The Quantum Mechanics Solver: How to Apply Quantum Theory to Modern Physics, 2nd edition

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Book review

Once Upon Einstein
Thibault Damour, Eric Novak (translator)
2006 A K Peters Ltd
199pp $24.95, £16.95 (paperback)
ISBN: 978-1-56881-289-2

Thibault Damour is a theoretical physicist, and a member of the French Academy of Sciences. This book is the translation, by Eric Novak, of the original French *Si Einstein m'etait conté* (Le Cherche Midi, 2005). It is neither a book of theoretical physics nor a biography of Einstein. It is not a book of history nor philosophy of science. In Damour's words it was written to encourage the reader to share with Einstein 'those times when he understood some part of the hidden order of the universe'. It is a relatively short book, written in a very fluent style, but it deals with all the major problems and achievements of Einstein's works.

Starting from special relativity, it continues with general relativity, quantum theories, unified field theory and a brief overview of the actual research related to Einstein's legacy. It is essentially a popular science book with some related exploration in history and philosophy to interpret physical theories. The most important problem discussed by Damour is the nature of time. On this subject, there is a very interesting short paragraph (pp 33–35) dedicated to the reception of the relativity idea by the great writer Marcel Proust and its counterpart within *À la Recherche du Temps Perdu*. A correct discussion of the implications of a relativistic time should imply the distinction of the different possible interpretations of this concept. Damour seems to conclude that only one interpretation is possible: 'time does not exist', flowing of time is an illusion. One has to know that Einstein's ideas on time were related to Spinoza's perspective of a knowledge *sub specie aeternitatis*. However, other interpretations are possible and are related to the idea of time as an actuality. Damour speaks about the controversy between Einstein and Bergson, but Bergson is considered as a philosopher who did not understand relativity.

This philosophical problem of relativistic time is indeed related to a historical problem briefly discussed by Damour (pp 17–21, 48–52 and related endnotes): had Henri Poincaré constructed a special relativistic dynamics before Einstein? There is a long debate on this subject in the literature. Damour's answer is negative and his conclusions seem related to the conservation of a myth of Einstein, that is, the rise of special relativity is considered as a *creatio ex nihilo* within Einstein's mind and Einstein is considered as the only genius able to conceive the relativity of time. Poincaré's texts are undervalued and misunderstood by Damour's cutting quotations from their context. Damour never quotes *La Science et l'Hypothèse* (1902): we know it was read by Einstein and here Poincaré first (within chapters already published as separate papers in 1900) stated the relativity of time and of simultaneity. Damour never quotes Poincaré's paper published on 5 June 1905, La dynamique de l'èlectron, which presents the first relativistic dynamics, invariant by Lorentz transformations. Poincaré's (July 1905) introduction of a quadrimensional space-time is considered by Damour only a mathematical artifice (p 51) and Damour never said that Minkowski took this idea from Poincaré! Poincaré's interpretation of relativistic time implies that it is not an illusion but a complex net of different real flows related to different processes.

Poincaré and Einstein had different conceptions of Nature at the root of special relativity: respectively an electromagnetic conception (Poincaré) and a semi-mechanist one (Einstein). Thus, the (philosophical) meaning of relativity can be very different from the one presented by Damour. Furthermore, Damour accepts Kantian philosophy as a key to understanding relativity and quantum theories. This perspective seems to me very anachronistic and based on a misunderstanding: an interpretation of 20th century physical theories (relativity and quantum physics) is given within the framework of an 18th century philosophical perspective, created to give a foundation to Newton's theory. Relativity and quantum physics imply a breakdown of Kantian philosophy (see, for instance, G Bachelard's *La Philosophie du Non*). Relativity of space and time was considered possible only by overcoming the epistemological obstacle of Kantian idealistic foundation of Euclidean geometry and of Newton's absolute space and time. Relativity and quantum theories turn up not only the hierarchy between mathematics and physics, but also between epistemology (and logic) and physics: quantum physics implies not only a new conception of an indeterminate and unpredictable Nature, but a quantum logic too, that is, it implies a change in our way of thinking and knowing. When will the revolutionary impact of 20th century physics be reduced (by physicists themselves) to an already given philosophical framework?

