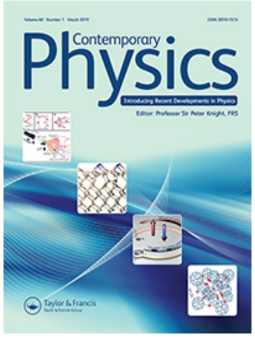

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The semiclassical way to dynamics and spectroscopy

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brackets, canonical transformations, Hamilton-Jacoby theory, Liouville formulation, and briefly introduces the so called Kolmogorov, Arnold and Moser (KAM) theory as well as chaos. Part IV contains an introduction to classical field theory and to path-integrals as well. Parts V and VI contain short reviews of the mathematics required throughout the chapters as vector calculus, differential equations, linear algebra and differential geometry. Part VII is the shortest, this includes some questions suggested as prototypical to prepare exams in order to evaluate learning in consistency with the aims of the book. A series of appendices offer detailed material that, although necessary to cover the topics developed in chapters, can be overpassed in a first reading. They include Noether's theorem, action principle, Nambu brackets and action-angle variables, among other. A final appendix contains the biographies of mathematicians and physicists who contributed in relevant form to the construction of the theory. The book ends with a short bibliography and an index that facilitates the looking for specific voices.

The manuscript is well written, the different notions and definitions are introduced in clear form, with an evident effort to teach didactically. In general, I agree with the attempts of the author to innovate the material that is commonly included in the textbooks on the subject. For instance, the book includes the application of the Gibbs-Appell equations to handle constraints (Chapter 13), the Koopman von-Neumann theory as an alternative to the Liouville formulation of probability density (Chapter 20), and the KAM theory to study perturbations in phase-space (Chapter 24). However, I disagree with the title of Chapter 5: 'Wave Mechanics & Elements of Mathematical Physics'. Although it contains the analysis of the wave-equation and its connection with the Helmholtz, Laplace, Bessel and Legendre equations, the expression 'wave mechanics' is not appropriate in this case because it misleads the material discussed in the chapter. I mean, the name *wave-mechanics* was coined by Schrödinger to distinguish his formulation of quantum mechanics from that of Heisenberg (nowadays called *matrix-mechanics*). Such expression is unambiguously used to refer the mathematical structure that sustains the notion of wave-function in quantum mechanics since the times of Heisenberg and Schrödinger, and would produce confusion in the non-specialised readers of the book.

In summary, my opinion is that the book *Lagrangian and Hamiltonian Dynamics* is appropriate for students that face for the first time the intricacies of analytical mechanics. It may also be used either as the companion to study books with higher technical profiles or to revisit specific subjects.

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The semiclassical way to dynamics and spectroscopy, by Eric J. Heller, Princeton, NJ, Princeton University Press, 2018, 472 pp., £77.00 (hardback), ISBN: 9780691163734. Scope: monograph. Level: postgraduate, early career researcher, researcher, scientist.

Classical mechanics constitutes the foundation of numerous scientific disciplines, and quantum mechanics is not an exception. As is well-known, various concepts in quantum mechanics are deeply rooted in classical physics. Beyond the traditional description of physical systems by using classical mechanics or quantum mechanics, there is a third alternative way. A rich collection of methods, called semiclassical, which are fundamentally based on classical mechanics have been developed to describe many aspects of quantum mechanics. With their help, we can obtain new insights and alternative ways to compute the dynamics of quantum systems and their applications to spectroscopy, among others. In the past few years, much progress has been made in the development of these methods, showing the potentialities for computing some quantum properties.

The present book *The Semiclassical Way to Dynamics and Spectroscopy* attempts to introduce the field by exploring different aspects of the semiclassical approach to quantum mechanics and showing many examples of applications. The author is a well-known and leading researcher in the area, professor of chemistry and professor of physics at Harvard University and a member of the US National Academy of Sciences. As he mentions, the book was written as an extension and complement of a previous book by David J. Tannor, *Introduction to Quantum Mechanics: A Time-Dependent Perspective* (University Science Books, 2007).

As pointed out in the introduction of the text, this is not exactly a textbook nor a monograph. Rather, it presents a rich collection of subjects aiming at showing the reader the key ideas and recent developments in semiclassical methods with the goal to provide a general overview of the field. It deserves to stand out its originality and breadth of contents.

