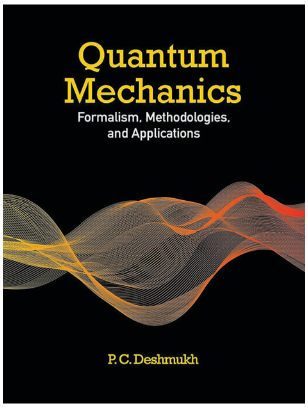

Quantum Mechanics: Formalism, Methodologies, and Applications. P. C. Deshmukh. Cambridge University Press, Cambridge, United Kingdom. 2024. 500 pages. Price: Rs 1250.

How does one teach a course on quantum mechanics to graduate students? This is a question that is faced both by instructors and by authors of a textbook on the subject. Should one take a historical approach describing experiments that show failure of classical theory and then give the development of quantum mechanics, introducing quantum ideas one by one, culminating in full development of wave mechanics and its applications? Many widely used books follow this route. A different way to present the subject is to introduce it as a full-fledged theory at the outset and contrast it with classical theory in their ways of describing nature, somewhat like the initial Einsteinian approach where the energy of a system is taken to be quantized right from the beginning. The book under review by P. C. Deshmukh is a welcome attempt to discuss quantum mechanics from this perspective. From among modern books on quantum mechanics, the present book, therefore, takes an approach similar to Sakurai's book and follows a similar sequence of topics. However, it has many more topics than the latter book, which makes it more contemporary. In addition to the detailed discussion on a topic, each chapter has at its end a collection of solved problems and exercises to be completed by students. Furthermore, within each chapter, there are questions in the form of 'funquest'. These help students get feedback on their understanding as they go through the book. In writing the book, the author has made a highly praiseworthy effort to comprehensively describe the formalism of quantum mechanics and its applications to a wide range of phenomena. Especially noted is the inclusion of a chapter on quantum information and quantum computing since this is fast becoming an important topic of interdisciplinary interest. The book is intended for graduate students and, as such, starts at an advanced level.

A novel idea of the author is to introduce the path-integral formulation of non-relativistic quantum mechanics in chapter 2. The chapter concludes with the path-integral analysis of geometric phases, which is indeed useful. Another topic that the author has explained in detail is the degeneracy of bound states in hydrogen atoms (chapter 5); discussed in an equally detailed manner are the states in the continuum. I have not seen such descriptions in a majority of books on the subject and found these to be useful. Chapter 7 presents the solution of Dirac equation for hydrogen atom, which will prove useful to readers. I like the detailed introduction to oscillator strength using classical physics and related sum rules in chapter 8. In chapter 9, the author discusses the idea of a self-consistent field, the Hartree–Fock method, and Koopmans' theorem. The chapter ends with a discussion of the local-density approximation. It is indeed a good idea to introduce readers to the first attempts towards solving the many-electron Schrödinger equation and the related simplification.

Having highlighted the width of the topics and their timeliness in a contemporary book, I now give my critical observations on some aspects of the book.

Starting with chapter 1, I have a general observation about the presentation style of the book. First, it is proposed that Planck's constant be referred to as Planck–Einstein–Bose (PEB) constant. While the spirit behind such a proposition is fine, introducing such a new name takes the focus away from the main purpose of the book and may raise an unnecessary issue, somewhat like the factor of 2 controversy in connection with Bose's derivation of the energy distribution formula for photons. On a more serious note, section 1.2 begins with the statement that uncertainty means that representing the state of a system by a point in phase space is intrinsically flawed and then suddenly, the idea of representing the state by a vector in Hilbert space is introduced without any basis. The reader is lost, looking for connections and explanations.

A further observation is that adjectives such as 'shocking', 'remarkable', 'bizarre', 'mind-boggling', etc. are used too often in the presentation. Use of such adjectives tends to distance the reader from the content. For example, in chapter 1, the results of Stern-Gerlach (SG) experiments are presented by stating that they will shock the reader. In contrast, historically, the experiment was carried out to confirm space-quantization, and a congratulatory note was sent to Bohr by the experimenters stating that his proposal for space-quantization was confirmed. In this connection, the statement that in the SG experiment, atoms passing through the SG apparatus, will be expected to have no deviation is incorrect. As expected from the Bohr model with quantized angular momentum, an atom with zero charge would still have a magnetic dipole moment and therefore experience a force in a varying magnetic field (this is precisely what Stern and Gerlach were looking for). Finally, while describing the SG experiment, the author also had an opportunity to analyse the results using electron spin and discuss what happens when the basis is changed. It is important because of the use of electron spin as a qubit in quantum information, which the book discusses in a later chapter.

If students follow this book, chapter 2 is probably the first instance that majority of graduate students will get exposure to path-integral formulation. In this regard, a review of the action principle for both light and material particles and its connection with Huygens' theory for light and Schrödinger's interpretation of wave mechanics at the beginning of the chapter would have been useful for the readers. Instead, it is discussed later in the context of WKB approximation. Since the book also often connects with the Hamilton–Jacobi theory, discussing how Schrödinger introduced the eponymous equation in his first paper on wave mechanics would have formed a nice section of the chapter. Following this, starting with presentation of ideas in a manner similar to Feynman's article in Reviews of Modern Physics (1948) on the subject would have made students understand the formulation better. Finally, I wish the final section was called 'Geometric phase and Aharonov–Bohm effect and its analysis using path-integral formulation' and then divided into two subsections – one describing the phenomena and the second one the analysis.