E Giannetto
Dipartimento di Fisica 'A Volta', via A Bassi 6, I-27100 Pavia, Italy

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The Quantum Mechanics Solver: How to Apply Quantum Theory to Modern Physics, edition 2nd
Jean-Loius Basdevant and Jean Dalibard
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292pp EUR49.95 (hardback)
ISBN 978-3-540-27721-7

The hallmark of a good book of problems is that it allows you to become acquainted with an unfamiliar topic quickly and efficiently. *The Quantum Mechanics Solver* fits this description admirably. The book contains 27 problems based mainly on recent experimental developments, including neutrino oscillations, tests of Bell's inequality, Bose–Einstein condensates, and laser cooling and trapping of atoms, to name a few. Unlike many collections, in which problems are designed around a particular mathematical method, here each problem is devoted to a small group of phenomena or experiments. Most problems contain experimental data from the literature, and readers are asked to estimate parameters from the data, or compare theory to experiment, or both. Standard techniques (e.g., degenerate perturbation theory, addition of angular momentum, asymptotics of special functions) are introduced only as they are needed. The style is closer to a non-specialist seminar rather than an undergraduate lecture. The physical models are kept simple; the emphasis is on cultivating conceptual and qualitative understanding (although in many of the problems, the simple models fit the data quite well). Some less familiar theoretical techniques are introduced, e.g. a variational method for lower (not upper) bounds on ground-state energies for many-body systems with two-body interactions, which is then used to derive a surprisingly accurate relation between baryon and meson masses. The exposition is succinct but clear; the solutions can be read as worked examples if you don't want to do the problems yourself. Many problems have additional discussion on limitations and extensions of the theory, or further applications outside physics (e.g., the accuracy of GPS positioning in connection with atomic clocks; proton and ion tumor therapies in connection with the Bethe–Bloch formula for charged particles in solids). The problems use mainly non-relativistic quantum mechanics and are organised into three sections: Elementary Particles, Nuclei and Atoms; Quantum Entanglement and Measurement; and Complex Systems. The coverage is not comprehensive; there is little on scattering theory, for example, and some areas of recent interest, such as topological aspects of quantum mechanics and semiclassics, are not included. The problems are based on examination questions given at the École Polytechnique in the last 15 years. The book is accessible to undergraduates, but working physicists should find it a delight.

J M Robbins
School of Mathematics, University Walk, Bristol, BS8 1TW, UK

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Chaos: A Very Short Introduction
Leonard Smith
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180pp £6.99 (paperback)
ISBN 978-0-19-285-378-3

This book is a new volume of a series designed to introduce the curious reader to anything from ancient Egypt and Indian philosophy to conceptual art and cosmology. Very handy in pocket size, *Chaos* promises an introduction to fundamental concepts of nonlinear science by using mathematics that is 'no more complicated than $X = 2$.'

Anyone who ever tried to give a popular science account of research knows that this is a more challenging task than writing an ordinary research article. Lenny Smith brilliantly succeeds to explain in words, in pictures and by using intuitive models the essence of mathematical dynamical systems theory and time series analysis as it applies to the modern world. In a more technical part he introduces the basic terms of nonlinear theory by means of simple mappings. He masterly embeds this analysis into the social, historical and cultural context by using numerous examples, from poems and paintings over chess and rabbits to Olbers' paradox, card games and 'phynance'.

Fundamental problems of the modelling of nonlinear systems like the weather, sun spots or golf balls falling through an array of nails are discussed from the point of view of mathematics, physics and statistics by touching upon philosophical issues. At variance with Laplace's demon, Smith's 21st century demon makes 'real world' observations only with limited precision. This poses a severe problem to predictions derived from complex chaotic models, where small variations of initial conditions typically yield totally different outcomes. As Smith argues, this difficulty has direct implications on decision-making in everyday modern life. However, it also asks for an inherently probabilistic theory, which somewhat reminds us of what we are used to in the microworld.

There is little to criticise in this nice little book except that some figures are of poor quality thus not really reflecting the beauty of fractals and other wonderful objects in this field. I feel that occasionally the book is also getting a bit too intricate for the complete layman, and experts may not agree on all details of the more conceptual discussions.

Altogether I thoroughly enjoyed reading this book. It was a happy companion while travelling and a nice bedtime literature. It is furthermore an excellent reminder of the 'big picture' underlying nonlinear science as it applies to the real world. I will gladly recommend this book as background literature for students in my introductory course on dynamical systems. However, the book will be of interest to anyone who is looking for a very short account on fundamental problems and principles in modern nonlinear science.

R Klages
School of Mathematical Sciences, Mile End Road, London, E1 4NS, UK

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