The author has organised the contents into four main parts, containing twenty-six chapters and two brief mathematical appendixes. The first part is fully devoted to classical mechanics and contains four chapters that offer an excellent synthesis of the key foundations of classical mechanics necessary for an appropriate understanding of the semiclassical approach. An excellent synthesis as well on what is known as Hamiltonian chaos. The largest part of the book is the second part that includes eleven chapters on different methods of quantum and semiclassical mechanics. Topics such as time-dependent quantum mechanics, the Feynman path integral, WKB methods and tunnelling are extensively described. A third part deals with applications, comprising five chapters, where mainly the Born-Oppenheimer approximation and time-dependent formulations of molecular spectroscopy are discussed. The fourth part with six chapters is entirely dedicated to chaos and quantum mechanics.

Special interest is devoted to the discussion of quantum manifestations of classically chaotic systems, quantum scars, random waves, and branched flow. Finally, a careful and personal selection of references with useful comments is provided besides a more complete bibliography.

In summary, I can highlight a comprehensive presentation of important techniques to understand the semiclassical approach to quantum mechanics. Furthermore, the numerous applications in physics and chemistry, many beautiful illustrations of phase-space methods and different computer simulations that contribute to visualise some abstract concepts and ideas. Some interesting new aspects of modern dynamics such as branched flow and quantum scarring, related to the quantum mechanics of classically chaotic systems are neatly described.

I believe the text can become a key reference for acquiring an excellent picture of semiclassical methods in quantum mechanics. Some prerequisites of advanced mathematics, classical mechanics, quantum mechanics, and chemistry are required for a better understanding of the contents of the book. Evidently, there are chapters that are more technical than others, and some of them present new useful ideas for further research in the subject. Furthermore, some parts are possible to be read independently of others. From this perspective, the book can be of interest to a wide audience, ranging from postgraduates and researchers in physics and chemistry to scientists interested in the deep insights offered by the semiclassical methods connecting classical mechanics and quantum mechanics, including an excellent synthesis of classical mechanics and a careful discussion of quantum chaology.

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Review of application-driven quantum and statistical physics, vol. 1: foundations, by J. M. Gillet, Hackensack, NJ, World Scientific, 2018, $98 (hardback)/$45 (softback), ISBN: 9781786345547. Scope: textbook. Level: undergraduate.

The story of modern physics is full of curious characters, quirky savants, intellectual heroes, and even a few villains. Paul Dirac hated public attention so much that he toyed with refusing the Nobel Prize until he decided that would simply draw more attention. Werner Heisenberg was criticised at his PhD thesis defense for his 'bottomless ignorance' of experiments. The 'necessary fuel' for Erwin Schrödinger's scientific inspiration was 'romantic intercourses'. Max Planck's son was executed for plotting against Hitler. In contrast, Philipp von Lenard prized a letter he received from Hitler recognising his promotion of 'Aryan science'. Such fascinating historical tidbits and other features that pepper the text make *Application-Driven Quantum and Statistical Physics, Vol. 1: Foundations* an interesting and unconventional textbook.

This first volume of an envisioned trilogy is aimed at science and engineering students with a strong background in math and physics. It details the experimental and theoretical developments of the late nineteenth century necessitating a new 'modern' approach to physics, and introduces the basic form that new approach took. In broad terms, that outline could describe many modern physics texts. But several features make this book unusual. The first is the historical content already cited. Physics students are often familiar with stories of the founders of quantum physics, but treatments aimed at engineers tend to stick to the technical facts. I expect many engineering students will find the biographical data every bit as entertaining as physics students do. Second, the practical importance of quantum physics is demonstrated by the inclusion of numerous summary discussions of technological applications. For example, the solution of Schrödinger's equation for a one dimensional potential well is used to explain the phenomenon of thermoluminescence and its use by archeologists to date ancient pottery. Each chapter of the book begins with a box advertising the applications a student will be able to understand upon completion of the chapter providing motivation to slog through the heavy math. A third unusual feature of this book is a detailed solution immediately following each in-text exercise. Each such problem is used to advance the discussion, and the question-and-answer format encourages the student to wrestle with the ideas personally rather than simply reading passively.

In selecting this book as the primary text for a course, I would take seriously the author's mention in the preface that his students ' . . . had to study hard to keep up with our high expectations in the basic sciences'. The brevity of this book would necessitate a strong set of accompanying lectures. On the other hand, this short book would easily make a helpful secondary text allowing an instructor to touch on some nontraditional topics such as least action principles and path integrals. The one area in which this book could be improved is the sometimes clumsy English translation from the original French. Nonetheless, I eagerly look forward to reading the next two volumes in the series.

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