I had a difficult time following the contents of chapter 3, and therefore, my most critical observations are on this chapter. It is titled 'Probability tangles and eigenstates of one-dimensional potentials'. I could not understand why the word 'tangles' is used in connection with probability interpretation.

Going into the chapter, it would have been only proper to explicitly write the probability density in terms of the wave function and then connect it with the probability current density. Further down, these concepts are discussed in the context of a double slit experiment and then the new idea of measurement destroying interference and that of a quantum eraser is introduced. The chapter further describes one-dimensional problems and phenomena of tunnelling and bound states in these systems. In discussing the bound states, statements about the coefficients F and G in connection with equations 3.42a, 3.42b and 3.42c being zero are not correct. First the solutions in the classically forbidden regions do not represent a travelling wave since a travelling wave must depend on x and t as a function of $(kx - \omega t)$ or some other form of such combination of x and t. Secondly, these coefficients are set to zero to satisfy the boundary conditions at $x = \pm\infty$ that the wavefunction vanish there. Similarly, while discussing quantum dots, optical properties are explained in terms of excitonic effects. This explanation is not correct. The energy gap between the electron and hole states in a quantum dot increases in inverse proportion to the square of its radius, and that explains the colour of these dots; excitonic effects are neglected in the zeroth level approximation (an interesting reference for these is the material available on the Nobel Prize website). Finally, Lambert's solution for the square well problem using conformal mapping is presented in the last section. It shows the power of using different mathematical techniques to get an exact solution. Interested readers will be attracted to this solution.

On a separate account, inclusion of computational methods for solving the Schrödinger equation in chapter 3 would prove useful to readers. Computational methods have become an integral part of any application of quantum mechanics, and their introduction at the beginning would make the readers of the book more proficient in problem-solving.

Chapter 4 introduces the angular momentum operator as the generator of rotations. However, the discussion is at times confusing. Terms up to second order in the infinitesimal angle are kept in equations 4.11a, 4.11b and 4.11c, probably to show that finite rotations about different axes do not commute. However, one has grown up learning that finite rotations about mutually perpendicular axes do not commute, but infinitesimal rotations do. So, the statement to the contrary after equation 4.12 is a little confusing. Further into the discussion of angular momentum, on page 153, the spin angular momentum is talked about. Like at many other places in the book, too many connections are being made here between different theories and a reader tends to get defocused.

Since this is a graduate-level text, chapter 9 would have been even more useful if a thorough discussion of exchange effects, connection of exchange with Hund's rules and some introduction to correlation effects were also given. Furthermore, instead of just discussing the local density approximation, an introduction to density-functional theory would have proved to be very helpful to the readers for whom the book is intended. Similarly, in chapter 10 some more insights could have been provided by discussing polarization of light and its connection with qubits. Also, a section on quantum cryptography would have been useful.

To summarize, the book is a nice attempt to present quantum mechanics in a different way and by incorporating some new topics of interest. It also gives ample details on many important topics. However, in the author's effort to do so, the book sometimes tends to become too verbose, and in trying to connect too many ideas in one place, in many instances, it makes the reader lose focus on the main topic. I would, therefore, hesitate in using it as the main text-book for an advanced course in quantum mechanics but will definitely recommend it strongly as a reference book for its width of content and inclusion of many important topics.

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Annual Review of Cell and Developmental Biology, 2023. Ruth Lehmann, Jennifer Lippincott-Schwartz and Alexander F. Schier (eds). Annual Reviews, 1875 S. Grant Street, Suite 700, San Mateo, El Camino Way, California 94402, USA. Vol. 39. xi + 437 pages. Price: US$ 511.

The editorial by Ruth Lehmann in this Annual Review would make it interesting for researchers who keep in touch with literature via the internet and are habituated to looking at PDFs rather than in the hard copy of the journal. Lehmann reminisces how early on, researchers began their scientific career by keeping in touch with literature via current contents. Lehmann discusses at length the cost of publication, peer review and open access. The editorial would interest early career researchers who are confounded by open access, preprints, predatory journals, impact factors, H-index and increasing use of machine learning.

There are 17 reviews in this volume. They cover a wide spectrum of cell and developmental biology, highlighting the importance of model systems and state-of-the-art techniques. From the reviews, it is evident that structures obtained from cryo-electron microscopy (cryo-EM) and fluorescence microscopy are increasingly used in cell and developmental biology. Quantitative analysis of experimental data and theoretical analysis are being increasingly used. Although the editors have not commissioned the reviews based on specific themes, I have grouped them where there could be some connectivity in terms of techniques or approach.

Two reviews discuss patterning. Toll is well known to those working in immunology for its role in host defense against pathogens. However, its role in development was discovered much earlier. 'Neofunctionalization of Toll signaling in insects: from immunity to dorsoventral patterning' by Roth details the crucial role played by Toll signalling in dorsoventral axis formation patterning in *Drosophila* and other insects. Roth mentions that Toll signalling strongly supports the analysis of the emergence of an evolutionary novelty. Milinkovitch *et al.* in 'The unreasonable effectiveness of reaction diffusion (RD) in vertebrate skin color patterning', describe a theoretical approach involving the reaction–diffusion framework developed by Alan Turing to skin colour patterning. The introductory section describes Turing's contributions to computer science and the objectives of the review that should help readers not familiar with the methodology to appreciate the approach. They discuss the theoretical framework, taking zebra and lizards as examples. The conclusion section links the experimental observations with the RD mathematical framework.

Two reviews broadly relate to evolutionary aspects wherein genetic programming occurs due to environmental factors. The review by Perera *et al.* discusses how various organ systems in animals evolve