

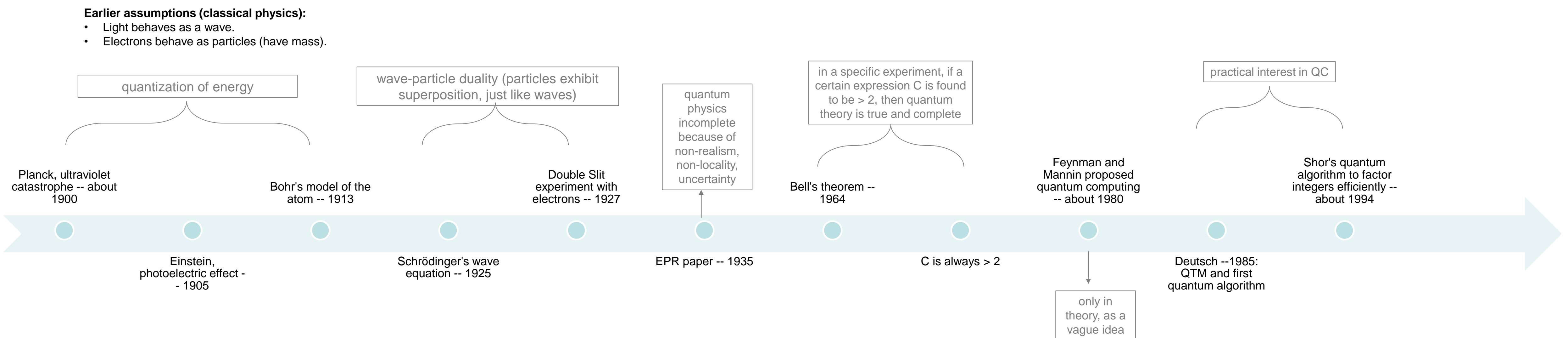


SRTA-CITY WINTER SCHOOL (2022)

Basics of Quantum Computing and Its Applications ("The QC Game")



Introduction: From Planck to Shor

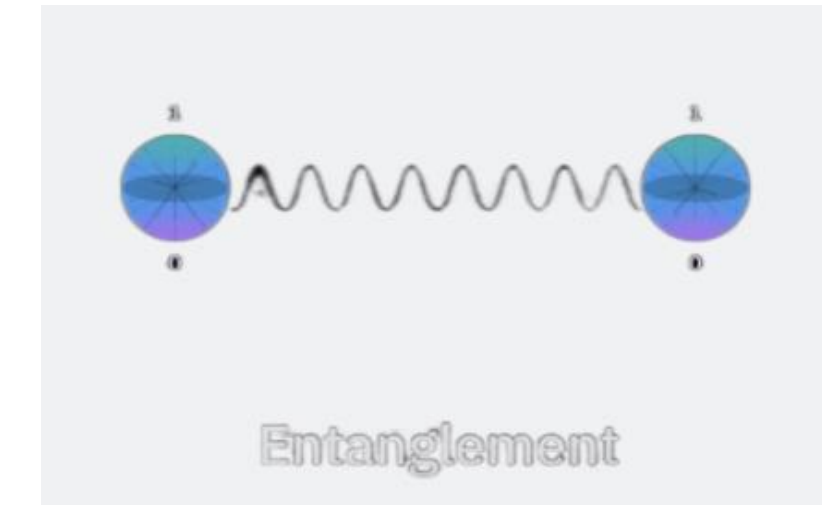


Superposition and Entanglement



Non-realism and Uncertainty

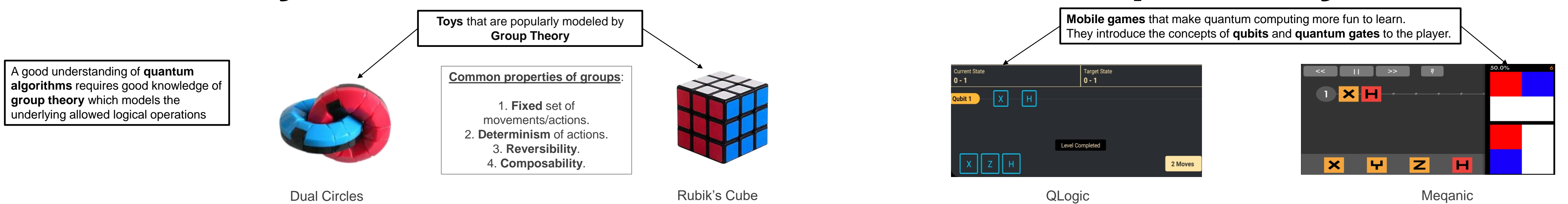
The feature of a quantum object whereby it appears to exist in several distinct quantum states at the same time. Each object, until it is measured, will have some finite chance of being in either state.



