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Niels Bohr, 1913 - 2013

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[Reviewed by Felipe Zaldivar, on 08/10/2016]

The book under review is the product of a Paris seminar devoted to the celebration of the hundredth anniversary of the publication in 1913 of Niels Bohr's three seminal papers on what is known nowadays as the *Bohr model* of the hydrogen atom. It collects several essays presented in this seminar that are quite accessible to a broad section of readers, either mathematicians, physicists or philosophers.

The first part of the book starts with an essay that discusses the context, both experimental and theoretical, of Bohr's contributions in 1913. The second essay is a transcription of Bohr's first paper of the 1913 trilogy. Taking into consideration the introductory essay, Bohr's classical paper is fully accessible and a real pleasure to read. This first part of the book also includes two more essays of a historical nature. The first, a memoir written by Tomas Bohr, a physicist and grandson of Niels Bohr, explores some aspects of Niels Bohr's personality and approach to physics, and includes some wonderful pictures of Bohr and his family. The last essay in this first part is historian's take on the personal history of the man that created the Bohr model around the year 1913. These four essays in the first part of the book fulfill the goals of the Paris seminar, but Niels Bohr's scientific legacy is of course not restricted to his youthful publications on the structure of the hydrogen atom.

The essays in the second part of the book discuss some further contributions of Niels Bolhr to quantum physics. The subjects are well chosen; most deal with the deep, controversial interpretation of quantum mechanics, whose counter-intuitive nature is rather baffling.

The first essay in this second part is a modern exploration of some of Bohr's thought experiments. It describes in detail the implementations of Bohr's ideas using cavity quantum electrodynamics experiments. If this essay is somehow devoted to the problem of *decoherence* of quantum states, the

next essay, by Alain Aspect, focuses on the weird notion of *entanglement*. Again, this notion goes back to some of Bohr's debates with other giants of 20th century physics, Einstein and Schrodinger. Aspect describes some experiments that he performed in 1980s to test Bell's inequalities. Perhaps I may be allowed to add that decoherence and entanglement have now evolved from philosophical issues to concrete technological instruments for the next generation of computers.

The following essay focuses on recent experiments to produce implementations of quantum computers: One consequence of Bohr's atomic model was an explanation for Rydberg's empirical formula for the line spectrum of an element, and the essay takes as its motivation the study of excited atoms with some electrons having a large principal quantum number, corresponding to an orbit far from the nucleus. From the several remarkable properties of these Rydberg atoms, the authors review some recent advances on the interaction of a few Rydberg atoms, in particular for the so-called *Rydberg blockade* mechanism (the excitement of a Rydberg atom with a laser tuned to its frequency prevents the excitement of a second Rydberg atom, when the interacting distance between the atoms is small enough, whatever the laser power). The remarkable fact is that this is not done theoretically or in simulations, but in actual experiments using two or more alkali atoms with one electron in the outer shell. The authors describe these experiments, and their applications to produce entangled states to be used in quantum information.

The last essay is of a philosophical nature, focused on certain analogies between Bohr's complementarity and some ideas in Kant's epistemology. I may be under the influence of some Rydberg blockade, but after the exciting developments described in the previous essays, I was rather cool to the philosophical side. But I understand that Bohr himself was warmer to these ruminations. Being a mathematician I can do no more than just wonder how some elementary mathematics and a deep sense of the physics involved, grounded on real experiments and observations, made Bohr's contributions truly fundamental and still keep us busy and in awe.

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