示；既引进和介绍了世界物理学研究的发展动态，也面向国际主流领域传播中国物理的优秀专著。可以说，《中外物理学精品书系》力图完整呈现近现代世界和中国物理

科学发展的全貌，是一部目前国内为数不多的兼具学术价值和阅读乐趣的经典物理丛书。

《中外物理学精品书系》另一个突出特点是，在把西方物理的精华要义“请进来”的同时，也将我国近现代物理的优秀成果“送出去”。物理学科在世界范围内的重要性不言而喻，引进和翻译世界物理的经典著作和前沿动态，可以满足当前国内物理教学和科研工作的迫切需求。另一方面，改革开放几十年来，我国的物理学研究取得了长足发展，一大批具有较高学术价值的著作相继问世。这套丛书首次将一些中国物理学者的优秀论著以英文版的形式直接推向国际相关研究的主流领域，使世界对中国物理学的过去和现状有更多的深入了解，不仅充分展示出中国物理学研究和积累的“硬实力”，也向世界主动传播我国科技文化领域不断创新的“软实力”，对全面提升中国科学、教育和文化领域的国际形象起到重要的促进作用。

值得一提的是，《中外物理学精品书系》还对中国近现代物理学科的经典著作进行了全面收录。20 世纪以来，中国物理界诞生了很多经典作品，但当时大都分散出版，如今很多代表性的作品已经淹没在浩瀚的图书海洋中，读者们对这些论著也都是“只闻其声，未见其真”。该书系的编者们在这方面下了很大工夫，对中国物理学科不同时期、不同分支的经典著作进行了系统的整理和收录。这项工作具有非常重要的学术意义和社会价值，不仅可以很好地保护和传承我国物理学的经典文献，充分发挥其应有的传世育人的作用，更能使广大物理学人和青年学子切身体会我国物理学研究的发展脉络和优良传统，真正领悟到老一辈科学家严谨求实、追求卓越、博大精深的治学之美。

温家宝总理在 2006 年中国科学技术大会上指出，“加强基础研究是提升国家创新能力、积累智力资本的重要途径，是我国跻身世界科技强国的必要条件”。中国的发展在于创新，而基础研究正是一切创新的根本和源泉。我相信，这套《中外物理学精品书系》的出版，不仅可以使所有热爱和研究物理学的人们从中获取思维的启迪、智力的挑战和阅读的乐趣，也将进一步推动其他相关基础科学更好更快地发展，为我国今后的科技创新和社会进步做出应有的贡献。

《中外物理学精品书系》编委会 主任

中国科学院院士，北京大学教授

王恩哥

2010 年 5 月于燕园

PLASMA ASTROPHYSICS, PART I

Fundamentals and Practice

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Springer

About This Book

If you want to learn the most fundamental things about plasma astrophysics with the least amount of time – and who doesn't? – this text is for you. This book is addressed to young people, mainly to students, without a background in plasma physics; it grew from the lectures given many times in the Faculty of General and Applied Physics at the Moscow Institute of Physics and Technics (the well known 'fiz-tekh') since 1977. A similar full-year course was also offered to the students of the Astronomical Division of the Faculty of Physics at the Moscow State University over the years after 1990. A considerable amount of new material, related to modern astrophysics, has been added to the lectures. So the contents of the book can hardly be presented during a one-year lecture course, without additional seminars.

In fact, just the seminars with the topics '**how to make a cake**' were especially pleasant for the author and useful for students. In part, the text of the book retains the imprint of the seminar form, implying a more lively dialogue with the reader and more visual representation of individual notions and statements. At the same time, the author's desire was that these digressions from the academic language of the monograph will not harm the rigour of presentation of this textbook's subject – the physical and mathematical introduction to plasma astrophysics.

There is no unique simple model of a plasma, which encompasses all situations in space. We have to familiarize ourselves with many different models applied to different situations. We need clear guidelines when a model works and when it does not work. Hence **the best strategy** is to develop an intuition about plasma physics, but how to develop it?