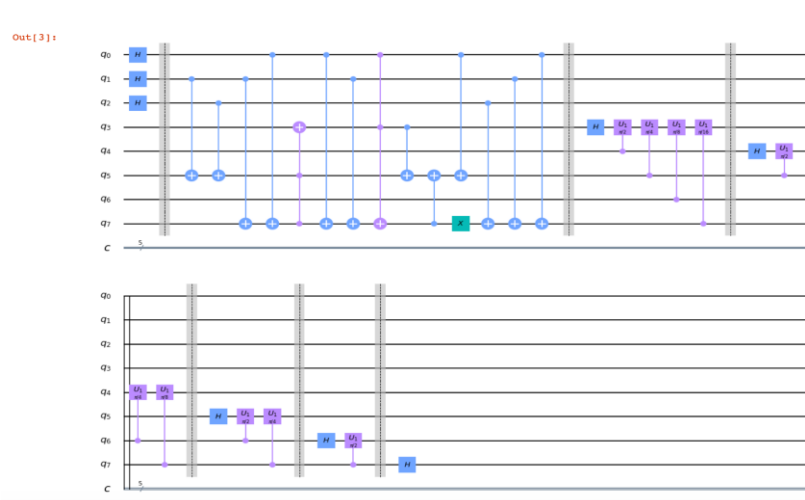
Non-locality

It is the apparent exchange of quantum information between two particles/objects, even if the two are separated from each other by a large distance.

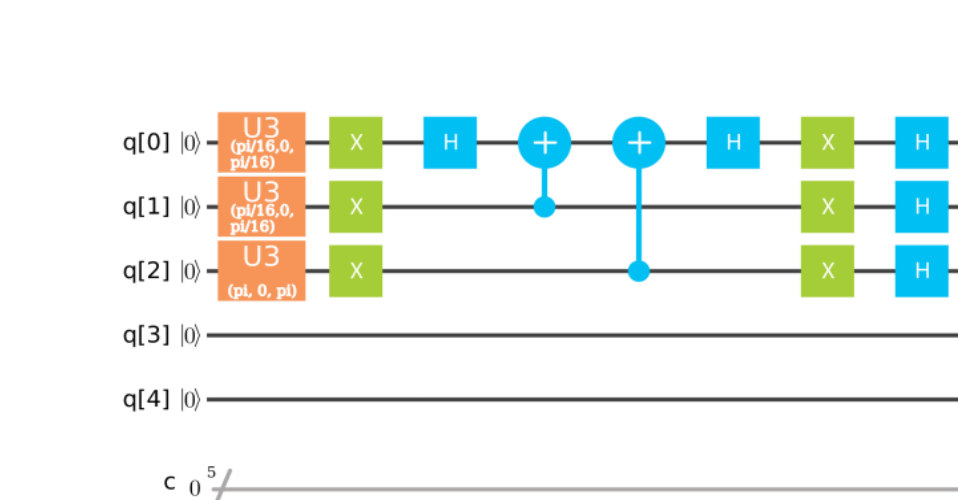
Toys, Mobile Games, and Visual Group Theory



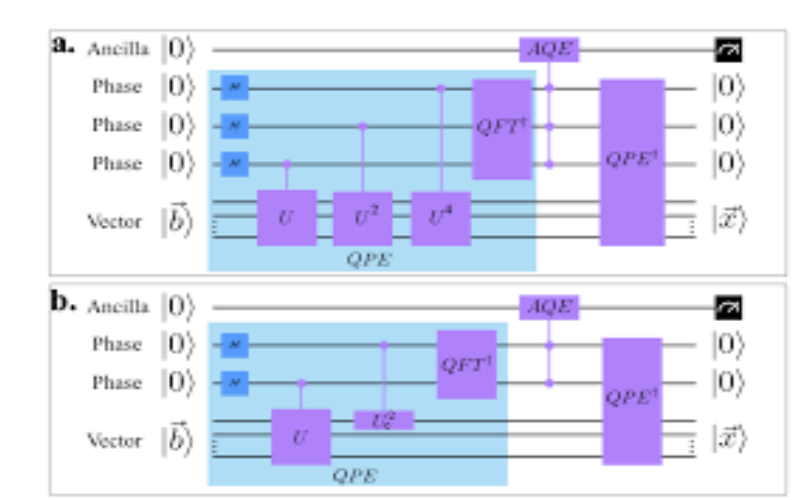
Quantum Applications: Factoring, Searching, and AI/ML



