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Sune Svanberg

Atomic and Molecular Spectroscopy

Basic Aspects and Practical Applications

Fourth, Revised Edition
With 404 Figures and 14 Tables

Springer

Professor Sune Svanberg
Department of Physics
Lund Institute of Technology
P.O. Box 118
221 00 Lund
Sweden
E-mail: sune.svanberg@fysik.lth.se

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To Katarina, Emilie, Kristina,
my Mother
and the memory of my Father

Preface

The present book – *Atomic and Molecular Spectroscopy – Basic Aspects and Practical Applications* – has been developed over a long time. The Third Edition, which appeared in 2001, was fully revised and updated to the state of the field at that time. The book appeared in hard cover well suited for individual and library use. However, the book is basically a text, also well suited as a base for a course on the topic. A lower-cost paper-back edition better serves such purposes, as did the Second (paper-back) Edition of the book. The Fourth Edition presented has now been corrected for misprints and contains some additional text. A number of important literature references up untill mid-2003 have been added to provide a fully updated account of the dynamic field of Atomic and Molecular Spectroscopy.

Lund, October 2003 *Sune Svanberg*

Preface to the Third Edition

Atomic and molecular spectroscopy – both in its basic and in its applied aspects – is in a dynamic state of development. It continues to provide new fascinating possibilities for a deeper understanding of the fundamental properties of the building blocks of matter and their interaction with electromagnetic irradiation. It generates new possibilities for practical applications in industry, chemistry, astronomy, geosciences, biology, medicine and information technology.

Ten years after the appearance of the first edition there was a need for a thorough revision of the book, again bringing it up to the leading edge in the new millennium. This has led to a considerable extension of the material and thus of the size of the book. As previously, the focus has been on the physical understanding of the processes and phenomena, and on providing a broad overview of the possibilities of atomic and molecular spectroscopy. Thus, the mathematical description is frequently superficial – for the benefit of students and scientists in other natural sciences without a rigourous physics background. My belief is that the physical (and intuitive) understanding, when possible, is also the most important aspect for the hard-core physicist. The reader will find ample references to textbooks, review articles and research papers providing all the details on almost any topic in the field, and the reference list was, with considerable effort, updated till mid-2000 and in some cases till early 2001. This could still mean that important references are lacking, and I apologize to the authors for unfortunate omissions.

The reader who already knows the previous editions will notice that new material is added, particularly in the following fields: clusters, satellite remote sensing, astrophysical applications, the generation of ultrafast and ultraintense laser radiation, diode laser spectroscopy, ultrafast spectroscopy, femtochemistry, high-power laser–matter interaction, laser cooling and trapping, Bose–Einstein condensation, and lasers in environmental and medical research. Thus, it is felt that the book provides a rather extensive overview of the major spectroscopy fields.

In order to improve the usefulness of the book as a text for a course on the topic at the pre- or postgraduate level, a section of questions and exercises has been added. The material is presented following the chapters, and, in addition, material connecting wider areas is supplied. A detailed subject index

is also provided, helping the reader to easily find an entry to the introduction of a subfield and references to the relevant literature.

The author benefited a lot from the interaction with students and colleagues when developing this book. He is very grateful for comments and corrections.

Finally, I would like to thank Gertrud Dimler, Adelheid Duhm and Claus Ascheron at Springer-Verlag for their professional work, and Helmut Lotsch for his encouragement throughout this book project.

Lund, June 2001 *Sune Svanberg*

Preface to the First Edition

Atomic and molecular spectroscopy has provided basic information leading to the development of quantum mechanics and to the understanding of the building blocks of matter. It continues to provide further insight into the statics and dynamics of the microcosmos, and provides the means for testing new concepts and computational methods. The results of atomic and molecular spectroscopy are of great importance in astrophysics, plasma and laser physics. The rapidly growing field of spectroscopic applications has made considerable impact on many disciplines, including medicine, environmental protection, chemical processing and energy research. In particular, the techniques of electron and laser spectroscopy, the subjects of the 1981 Nobel prize in physics, have contributed much to the analytical potential of spectroscopy.

This textbook on *Atomic and Molecular Spectroscopy* has been prepared to provide an overview of modern spectroscopic methods. It is intended to serve as a text for a course on the subject for final-year undergraduate physics students or graduate students. It should also be useful for students of astrophysics and chemistry. The text has evolved from courses on atomic and molecular spectroscopy given by the author since 1975 at Chalmers University of Technology and at the Lund Institute of Technology. References are given to important books and review articles which allow more detailed studies of different aspects of atomic and molecular spectroscopy. No attempt has been made to cover all important references, nor have priority aspects been systematically considered.

It is assumed that the reader has a basic knowledge of quantum mechanics and atomic physics. However, the completion of a specialized course on atomic and molecular physics is not required. The present treatise (disregarding Chap. 4) is not particularly mathematical, but emphasizes the physical understanding of the different techniques of spectroscopy. In the course given by the author, the time for solving calculational problems has been reduced to allow a more complete overview of the field in the time available. Particular emphasis has been given to technical applications. However, by increasing the allotted problem-solving time or by omitting certain areas of spectroscopy, a more problem-oriented course can easily be taught based on this book. In his courses, the author has combined lectures with a number of 5-hour

laboratory experiments (performed on research equipment) and a number of 1-2 hour visits to local research groups in physics, chemistry and astronomy.

Part of the material is reworked from the Swedish textbook *Atomfysik* by I. Lindgren and S. Svanberg (Universitetsförlaget, Uppsala 1974). The author is very grateful to his teacher Prof. I. Lindgren for contributions and support through the years. He would also like to thank many colleagues, including Prof. D. Dravins, Dr. Å Hjalmarsson, Prof. I. Martinson, Prof. J. Nordgren, Prof. C. Nordling, Dr. W. Persson, Prof. A. Rósen, Prof. H. Siegbahn and Dr. C.-G. Wahlström for valuable suggestions and corrections.

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Lund, September 1990 *Sune Svanberg*

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