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Compiled by Virginia Greco, CERN

Modern Atomic Physics
By Vasant Natarajan
CRC Press

This book collates information from various literature to provide students with a unified guide to contemporary developments in atomic physics. In just 400 pages it largely succeeds in achieving this aim.

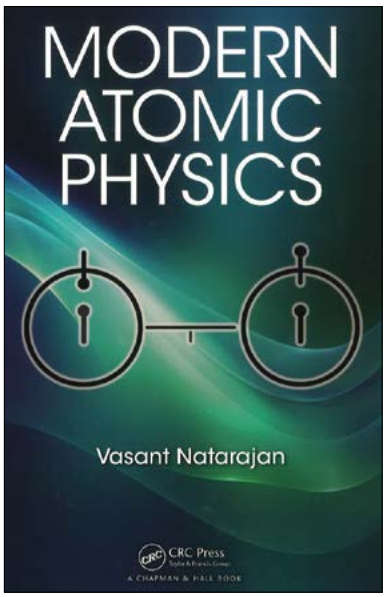
The author is a professor of physics at the Indian Institute of Science in Bangalore. His research focuses on laser cooling and trapping of atoms, quantum optics, optical tweezers, quantum computation in ion traps, and tests of time-reversal symmetry using laser-cooled atoms. He received a PhD from the Massachusetts Institute of Technology under the supervision of David Pritchard, a leader in modern atomic physics and a mentor of two researchers – Eric Cornell and Wolfgang Ketterle – who went on to become Nobel laureates.

The book addresses the basis of atomic physics and state-of-the-art topics. It explains material clearly, although the arrangement of information is quite different to classical atomic-physics textbooks. This is clearly motivated by the importance of certain topics in modern quantum-optics theory and experiments. The physics content is often accompanied by the history behind concepts and by explanations of why things are named the way they are. Historical notes and personal anecdotes give the book a very appealing flair.

Chapter one covers different measurement systems and their merits, followed by universal units and fundamental constants, with a detailed explanation of which constants are truly fundamental. The next chapter is devoted to preliminary materials, starting with the harmonic oscillator and moving to concepts – namely coherent and squeezed states – that are important in quantum optics but not explicitly covered in some other books in the field. The chapter ends with a section on radiation, even including a description of the Casimir effect.

Chapter three is called Atoms. Alongside classical content such as energy levels of one-electron atoms, interactions with magnetic and electric fields, and atoms in oscillating fields, this chapter explains dressed atoms and also, unfortunately only briefly, includes a description of the permanent atomic electric dipole moment (EDM).

The following chapter is devoted to nuclear effects, the isotope shift and hyperfine structure. At this point it would have been nice to see some mention of the flourishing field of laser spectroscopy of radioactive nuclei, which exploits the two above effects to investigate the ground-state properties of nuclei far from the valley of stability.



Chapter five is about resonance, which is often scattered around in other books about atomic physics. Here, interestingly, nuclear magnetic resonance (NMR) plays a central role, and the chapter connects this topic very naturally to atomic physics. The chapter closes with a description of the density matrix formalism. After this comes a chapter devoted to interactions, including the electric dipole approximation, selection rules, transition rates and spontaneous emission. The last section is concerned with differences in saturation intensities by broadband and monochromatic radiation.

Multiphoton interactions are the topic of chapter seven, which is clearly motivated by their importance in modern quantum-optics laboratories. Two-photon absorption and de-excitation, Raman processes and the dressed atom description are all explained. Another crucial concept in modern quantum optics is coherence. Thus it is included as a full chapter, which includes coherence in a single atom and in ensembles of atoms, as well as coherent control in multilevel atoms. Spin echo appears as well, showing again how close the topics presented in the book are to NMR.

Chapter nine is devoted to lineshapes, which is clearly a subject relevant for modern atomic spectroscopists. Spectroscopy is the next chapter, which starts with alkali atoms – used extensively in laser cooling and Bose–Einstein condensates. The rest of the material is aimed at experimentalists. Uniquely for such a book, it includes a description of the key experimental tools, followed by Doppler-free techniques and nonlinear magneto-optic rotation.

The last chapter covers cooling and trapping, with so many relevant concepts already presented in the preceding chapters. The content includes different cooling approaches, principles of atom and ion traps, the cryptic and equally common Zeeman slower, and even more intriguing optical tweezers.

Each chapter ends with a problems section, in which the problems are often relevant to a real quantum-optics lab, for example concerning quantum defects, RF-induced magnetic transitions, Raman scattering cross-sections, quantum beats or the Voigt line profile. The problems are worked out in detail, allowing readers to follow how to arrive at the solution.

The appendices cover the standards and the frequency comb, which is one of the ingenious devices to come from the laboratory of Nobel laureate Theodor Hänsch and which can be now found in an ever-growing number of laser-spectroscopy and quantum-optics labs. Two other appendices are very different: they have a philosophical flair and deal with the nature of the photon and with Einstein as nature's detective.