The idea of the book is not typical for the majority of textbooks on plasma astrophysics. Its idea is

> the consecutive consideration of physical principles, starting from the most general ones, and of simplifying assumptions which give us a simpler description of plasma under cosmic conditions.

Thus I would recommend the students to read the book straight through each chapter to see the central line of the plasma astrophysics, its **classic fundamentals**. In so doing, the boundaries of the domain of applicability of the approximation at hand will be outlined from the viewpoint of physics

rather than of many possible astronomical applications. After that, as an aid to detailed understanding, please return with pencil and paper to work out the missing steps (if any) in the formal mathematics.

On the basis of such an approach the student interested in modern astrophysics, its **current practice**, will find the answers to two key questions:

(1) what approximation is the best one (the simplest but sufficient) for description of a phenomenon in astrophysical plasma;

(2) how to build an adequate model for the phenomenon, for example, a solar flare or a flare in the corona of an accretion disk.

Practice is really important for the theory of astrophysical plasma. Related exercises (problems and answers supplemented to each chapter) to improve skill do not thwart the theory but serve to better understanding of plasma astrophysics.

As for the applications, preference evidently is given to physical processes in the solar plasma. Why? – Much attention to solar plasma physics is conditioned by the possibility of the all-round observational test of theoretical models. This statement primarily relates to the processes in the solar atmosphere. For instance, flares on the Sun, in contrast to those on other stars as well as a lot of other analogous phenomena in the Universe, *can be seen* in their development, i.e. we can obtain a sequence of images during the flare's evolution, not only in the optical and radio ranges but also in the ultraviolet, soft and hard X-ray, gamma-ray ranges.

This book is mainly intended for students who have mastered a course of general physics and have some initial knowledge of theoretical physics. For beginning students, who may not know in which subfields of astrophysics they wish to specialize,

> it is better to cover a lot of fundamental theories thoroughly than to dig deeply into any particular astrophysical subject or object,

even a very interesting one, for example black holes. Astronomers and astrophysicists of the future will need tools that allow them to explore in many different directions. Moreover astronomy of the future will be, more than hitherto, *precise science* similar to mathematics and physics.

The beginning graduate students are usually confronted with a confusing amount of work on plasma astrophysics published in a widely dispersed scientific literature. Knowing this difficulty, the author has tried as far as possible to represent the material in a self-contained form which does not require the reading of additional literature. However there is an extensive bibliography in the end of the book, allowing one to find the original works. In many cases, particularly where a paper in Russian is involved, the author has aimed to give the full bibliographic description of the work, including its title, etc.

Furthermore the book contains recommendations as to an introductory (unavoidable) reading needed to refresh the memory about a particular fact, as well as to additional (further) reading to refine one's understanding of the subject. Separate **remarks of an historical character** are included in many

places. It is sometimes simpler to explain the interrelation of discoveries by representing the subject in its development. It is the author's opinion that the outstanding discoveries in plasma astrophysics are by no means governed by chance. With the same thought in mind, the author gives preference to original papers on a topic under consideration; it happens in science, as in art, that an original is better than nice-looking modernizations. Anyway,

> knowledge of the history of science and especially of natural science is of great significance for its understanding and development.

The majority of the book's chapters begin from an 'elementary account' and illustrative simple examples but finish with the most modern results of scientific importance. New problems determine the most interesting perspectives of plasma astrophysics as a new developing science. The author hopes, in this context, that professionals in the field of plasma astrophysics and adjacent sciences will enjoy reading this book too. Open issues are the focus of our attention in many places where they are. In this way, **perspectives of the plasma astrophysics** with its many applications will be also of interest for readers. The book can be used as a textbook but has higher potential of modern scientific monograph.

The first volume of the book is unique in covering the basic principles and main practical tools required for understanding and work in plasma astrophysics. The second volume "Plasma Astrophysics. 2. Reconnection and Flares" (referred in the text as vol. 2) represents the basic physics of the magnetic reconnection phenomenon and the flares of electromagnetic origin in space plasmas in the solar system, relativistic objects, accretion disks, their coronae.

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Moscow, 2006 Boris V. Somov

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