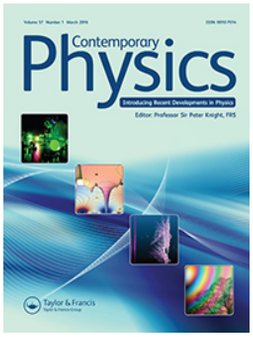

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An introduction to quantum physics: a first course for physicists, chemists, materials scientists, and engineers

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BOOK REVIEW

An introduction to quantum physics: a first course for physicists, chemists, materials scientists, and engineers, by Stefanos Trachanas, translated and edited by Manolis Antonoyiannakis and Leonidas Tsetseris, Weinheim, Germany, Wiley-VCH Verlag, 2018, 568 pp., £75.00 (paperback), ISBN 978527412471. Scope: textbook. Level: undergraduate.

The intriguing nature of quantum mechanics coupled with its pervasive and growing impact on modern technology has generated a large number of intermediate level textbooks for undergraduates. Often, the subject is categorised as being inherently non-intuitive and consequently, textbook authors frequently adopt a strong calculational approach – the main emphasis being placed on developing the skill set to solve a variety of standard problems. This English version of a popular Greek textbook by Stefanos Trachanas, recently translated and edited by Manolis Antonoyiannakis and Leonidas Tsetseris, takes a very different approach emphasising physical reasoning. Readers are encouraged to develop a 'quantum intuition', based on recurrent applications of the key ideas of quantum physics: the particle-wave duality, that confinement leads to discrete energy levels and the uncertainty principle associated with non-commuting variables.

The book is divided into three sections. The first develops the core concepts of a quantum wave, provides a heuristic justification of the Schrödinger equation and emphasises the consequences of non-commuting variables. A second section is devoted to a streamlined discussion of several classic problems in an intermediate quantum mechanics course, potential wells and barriers, the harmonic oscillator, angular momentum, the hydrogen atom, spin and the Pauli Exclusion Principle. A lengthy final section explores the quantum description of matter in much greater detail that would be typically treated in an undergraduate quantum mechanics course for physicists but might be found in a first quantum course for chemists or material scientists. Multi-electron atoms, the elementary chemical bonds, and the notions of hybridisation and delocalisation with a focus on carbon compounds are covered in the first three chapters. This leads naturally to a first-order description of crystalline materials, energy bands, crystal momentum, and the concept of Fermi levels. A wide-ranging final chapter provides an introduction to the interaction of radiation with matter, Fermi's golden rule, lasers and an elementary description of polarised photons. The text is enhanced by close to 200 line drawn figures to help the reader visualise key concepts.

Throughout the book, the reader is often urged to make use of dimensional analysis and carry out order of magnitude estimates, an effective means to direct the reader's attention to key relationships. To aid in this endeavour, Professor Trachanas has somewhat controversially opted for the elegance and simplicity of the electrostatic cgs system of units, going against the increasing trend to uniformly present undergraduate physics using SI units. While some may dislike this choice, the encouragement to develop a taste for making quick meaningful 'back of the envelope' calculations is arguably just as important to a working physicist as is mathematic prowess.

Often, even the mathematics is physically motivated. One prominent example is the extended solution to the hydrogen atom as the main paradigm of a central potential. The solution of the radial component of the associated Schrödinger equation is the best-motivated discussion that I have encountered on a topic that students often have difficulty following. The treatment of the hydrogen atom ends with the observation that in general ground states are non-degenerate and reflect the overall symmetry of the physical problem, a valuable insight not often encountered in textbooks at this level.

While most of the core topics are treated with care, rigour and insight, many will notice the absence of some topics that are traditionally included in an intermediate quantum mechanics course for physicists. Missing from the printed text is the use of Dirac notation, an algebraic treatment of angular momentum and operator methods in general, a systematic development of perturbation theory, quantum scattering in three dimensions or an introduction to the key ideas of entanglement and quantum information. A clear choice was made to appeal to a broader audience by favouring applications of quantum theory in chemistry and materials science while sacrificing more formal topics that some will view as essential to build a strong theoretical foundation.

An especially contemporary enhancement to the text is the extensive support provided on an accompanying website where readers can test their understanding by responding to multiple choice quizzes (one for each chapter) or access material on an impressive number of additional topics. These tutorial sections are primarily presented in the form of challenge questions followed by solutions. This in part mitigates the omission of some of the topics previously listed. These include tutorials on probability currents, Erhenfest's theorem, creation and annihilation operators applied to the harmonic oscillator, conservation of angular momentum in central potentials and second-order non-degenerate time-independent perturbation theory. A striking omission is the inclusion of topics associated with the fast developing

and increasingly important field of quantum information, but perhaps these will be added to the website in the future.

In summary, this fresh alternative to the standard intermediate quantum textbooks distinguishes itself from a crowded field by focusing on core quantum concepts to develop physical intuition and explain a wide range of physical phenomena concentrating on aspects associated with the structure of matter. Repeated challenges to carryout order of magnitude estimates and a well-executed accompanying website are other positive aspects that differentiate *An Introduction to Quantum Physics* from the many other textbooks on offer.

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