The presented theoretical basis leads to state-of-the art experiments, especially related to ion and atom cooling and to Bose–Einstein condensates. The selection of topics is thus clearly tailored for experimentalists working in a quantum optics lab. One small criticism is that it would be good to read more about the EDM experiments and laser spectroscopy of radioactive ions, which are currently two very active fields. Readers interested in different classic subjects, like atomic collisions, should turn to other books such as Bransden and Joachain's *Physics of Atoms and Molecules*.

The level of the book makes it suitable for undergraduate level, but also for new graduate students. It can also serve as a quick reference for researchers, especially concerning the topics of general interest: metrology, what is a photon or how a ▷

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frequency comb works, and how to achieve a Bose–Einstein condensate. Overall, the book is a very good guide to the topics relevant in modern atomic physics and its style makes it quite unique and personal.

● *Magdalena Kowalska, CERN.*

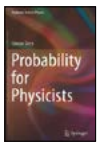
Books received

Probability for Physicists

By Simon Širca

Springer

Also available at the CERN bookshop



This book aims to deliver a concise, practical and intuitive introduction to probability and statistics for undergraduate and graduate students of physics and other natural sciences. The author attempts to provide a textbook in which mathematical complexity is reduced to a minimum, yet without sacrificing precision and clarity. To increase the appeal of the book for students, classic dice-throwing and coin-tossing examples are replaced or accompanied by real physics problems, all of which come with full solutions.

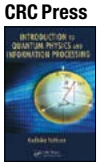
In the first part (chapters 1–6), the basics of probability and distributions are discussed. A second block of chapters is dedicated to statistics, specifically the determination of distribution parameters based on samples. More advanced topics follow, including Markov processes, the Monte Carlo method, stochastic population modelling, entropy and information.

The author also chooses to cover some subjects that, according to him, are disappearing from modern statistics courses. These include extreme-value distributions, the maximum-likelihood method and linear regressions using singular-value decomposition. A set of appendices concludes the volume.

Introduction to Quantum Physics and Information Processing

By Radhika Vathsan

CRC Press



An introduction to the novel and developing field of quantum information, this book aims to provide undergraduate and beginning graduate students with all of the basic concepts needed to understand more advanced books and current research publications in the field. No background in quantum physics is required because its essential principles are provided in the first part of the book.

After an introduction to the methods and notation of quantum mechanics, the authors explain a typical two-state system and how it is used to describe quantum information. The broader theoretical framework is also set out, starting with the rules of quantum mechanics and the language of algebra.

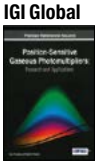
The book proceeds by showing how quantum properties are exploited to develop algorithms that prove more efficient in solving specific problems than their classical counterparts. Quantum computation, information content in qubits, cryptographic applications of quantum-information processing and quantum-error correction are some of the key topics covered in this book.

In addition to the many examples developed in the text, exercises are provided at the end of each chapter. References to more advanced material are also included.

Position-Sensitive Gaseous Photomultipliers: Research and Applications

By Tom Francke and Vladimir Peskov

IGI Global



Gaseous photomultipliers are gas-filled devices capable of detecting single photons (in the visible and UV spectrum) with a high position resolution. They are used in various research settings, in particular high-energy physics, and are among several types of contemporary single-photon detectors. This book provides a detailed comparison between photosensitive detectors based on different technologies, highlighting their advantages and disadvantages of them for diverse applications.

After describing the main principles underlying the conversion of photons to photoelectrons and the electron avalanche multiplication effect, the characteristics (and requirements) of position-sensitive gaseous photomultipliers are discussed. A long section of the book is then dedicated to describing and analysing the development of these detectors, which evolved from photomultipliers filled with photosensitive vapours to devices using liquid and then solid photocathodes. UV-sensitive photodetectors based on caesium iodide and caesium telluride, which are mainly used as Cherenkov-ring imaging detectors and are currently employed in the ALICE and COMPASS experiments at CERN, are presented in a dedicated chapter. The latest generation of gaseous photomultipliers, sensitive up to the visible region, are also discussed, as are alternative position-sensitive detectors.

The authors then focus on the Cherenkov light effect, its discovery and the way it has been used to identify particles. The introduction of ring imaging Cherenkov (RICH) detectors was a breakthrough and led to the application of these devices in various experiments, including the Cosmic AntiParticle Ring Imaging Cherenkov Experiment (CAPRICE) and the former CERN experiment Charge Parity violation at Low Energy Antiproton Ring (CP LEAR).

The latest generation of RICH detectors and applications of gaseous photomultipliers beyond RICH detectors are also discussed, completing the overview of the subject.

17 Big Bets for a Better World

By S Tackmann, K Kampmann and H Skovby (eds)

Forlaget Historika/Gad Publishers

This book, which includes a contribution by CERN Director-General Fabiola Gianotti, presents 17 radical and game-changing ideas to help reach the 2030 Global Goals for Sustainable Development identified by the United Nations General Assembly.

