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Review of *Computing With Quantum Cats: From Colossus To Qubits* and *Schrödinger's Killer App: Race To Build The World's First Quantum Computer*

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Comments
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BOOK REVIEW

Computing With Quantum Cats: From Colossus To Qubits
by John Gribbin
Bantam Press, 2013, **$28.95**
ISBN-13: 9780593071151 (hardcover)

Schrödinger's Killer App: Race To Build The World's First Quantum Computer
by Jonathan Dowling
CRC Press, 2013, **$39.95**
ISBN-13: 9781439896730 (paperback)

The task of writing a popular book on quantum computing is a daunting one. In order to get it right, you need to explain the subtleties of theoretical computer science, at least to the point of understanding what makes some problems hard and some easy to tackle on a classical computer. You then need to explain the subtle distinctions between classical and quantum physics. Both of these topics could, and indeed have, filled entire popular books on their own. Gribbin's strategy is to divide his book into three sections of roughly equal length, one on the history of classical computing, one on quantum theory, and one on quantum computing. The advantage of this is that it makes the book well paced, as the reader is not introduced to too many new ideas at the same time. The disadvantage is that there is relatively little space dedicated to the main topic of the book.

In order to weave the book together into a narrative, Gribbin dedicates each chapter except the last to an individual prominent scientist, specifically: Turing, von Neumann, Feynman, Bell and Deutsch. This works well as it allows him to interleave the science with biography, making the book more accessible. The first two sections on classical computing and quantum theory display Gribbin's usual adeptness at popular writing. In the quantum section, my usual pet peeves about things being described as "in two states at the same time" and undue prominence being given to the many-worlds interpretation apply, but no more than to any other popular treatment of quantum theory. The explanations are otherwise very good. I would, however, quibble with some of the choice of material for the classical computing section. It seems to me that the story of how we got from abstract Turing machines to modern day classical computers, which is the main topic of the von Neumann chapter, is tangential to the main topic of the book, and Gribbin fails to discuss more relevant topics such as the circuit model and computational complexity in this section. Instead these topics are squeezed very briefly into the quantum computing section, and Gribbin flubs the description of computational complexity. For example, see if you can spot the problems with the following three quotes:

"...problems that can be solved by efficient algorithms belong to a category that mathematicians call `complexity class P'..."

"Another class of problem, known as NP, are very difficult to solve..."

"All problems in P are, of course, also in NP."

The last chapter of Gribbin's book is a tour of the proposed experimental implementations of quantum computing and the success achieved so far. This chapter tries to cover too much material too quickly and is rather credulous about the prospects of each technology. Gribbin also persists with the device of including potted biographies of the main scientists involved. The total effect is like running at high speed through an unfamiliar woods, while someone slaps you in the face rapidly with CVs and scientific papers. I think the inclusion of such a detailed chapter was a mistake, especially since it will seem badly out of date in just a year or two. Finally, Gribbin includes an epilogue about the controversial issue of discord in non-universal models of quantum computing. This is a bold inclusion, which will either seem prescient or silly after the debate has died down. My own preference would have been to focus on well-established theory.

In summary, Gribbin has written a good popular book on quantum computing, perhaps the best so far, but it is not yet a great one. It is not quite the book you should give to your grandmother to explain what you do. I fear she will unjustly come out of it thinking she is not smart enough to understand, whereas in fact the failure is one of unclear explanation in a few areas on the author's part.

Dowling's book is a different kettle of fish from Gribbin's. He claims to be aiming for the same audience of scientifically curious lay readers, but I am afraid they will struggle. Dowling covers more or less everything he is interested in and I think the rapid fire topic changes would leave the lay reader confused. However, we all know that popular science books written by physicists are really meant to be read by other physicists rather than by the lay reader. From this perspective, there is much valuable material in Dowling's book.

Dowling is really on form when he is discussing his personal experience. This mainly occurs in chapters 4 and 5, which are about the experimental implementation of quantum computing and other quantum technologies. There is also a lot of material about the internal machinations of military and intelligence funding agencies, which Dowling has

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copious experience with on both sides of the fence. Much of this material is amusing and will be of value to those interested in applying for such funding. As you might expect, Dowling's assessment of the prospects of the various proposed technologies is much more accurate and conservative than Gribbin's. In particular his treatment of the cautionary tale of NMR quantum computing is masterful and his assessment of non-fully universal quantum computers, such as the D-Wave One, is insightful. Dowling also gives an excellent account of quantum technologies beyond quantum computing and cryptography, such as quantum metrology, which are often neglected in popular treatments.