Shor's algorithm is a quantum algorithm for integer factorization. The time complexity of Shor's algorithm to decompose integer N on a quantum computer is $O(\log^2 N)$.



Grover's algorithm, also known as the quantum search algorithm, refers to a quantum algorithm for unstructured search. Grover's algorithm takes $O(\sqrt{N})$ time.



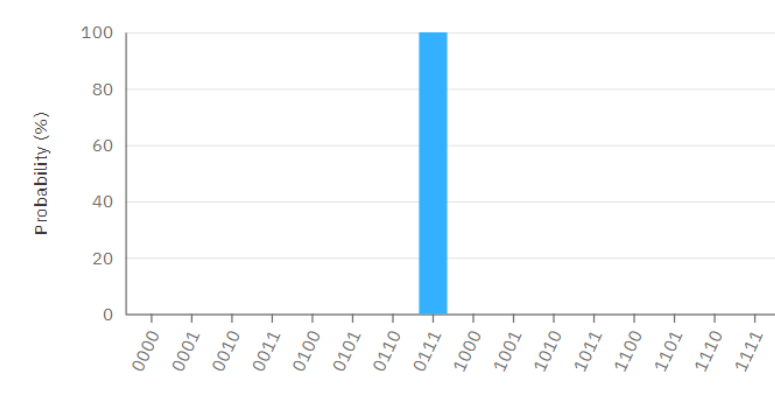
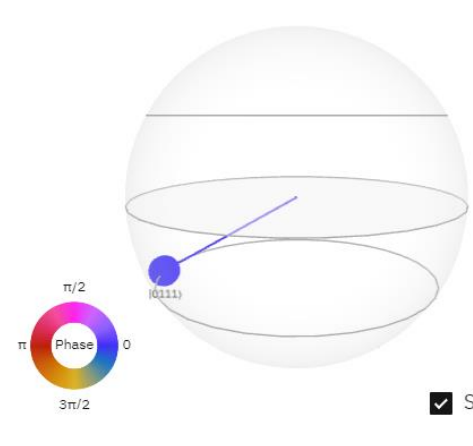
The HHL algorithm solves a system of linear equations and is used as a component in the machine learning classification algorithm SVM to define a faster quantum version of the algorithm called QSVM. HHL depends on the availability of QRAM.

Hands-on Quantum Computing

Real Quantum Computers

E.g., IBM Q Experience

```
1 OPENQASM 2.0;
2 include "qelib1.inc";
3
4 qreg q[4];
5 creg c[4];
6
7 x q[0];
8 x q[1];
9 x q[3];
10 ccx q[0],q[1],q[2];
11 ccx q[0],q[1],q[3];
12 ccx q[3],q[2],q[1];
```



QC Simulators (Reproducible Experiments)

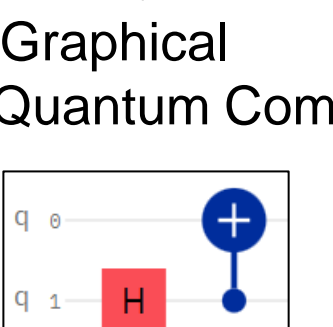
Programmatic

E.g., QC Engine

```
qc.reset(2);
qc.write(0b00);
qc.had(0b10);
qc.cnot(0b01, 0b10);
var result = qc.read();
```

Graphical

E.g., IBM Quantum Composer



Bibliography

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4. The Princeton Companion to Mathematics, Tim Gowers (Ed.), 2008.

Team

- Team Lead: Dr. Moez A. AbdelGawad moez@alexu.edu.eg
- Jehad Aly (Fac. of Eng.)
- Nada Rabea (Fac. of Sci.)
- Noha Ahmed (Fac. of Eng.)
- Reem Ahmed (Fac. of Sci.)