

## Space Physics

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May-Britt Kallenrode

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# Space Physics

An Introduction  
to Plasmas and Particles  
in the Heliosphere  
and Magnetospheres

Third, Enlarged Edition

With 211 Figures, 12 Tables,  
Numerous Exercises and Problems



Springer

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## Preface to the Third Edition

This book is a revised and expanded version of the second edition of *Space Physics*. The first part introduces basic concepts and formalisms which are used in almost all branches of space physics. The second part is concerned with the application of these concepts to plasmas in space and in the heliosphere. More specialized concepts, such as collisionless shocks and particle acceleration, are also introduced. The third part deals with methodological considerations. It consists of an expanded chapter on space measurement methods and a new chapter on general methodological problems. This last chapter is relevant in that it points out the differences between laboratory physics and physics in a complex natural environment, in particular the problems of limited knowledge – or as Pollack [415] puts it, “Uncertain Science . . . Uncertain World”. In Part II, in most chapters a section “What I Did Not Tell You” has been added – it should help the reader to understand some crucial assumptions underlying the basic ideas introduced in the text and might help you to appreciate the limitations of our knowledge and our models. These sections also give illustrative examples that help to understand the last chapter.

This edition has also been expanded by numerous examples, in particular in Part I. They illustrate basic concepts and aid the reader in the application of these concepts to real problems. In addition, new results from recent space missions, such as ACE, TRACE, and Wind, have been added. In the appendix, a list of Internet resources has been added. This list can also be found (in a “clickable” version) at [www.physik.uni-osnabrueck.de/sotere/spacebook/intro.html](http://www.physik.uni-osnabrueck.de/sotere/spacebook/intro.html). On that page, supplementary material to this course can be found, too.

The idea of the book is an introduction to many aspects of space plasmas. Obviously, this approach has the disadvantage that a specialist in any of the subfields will be disappointed that his or her field is dealt with in only a brief and very elementary way. That is, without doubt, true. My idea, however, is to introduce the basic concepts to the novice not already specialized in any field and to help the specialist to easily grasp some ideas in other fields. Therefore the focus is on concepts rather than on detailed mathematical analysis. References should help both the novice who is looking for a deeper

formal treatment and the specialist who wants to find reviews giving more details.

There are also a few good books on plasma physics and/or space physics which can be recommended to the reader. A very accessible, unmatched in its style and conscientious approach, book on plasma physics is *Plasma Physics and Controlled Fusion* by F.F. Chen [97]; a well-written and up-to-date account of the phenomena in space plasmas is given in *Introduction to Space Physics*, edited by M.G. Kivelson and C.T. Russell [290]. These two books cannot be matched by the present one and can serve as valuable supplements. More formal introductions to plasma physics are *Plasma Dynamics* by R.O. Dendy [128] and *Plasma Physics* by R.J. Goldston and P.H. Rutherford [192]. Very good introductions to plasma physics of the kind required by a space scientist are given in *Physics of Space Plasmas* by G.K. Parks [397], *Physics of Solar System Plasmas* by T.E. Cravens [113], and *Basic Space Plasma Physics* by W. Baumjohann and R.A. Treumann [36] and its sequel *Advanced Space Plasma Physics* [520]. A useful collection of plasma formulas can be found at [wwwppd.nrl.navy.mil/nrlformulary/nrlformulary.html](http://wwwppd.nrl.navy.mil/nrlformulary/nrlformulary.html).

As in the earlier editions, symbols in the margin help to guide you through the text. The symbols are



- This section contains an example from space plasmas to illustrate a physical concept. Such a section might be skipped by a reader who is interested primarily in the concepts and less in space science.



- This section is more formal, but is not vital for an understanding of basic observations and ideas. It might be skipped by a reader who is mainly interested in an introduction to space physics.



- An apparently confused reader, “Whatnow”, marks supplementary sections: although the ideas presented here are important in space physics, the theoretical background is complicated and only briefly sketched. In particular, the beginner in space physics should feel free to skip these sections on first reading and return to them later after becoming more acquainted with the topic.



- This text points to hotly debated topics and fundamental open problems.

I am grateful to the following persons, who all contributed to the development of this book: Andre Balogh, R.A. Cairns, Stanley H. Cowley, Ulrich Fischer, Roman Hatzky, Bernd Heber, Eberhard Moebius, Reinhold Müller-Mellin, Constantinos Paizes, Wilfried Schröder, Günter Virkus, C.L. Waters, Gerd Wibberenz, and even an anonymous reader who sent hints about errors without being traceable. I am grateful to the helpful team at Springer, in particular Claus Ascheron, Adelheid Duhm, Gertrud Dimler, Ian Mulvany, and Frank Holzwarth. And – last but not least – a big thank-you to Klaus Betzler.

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