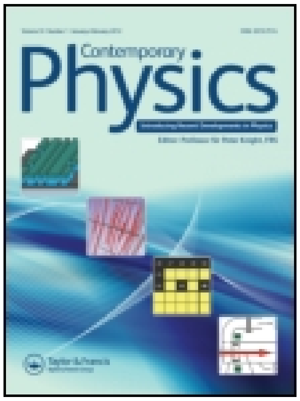

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Quantum Engineering: Theory and Design of Quantum Coherent Structures, by A.M. Zagoskin

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reader familiar with concepts such as energy or wave function, that are explained in a graphic and understandable manner. The authors' experience with their wide-range physics course for a general audience is obvious and pays off here. Thus prepared, the reader is presented the Quantum Enigma in the form of the two-slit experiment. To make sure that everybody got the point, the detailed description of the Quantum Enigma is followed by a chapter in which the reader confronts his own questions and bafflement in the form of a delighting dialogue.

One may think that after presenting the Enigma in all its splendour, it is time for consciousness to be brought into focus. However, there are still more surprises for the reader: the Copenhagen interpretation of quantum mechanics, the paradox of Schrödinger's cat, entanglement and Bell's theorem enter the picture. The significance of quantum mechanics for our present state of technology and development is not forgotten, and major practical applications of great importance for mankind are described. This puts things into perspective for the non-specialised reader. A new compact chapter introduced in the present second edition addresses (in a perhaps too technical style for the non-specialised reader) very recent entanglement experiments that confirm predictions of quantum mechanics with almost macroscopical objects. By the time the authors summarise the interpretations of quantum mechanics exploring for each of them where consciousness comes into play, the reader has become acquainted with all major topics of the quantum world.

Finally, the last three chapters of the book address the issues of consciousness. It is quite a phase transition for the reader: after speaking about facts and experiments in physics, one suddenly finds himself in deep philosophy and speculations. Consciousness seems to be a controversial term on its own, and even excursions in the realm of brain research, psychology and neuropsychology do not bring more than fascinating but still speculative arguments. The authors try hard to remain on solid ground and to draw a line between facts, interpretations and speculations. At the end, however, the reader has to decide for himself what to believe. The enigma is far from being solved and the role of consciousness in the universe, from micro to macro – arguments extend in the book from atomic constituents to the whole universe and the Big Bang – remains a matter of debate.

The contents of the *Quantum Enigma* offer food for thought for physicists and lay audience alike. Major physics topics are presented on a very understandable level, without any use of mathematical equations, and important points are repeated for the sake of the layman, admittedly reaching sometimes redundance for the physicist. Such repetitions together with certain peculiarities in the structure of the book may have propagated from the original physics course from which the book emerged.

This, however, doesn't make the account less easy to read or less interesting. As for the form, the new edition, published as paperback in the UK by Duckworth Overlook, has an attractive layout and the contents are neatly put together. Illustrative and at times funny drawings for the physics explanations are accompanied by cartoons and photos of famous physicists. Additional material related to the book, including notes on each chapter intended for instructors, is available online and advertised in the book.

The *Quantum Enigma* appears to have generated some controversy. It has been argued that by exhibiting the most delicate and counterintuitive aspects of quantum mechanics to the general public and linking physics to the mysteries of the conscious mind might encourage pseudo-science 'nonsense'. Fact is that the book gives a clear and correct account of major topics in quantum mechanics. Questions are raised that go beyond the related presently explored practical purposes in physics. The reader, whether specialist or layman, will find himself in the position to meditate upon these questions and speculate about answers. Obviously, with all clarity in the book, one cannot prevent completely that pseudo-science 'nonsense' may still enter speculations of some. But as far as science is concerned, ignorance has never brought any progress. For anyone seeking to understand more of quantum mechanics and eventually of our universe, the *Quantum Enigma* offers so much to ponder on.

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Quantum Engineering: Theory and Design of Quantum Coherent Structures, by A.M. Zagoskin, Cambridge, Cambridge University Press, 2011, 346 pp., £45.00 (hardback), ISBN 978-0-521-11369-4. Scope: monograph. Level: postgraduate.

