Book Review of
Q is for Quantum
Authors of Book: Terry Rudolph
Author of Review: William Gasarch

1 Introduction

Fred Green asked me to review two books for opposite reasons.

- *Fred:* Bill, could you review **An Introduction to Ramsey Theory: Fast Functions, Infinity, and Metamathematics** by Matthew Katz and Jan Reimann since you are an expert on Ramsey Theory.

  Bill: I WOULD NOT say I am an expert, but sure, I can review that.

- *Fred:* Bill, could you review **Q is for Quantum** by Terry Rudolph. It's aimed at people who know NOTHING about quantum mechanics and don't know that much math, so I thought of you.

  Bill: I WOULD say I know nothing about quantum and don't know that much math, so sure, I can review it.

This book really is written for people who know NOTHING about quantum mechanics and don't know much math, hence I was able to give it a fair review. Since I have sometimes heard people talk about quantum mechanics I could also recognize some of the discussions in the book as well known controversies in quantum mechanics.

I first thought this book would take Scott Aaronson's approach of starting with a very strange way to do probability. But even that is more math than this book wants to do. Instead the book describes very tangible but impossible-sounding devices whose macro-level behaviour is known and which really can be built, although there are controversies about what they are really doing on the micro level.

2 Summary of Contents

Part 1: Q-computing

The author describes a variety of devices where you drop white and black balls into them and some other (or the same) color balls come out of them. These are circuits though he does not use the term. Most of them are ordinary:

1. A NOT box: input a white ball, get out a black ball, and vice versa.

2. A SWAP box: BB goes to BB, BW goes to WB, WB goes to BW, WW goes to WW.

3. A CNOT (Controlled NOT): if the first ball is W then the second ball stays the same. If the first ball is B then the second ball changes color.

4. There are others.

He then introduces the PETE box.

1. If you input a white ball then with probability $\frac{1}{2}$ you get a white ball, and with probability $\frac{1}{2}$ you get a black ball.

2. If you input a black ball then with probability $\frac{1}{2}$ you get a white ball, and with probability $\frac{1}{2}$ you get a black ball.

That doesn't look so unusual. The PETE box obviously flips a coin or some such. Nothing to see here, move along folks.

Not so fast! If a ball goes through one PETE box and then the output to another PETE box (no peeking at what happens after the first PETE box!) then you *should* get, no matter which color ball you drop in, $P(W) = P(B) = \frac{1}{2}$. But you don't!

1. If you input a white ball through two PETE boxes you end up with a White ball. ALWAYS!

2. If you input a black ball through two PETE boxes you end up with a black ball. ALWAYS!

Well isn't that odd? It gets odder: (1) If you DO peek then the behavior stops, and (2) PETE boxes seem to really exist in nature. And people can build them. And they are useful in the real world. The question of what is going and how they work leads to that old saw:

$1 + i$ *quantum mechanics,* $2 + 2i$ *opinions.*

He explains this behavior in terms of the balls not really being white or black but being what he calls *misty balls* and what Physicists call *a superposition of white and black*. So the balls color is really something like $(W, -B)$. The key to the behavior is that negatives and positives can cancel out.

He then explains how you can use these misty balls to do all kinds of wonderful computations (he does not explain factoring, which makes sense given the math he assumes of the audience). Interwoven is some debate on whether the model is TRUE or just GOOD FOR CALCULATION BUT NOT REALLY TRUE which mirrors a current debate within the Physics community.

He is very careful to NOT say that a quantum computer visits an exponential number of options at one time, but to instead point to the canceling out as why these devices are powerful. I applaud this.

Part 2: Q-Entanglement

This Part begins with talking about alleged Psychics Alice and Bob. Alice is in a room with tester ONE, Bob is in a room with tester TWO. Both testers flip a coin. After the coin flip Alice and Bob they each say B or W (Black or White). We denote the coins they see by (Alice's coin, Bob's Coin).

- If HH then Alice and Bob say BW, WB, or WW to be okay. If they say BB then DOOM!
- If HT then Alice and Bob say BB, BW, or WW. If they say WB then DOOM!
- If TH then Alice and Bob say BB, WB, or WW. If they say BW then DOOM!
- If TT then Alice and Bob say BB, WB, or WW. If they say BB then they WIN!

If Alice and Bob want to take no chance on DOOM then because they can't know the other person's coin flip, it also appears they have no chance of ever winning. But the author shows that if both take lots of balls and a PETE box in their room they CAN always avoid DOOM yet still win some of the time. So quantum entanglement is tied to these PETE boxes.

Part 3: Q-Reality

Throughout the book there were some side comments about what is really going on. Part 3 expands on these notions. Many different points of view are presented to try to explain what is going on here. No conclusion is reached.

3 Opinion

I was going to write that this book is a great starting point to help you *understand* quantum mechanics. Then I read the following quote attributed to Richard Feynman:

> *There was a time when the newspapers said that only twelve men understood the theory of relativity*[1]*. I do not believe there was ever such a time. There might have been a time when only one man did, because he was the only guy who caught on, before he wrote his paper. But after people read the paper, a lot of people understood the theory of relativity one some way or other, certainly more than twelve. On the other hand, I think we can safely say that nobody understands quantum mechanics.*

So its not just laypeople who don't understand quantum mechanics. Even Physicists don't!

This book is excellent at explaining what is so strange about quantum mechanics without getting technical, without using mathematics beyond high school algebra, and without saying things I never quite understood like *the cat alive and dead!* or *It's a wave! It's particle! It's a desert topping! Its a floor wax!*. They do talk some about *once you look at something, it changes* but they do this in an intelligent way that is understandable. So it tells the the layperson what it is about quantum mechanics that people, even Physicists, don't understand.

When I finished reading the book I wanted to learn more (a sign of a good book). There is a website associated to the book

`www.qisforquantum.org`

which has some recommended books to read next.

[1] I wonder how many women did.