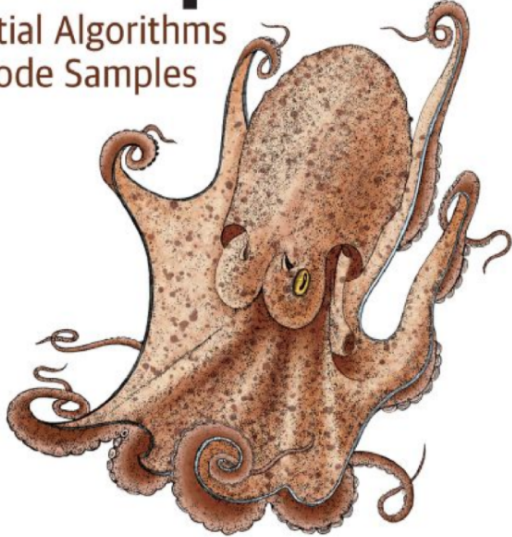


O'REILLY®

Programming Quantum Computers

Essential Algorithms
and Code Samples



Eric R. Johnston, Nic Harrigan
& Mercedes Gimeno-Segovia

Copyrighted material

Bookclub Wk2 – ch2

Jeremy Clark Presenting

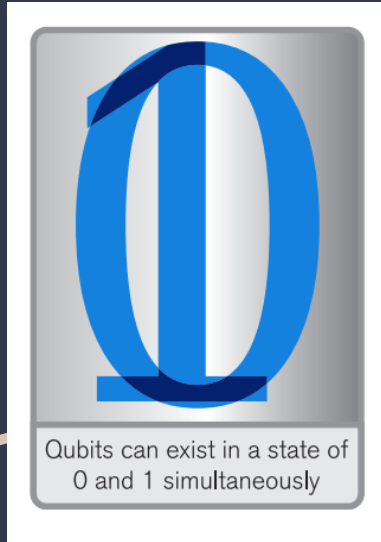
About Me



- Jeremy Clark
- Developer since 2000
 - Corporate / Startup / Contract
- Developer training / videos / conferences / workshops
- www.jeremybytes.com

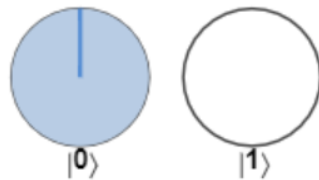
Chapter 2 – One Qubit

Chapter 2 - Info

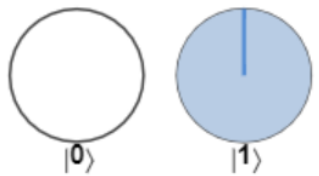


- Circle Notation
- QPU Operations
 - NOT
 - HAD
 - READ
 - WRITE
 - PHASE(θ)
 - ROTX(θ) / ROTY(θ)
 - ROOT-of-NOT
- Spy Hunter

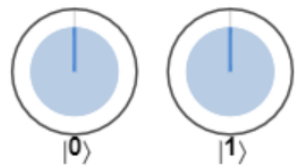
Circle Notation



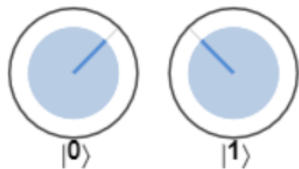
- 0



- 1



- 50% / 50%



- Relative phase

NOT



- NOT
- `qc.not();`
- Flips the 0 and 1 circle
- Reversible
 - NOT NOT = original state

HAD



- HAD (Hadamard)
- `qc.had();`
- Puts a qubit into superposition
 - Like a coin flip while the coin is in the air
- Reversible
 - $\text{HAD HAD} = \text{original state}$
 - Like unflipping a coin while it is still in the air

READ



- READ
- `qc.read();`
- Reads a value from a qubit
- Not reversible
 - Collapses superposition
 - Once a qubit is read all superposition information is lost

Note: using the "debugging" on the simulator will yield different values even on the same "run".

WRITE



- WRITE
- `qc.write(0);`
- Writes a value from a qubit
- Not reversible
 - Once a qubit is written all superposition information is lost

PHASE(θ)

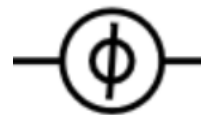
180°



- PHASE(θ)
- `qc.phase(180);`
- Manipulates the relative phase by a particular angle
- No real effect on single-qubit operations
- Reversible by applying negative angle

Other names for PHASES

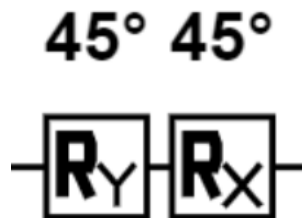
180°



- $\text{PHASE}(180) = \text{Z gate}$
- $\text{PHASE}(90) = \text{S gate}$
- $\text{PHASE}(45) = \text{T gate}$
- Environment notes
 - QCEngine uses the angle
 - OpenQASM uses Z/S/T notation

This is on page 7 of the book, but I did not see later mentions (and it is not in the index).

ROTY(θ)
ROTX(θ)



- ROTY(θ) / ROTX(θ)
- `qc.roty(45);` / `qc.rotx(45);`
- Manipulates the relative phase by a particular angle along the y or x axis (phase works on z axis)
- Need a sphere to really see this.

RNOT



- $\text{RNOT} = \text{ROOT-of-NOT}$
- `qc.rootnot();`
- The square root of the NOT operation
 - If you RNOT twice, it's the same as a NOT
- Not directly reversible

Combining Operations



NOT = HAD | PHASE(180) | HAD

180°



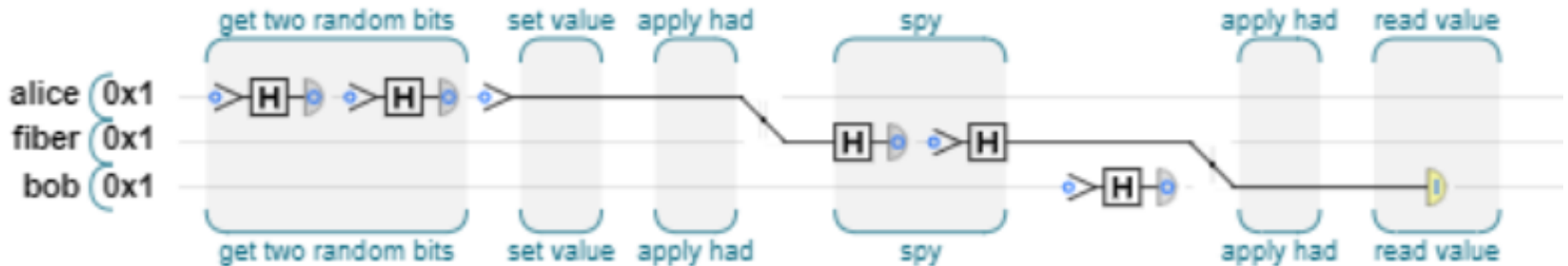
PHASE(180) = HAD | NOT | HAD



RNOT = HAD | PHASE(90) | HAD

Spy Hunter

- Man-in-the-middle attack collapses the superposition, potentially altering the outcome.
- If you do this enough times (1-in-50 probability), you will detect that someone was listening.



Resources

- Book "**Programming Quantum Computers**" - <https://learning.oreilly.com/library/view/programming-quantum-computers/9781492039679/>
- Lynn's '**learning-quantum**' GitHub Repo - <https://github.com/lynnlangit/learning-quantum>
- Jeremy's '**programming quantum experiments**' GitHub Repo - <https://github.com/jeremybytes/quantum-programming-experiments>
- more ???