Renowned and influential leaders propose innovative solutions for 17 "big bets" that the human race must face in the coming years. These experts in the environment, finance, food security, education and other relevant disciplines share their vision of the future and suggest new paths towards sustainability.

In the book, Gianotti replies to this call and shares her ideas about the importance of basic science and research in science, technology, engineering and maths (STEM) to underpin innovation, sustainable development and the improvement of global living conditions. After giving examples of breakthrough innovations in technology and medicine that came about from the pursuit of knowledge for its own sake, Gianotti contends that we need science and scientifically aware citizens to be able to tackle pressing issues, including drastic reduction of poverty and hunger, and the provision of clean and affordable energy. Finally, she proposes a plan to secure STEM education and funding for basic scientific research.

Published as part of the broader Big Bet Initiative to engage stakeholders around new and innovative ideas for global development, this book provides fresh points of view and credible solutions. It would appeal to readers who are interested in innovation and sustainability, as well as in the role of science in such a framework.

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Atomic weight
Density
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Melting point (Solids & **Liquids**) • Boiling point (Gases)

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Hydrogen 1 H 1.0079 0.090 -252.87																	Helium 2 He 4.0026 0.177 -268.93
Lithium 3 Li 6.941 0.54 180.5	Beryllium 4 Be 9.0122 1.85 1287											Boron 5 B 10.811 2.46 2076	Carbon 6 C 12.011 2.27 3500	Nitrogen 7 N 14.007 1.251 -195.79	Oxygen 8 O 15.999 1.429 -182.95	Fluorine 9 F 18.998 1.696 -188.12	Neon 10 Ne 20.180 0.900 -246.08
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Potassium 19 K 39.098 0.86 63.4	Calcium 20 Ca 40.078 1.55 842	Scandium 21 Sc 44.956 2.99 1541	Titanium 22 Ti 47.867 4.51 1668	Vanadium 23 V 50.942 6.11 1910	Chromium 24 Cr 51.996 7.14 1907	Manganese 25 Mn 54.938 7.47 1246	Iron 26 Fe 55.845 7.87 1538	Cobalt 27 Co 58.933 8.90 1495	Nickel 28 Ni 58.693 8.91 1455	Copper 29 Cu 63.546 8.92 1084.6	Zinc 30 Zn 65.39 7.14 419.5	Gallium 31 Ga 69.723 5.90 29.8	Germanium 32 Ge 72.64 5.32 938.3	Arsenic 33 As 74.922 5.73 816.9	Selenium 34 Se 78.96 4.82 221	Bromine 35 Br 79.904 3.12 -7.3	Krypton 36 Kr 83.80 3.733 -153.22
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Francium 87 Fr [223] – –	Radium 88 Ra [226] 5.0 700	Lawrencium 103 Lr [262] – 1627	Rutherfordium 104 Rf [265] – –	Dubnium 105 Db [268] – –	Seaborgium 106 Sg [271] – –	Bohrium 107 Bh [272] – –	Hassium 108 Hs [270] – –	Meitnerium 109 Mt [276] – –	Darmstadtium 110 Ds [281] – –	Roentgenium 111 Rg [280] – –	Copernicium 112 Cn [285] – –	Ununtrium 113 Uut [284] – –	Flerovium 114 Fl [289] – –	Ununpentium 115 Uup [288] – –	Livermorium 116 Lv [293] – –	Ununseptium 117 Uus [294] – –	Ununoctium 118 Uuo [294] – –

57-70 *
89-102 **

*Lanthanoids	Lanthanum 57 La 138.91 6.146 920	Cerium 58 Ce 140.12 6.689 795	Praseodymium 59 Pr 140.91 6.64 935	Neodymium 60 Nd 144.24 6.80 1024	Promethium 61 Pm [145] 7.264 1100	Samarium 62 Sm 150.36 7.353 1072	Europium 63 Eu 151.96 5.244 826	Gadolinium 64 Gd 157.25 7.901 1312	Terbium 65 Tb 158.93 8.219 1356	Dysprosium 66 Dy 162.50 8.551 1407	Holmium 67 Ho 164.93 8.795 1461	Erbium 68 Er 167.26 9.066 1529	Thulium 69 Tm 168.93 9.321 1545	Ytterbium 70 Yb 173.04 6.57 824
**Actinoids	Actinium 89 Ac [227] 10.07 1050	Thorium 90 Th 232.04 11.72 1750	Protactinium 91 Pa 231.04 15.37 1568	Uranium 92 U 238.03 19.05 1132	Neptunium 93 Np [237] 20.45 637	Plutonium 94 Pu [244] 19.816 639	Americium 95 Am [243] 13.78 1176	Curium 96 Cm [247] 13.51 1340	Berkelium 97 Bk [247] 14.78 986	Californium 98 Cf [251] 15.1 900	Einsteinium 99 Es [252] 13.50 860	Fermium 100 Fm [257] – 1527	Mendelevium 101 Md [258] – 827	Nobelium 102 No [259] – 827

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