

Preface

This book represents the second part of a planned three-volume monograph on Particle Penetration and Radiation Effects. The aim of the series is to introduce students, researchers, engineers and radiologists working with accelerators and their applications in research and technology to theoretical tools and to some important predictions and results.

Volume 1, which appeared in 2006¹ has the additional goal to introduce students of physics and related fields to general aspects of particle penetration. About half the chapters of Volume 1, based on lectures delivered at the University of Copenhagen and later at the University of Southern Denmark, served that purpose. Also the present volume contains introductory material of general interest, but here this division refers to individual chapters, and no attempt has been made to define a precise border line.

Originally, in the late 1970s, the book was intended to be an introduction to the theory of particle stopping. Progress on the project was slow at that time because of the author's involvement in numerous parts of an active field of research. This, in turn, implied the wish to cover a broader research area, hence the expansion into a three-volume series.

Throughout this process it has been my ambition that a reader working within accelerator-oriented physics, trying to find an answer to a specific question, should get help here, either in the form of a reader-friendly formula or computer program, perhaps an outline of a theory, reference to pertinent literature, and if nothing else, a note that information is missing to the author's knowledge. It is up to the reader to judge the degree to which this ambition has been fulfilled. I am of course aware of gaps. Most notably, readers in high-energy physics and high-energy accelerators may ask numerous questions which this book does not answer. Conversely, my ambition had the consequence that numerous research programs were initiated and completed on the way, with the result that finishing the first volume took several decades and the present volume took about seven years.

¹ P. Sigmund, Particle Penetration and Radiation Effects. General Aspects and Stopping of Swift Point Charges, Springer 2006; paperback edition, Springer 2007.

Volume 1 introduced general concepts of the theory of particle penetration, and specific applications dealt with swift point charges, i.e., protons, antiprotons and alpha particles. This restriction has been given up in the present volume, which addresses the penetration of heavier ions as well as molecules and clusters. Also the restriction to swift ions has been relaxed. Moreover, the reader will find theoretical descriptions of phenomena which were discussed only briefly in Volume 1, such as multiple scattering and nuclear stopping. Special attention has been given to the charge states of penetrating ions, a topic of central importance in electronic stopping of partially-stripped ions.

I do not expect the average reader to read this book from one end to the other. The chosen structure should allow you to pick a chapter and read it from the beginning to the end. However, in view of numerous references to Volume 1, my recommendation is to have easy access to that book.

Theoretical tools available in the field of particle penetration and radiation effects have been developed over about a century. Like in all fields of research, and almost all aspects of modern life, computers have come to play an ever increasing role. It is useful here to distinguish between computation and simulation. Theory and simulation usually start at some basic equations, but the difference lies in the use of mathematics, which is replaced by numerics in simulation. My personal experience with simulation is that of an interested spectator. Although I have written a couple of small simulation codes, I doubt whether I would be able to write a code of the type that occupies a large machine for hours, days or months, and convince myself that it produces acceptable results. Therefore, simulation codes, when mentioned at all, are characterized by the physics that enters, rather than computational techniques.

As indicated above, this book is a direct continuation of Volume 1. Only in rare cases did I repeat calculations and/or arguments from there. As in Volume 1, I have marked some parts with a star, indicating that those parts can be left out in a first reading. There are few of the kind, since I expect mostly readers with a clear definition of their interests and needs.

There are problems in the end of each chapter, but they are fewer in number than in Volume 1, and mostly of the type where a calculation sketched in the main text should be carried through explicitly.

A notorious problem in a field of research with roots a century ago is the list of literature references. The BibTeX database which I collected for use in this series of monographs has now come up to over 7000 items. Even though not all of those are relevant to the present volume, a tough selection had to be made to generate a meaningful bibliography. In general, the number of references has been kept low in topics that are treated in extenso, while those treated in a cursory manner are represented more generously in the bibliography. Other selection criteria are clarity and simplicity of the arguments. Although there are numerous references to papers with my name in the by-line, I like to emphasize that also those titles represent a selection. I mention this to make sure that if you find that a relevant paper of mine is not referred to, you should not automatically deduce that it is obsolete.

Unquestionably, numerous worthwhile contributions had to be left out. However, I tried to catch papers that initiated major developments. With this, modern biblio-

graphic tools should enable the interested reader to complete the list of references for most of the topics discussed here.

The table of contents of this volume shows all those items that I mentioned in the preface of Volume 1. However, when arriving at the chapter on Channeling, it occurred to me that my colleague Jens Ulrik Andersen at Aarhus University had contributed a chapter to my collection on ‘Ion Beam Science, Solved and Unsolved Problems’², which deserves to be more widely known and, coming from first-hand experience, is much more well-disposed and formulated than I would be able to do it. Even though that chapter has been written with a slightly different target group in mind, I am glad to include it in the present book with the kind permission of the author and the publisher.

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² J. U. Andersen, Mat. Fys. Medd. Dan. Vid. Selsk. 52, 655-698 (2006)

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