Chapter 6 is also interesting, although it is a bit of a hodge-podge of different topics. It starts with a debunking of David Kaiser's thesis that the "hippies" of the Fundamental Fysiks group in Berkeley were instrumental in the development of quantum information via their involvement in the no-cloning theorem. Dowling rightly points out that the origins of quantum cryptography are independent of this, going back to Wiesner in the 1970's, and that the no-cloning theorem would probably have been discovered as a result of this. This section is only missing a discussion of the role of Wheeler, since he was really the person who made it OK for mainstream physicists to think about the foundations of quantum theory again, and who encouraged his students and postdocs to do so in information theoretic terms. Later in the chapter, Dowling moves into extremely speculative territory, arguing for “the reality of Hilbert space” and discussing what quantum artificial intelligence might be like. I disagree with about as much as I agree with in this section, but it is stimulating and entertaining nonetheless.

You may notice that I have avoided talking about the first few chapters of the book so far. Unfortunately, I do not have many positive things to say about them.

The first couple of chapters cover the EPR experiment, Bell's theorem, and entanglement. Here, Dowling employs the all too common device of psychoanalyzing Einstein. As usual in such treatments, there is a thin caricature of Einstein's actual views followed by a lot of comments along the lines of “Einstein wouldn't have liked this” and “tough luck Einstein.” I personally hate this sort of narrative with a passion, particularly since Einstein's response to quantum theory was perfectly rational at the time he made it and who knows what he would have made of Bell's theorem? Worse than this, Dowling's treatment perpetuates the common myth that determinism is one of the assumptions of both the EPR argument and Bell's theorem. Of course, CHSH does not assume this, but even EPR and Bell's original argument only use it when it can be derived from the quantum predictions. Thus, there is not the option of "uncertainty" for evading the consequences of these theorems, as Dowling maintains throughout the book.

However, the worst feature of these chapters is the poor choice of analogy. Dowling insists on using a single analogy to cover everything, that of an analog clock or wristwatch. This analogy is quite good for explaining classical common cause correlations, e.g. Alice and Bob's watches will always be anti-correlated if they are located in timezones with a six hour time difference, and for explaining the use of modular arithmetic in Shor's algorithm. However, since Dowling has earlier placed such great emphasis on the interpretation of the watch readings in terms of actual time, it falls flat when describing entanglement in which we have to imagine that the hour hand randomly points to an hour that has nothing to do with time. I think this is confusing and that a more abstract analogy, e.g. colored balls in boxes, would have been better.

There are also a few places where Dowling makes flatly incorrect statements. For example, he says that the OR gate does mod 2 addition and he says that the state |00> + |01> + |10> + |11> is entangled. I also found Dowling's criterion for when something should be called an ENT gate (his terminology for the CNOT gate) confusing. He says that something is not an ENT gate unless it outputs an entangled state, but of course this depends on what the input state is. For example, he says that NMR quantum computers have no ENT gates, whereas I think they do have them, but they just cannot produce the pure input states needed to generate entanglement from them.

The most annoying thing about this book is that it is in dire need of a good editor. There are many typos and basic fact-checking errors. For example, John Bell is apparently Scottish and at one point a D-Wave Systems computer costs a mere $10,000. There is also far too much repetition. For example, the tale of how funding for classical optical computing dried up after Conway and Mead instigated VLSI design for silicon chips, but then the optical technology was reused to build the internet, is told in reasonable detail at least three different times. The first time it is an insightful comment, but by the third it is like listening to an older relative with a limited stock of stories. There are also whole sections that are so tangentially related to the main topic that they should have been omitted, such as the long anti-string-theory rant in chapter six.

Dowling has a cute and geeky sense of humor, which comes through well most of the time, but on occasion the humor gets in the way of clear exposition. For example, in a rather silly analogy between Shor's algorithm and a fruitcake, the following occurs:

“We dive into the molassified rum extract of the classical core of the Shor algorithm fruitcake and emerge (all sticky) with a theorem proved in the 1760s...”

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Review, continued

If this were a piece of student writing, Dowling would surely get kicked out of class for it. Finally, unless your name is David Foster Wallace, it is not a good idea to put things that are essential to following the plot in the footnotes. If you are not a quantum scientist then it is unlikely that you know who Charlie Bennett and Dave Wineland are or what NIST is, but then the quirky names chosen in the first few chapters will be utterly confusing. They are explained in the main text, but only much later. Otherwise, you have to hope that the reader is not the sort of person who ignores footnotes. Overall, having a sense of humor is a good thing, but there is such a thing as being too cute.

Despite these criticisms, I would still recommend Dowling's book to physicists and other academics with a professional interest in quantum technology. I think it is a valuable resource on the history of the subject. I would steer the genuine lay reader more in the direction of Gribbin's book, at least until a better option becomes available.

–Matt Leifer