The great aerospace engineer, von Karman, described his discipline thus: 'Science is about understanding nature, understanding what is. By contrast, engineering is synthetic; it is about creating what has never been'. From this perspective, a book entitled 'Quantum Engineering' might seem to some a little premature. Of course it depends on one's definition of the topic. After all quantum effects, such as energy quantisation, are already exploited in a wide range of engineering applications, lasers and semiconductors for example.

Zagoskin offers a clear (but narrow) definition in his introduction: 'Quantum engineering ... is about how to build devices out of solid state qubits, and how they can be used'. A physical qubit is a two state system, but unlike a physical bit, which can only be prepared in one or other of its two states, a qubit can be prepared in an arbitrary superposition of its two states. In other words, qubits can exhibit quantum coherence between the two possible physical states. Quantum coherence is an entirely new lever for control of the physical word.

Quantum engineering might be more generally defined as the ability to arbitrarily control quantum coherence in physical systems. This need not be restricted to solid-state systems, or indeed qubits: engineering teams are already developing quantum optical communication systems, and quantum nanomechanics are not about controlling qubits.

Zagoskin's more restrictive definition has enabled him to write an elegant and compact book that covers a lot of ground. The focus is primarily on devices based on superconducting junctions and the two dimensional electron gas in semiconductors. The first chapter, titled 'Quantum mechanics for engineers', covers essential definitions with a passing mention of open quantum systems. (I suspect the average engineer may need a little more background than this.)

The second chapter is a very nice introduction to superconducting quantum circuits. The very mention of 'circuits' echoes the *leitmotif* of quantum engineering: the quantisation is not done by solving Schrödinger's equation for complex many body systems (like electronic circuits), rather an effective quantisation is done by first identifying the key collective variables that will be subject to coherent quantum control, and quantising them directly. This idea goes back to Leggett in the case of superconducting systems but is far more general, recently being applied with great success to bulk mechanical resonators (a field of solid state quantum engineering that Zagoskin's book omits entirely).

The third chapter covers the necessary background to what is usually called mesoscopics, based on phase coherent transport and quantum dots in two dimensional electron gas semiconductors. Chapter 4 returns to superconducting devices with a look at current areas of research including the exciting new field of circuit quantum electrodynamics: a new frontier for quantum optics. This chapter would prepare a postgraduate student to read current papers in the field.

Classical engineering, of course, has to deal with noise and error, usually by some sort of stochastic control. In quantum systems, noise has an additional, purely quantum, effect; it prevents us from keeping track of quantum coherence. Noise and decoherence are flip sides of the same coin. For example, any process that leads to diffusion in momentum necessarily causes the decay of coherence in the position basis. Chapter 5 gives a very elementary introduction to noise and decoherence. This is a big subject with classical texts, such as Gardiner and Zoller, to compete with. While there is no mention of quantum error correction or quantum stochastic control, Zagoskin does a fine job presenting the basic ideas of quantum decoherence in just sufficient detail to understand why quantum engineering is a huge challenge.

In his final chapter, Zagoskin describes a few applications; not that there are many yet to choose from, especially for solid state devices. The examples chosen are a little eclectic. It would have been nice to see one example from quantum metrology. One hopes that this chapter will grow in future editions.

When Maxwell wrote down a set of partial differential equations just over 150 years ago, he opened a door to a new world of engineering capability. Schrödinger's partial differential equation is only now offering a similar technological promise. As Maxwell showed, 'understanding what is' enables us to control the world in entirely new ways and create 'what has never been'. The same will inevitably follow for the quantum world. Zagoskin's book is a useful introduction for any postgraduate student in physics or electrical engineering inspired to become a pioneering quantum engineer.

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Advances in Nanotechnology and the Environment, edited by Juyoung Kim, Singapore, Pan Stanford, 2012, 224 pp., $149.95 (hardback), ISBN 978-9-814-24155-7. Scope: review. Level: researcher, specialist and scientist.

What would anyone expect from the title of this volume? I believe that it would be reasonable to expect to see a review of what nanoparticles are naturally present in the environment and what the impact of