HTTP://QERKY.ORG

Quantum Education & Research in KentuckY

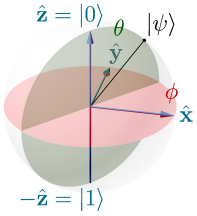
QERKY.ORG is about advancing quantum education and research in the Commonwealth of Kentucky. The lead institution in this effort is the University of Kentucky, the R1 flagship state university based in Lexington, KY.

This effort began in May 2019 as a branch from Professor Henry (Hank) Dietz's **Aggregate.Org** informal research consortium. In February 1994, Dietz's **PAPERS group** at Purdue University built the world's first Linux PC cluster supercomputer, and he immediately focused on making the technology more accessible. He authored the *Parallel Processing HOWTO* for the Linux Documentation Project, has had a research exhibit at every SC since 1994, and his group has created a wide range of open source software and hardware for supercomputing including *SWAR*, *FNN* networks, and *MOG* (MIMD On GPU). Similarly, **QERKY.ORG** is about helping ***QPUs*** (*Quantum Processing Units*), and more generally *quantum* and *quantum-inspired concepts*, mature into practical technologies that can be leveraged to improve computing systems.

Thus far, progress has been mostly in the form of local collaborations among the faculty. However, as of SC26, we are letting the world know we're here and releasing several cool educational toys you can play with...

Physical Models of Bloch Spheres

Physicists describe the value of a quantum bit, or ***qubit***, as a continuous wave function that defines probability amplitudes for 0 and 1. That's not the easiest concept for most people to grasp. Graphically representing a qubit's value as coordinates (θ, ϕ) on a ***Bloch sphere*** is a common way to make the ideas more concrete:



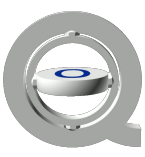
$$|\psi\rangle = \cos(\theta/2)|0\rangle + e^{i\phi}\sin(\theta/2)|1\rangle$$
$$= \cos(\theta/2)|0\rangle + (\cos\phi + i\sin\phi)\sin(\theta/2)|1\rangle$$

where $0 \le \theta \le \pi$ and $0 \le \phi < 2\pi$

So, here we present three different open-source physical representations of Bloch spheres that you can easily make using a consumer-level 3D printer.

Qubit Spinner Keychain





The original qubit keychains from **Aggregate.Org** had only one rotational axis. We are giving away a new two-axis version in our SC26 exhibit (booth #5637), and you also can print your own using the model posted at:

https://www.printables.com/model/1911294

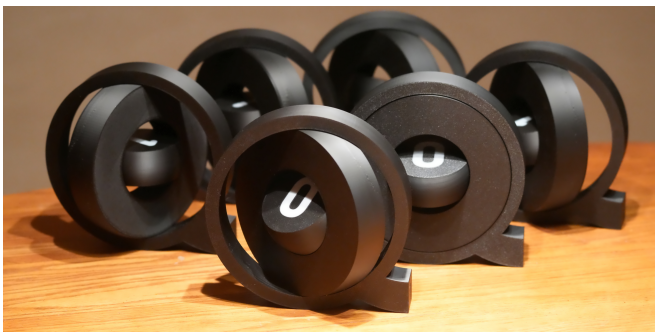
Qubit Classroom Model



Very much like the qubit keychain is our qubit classroom model. It is large enough to be used in classroom presentations, spins just as freely as the keychain, and quickly prints assembled. There are two versions: one with a 0/1 core, the other with an arrow. Both designs are posted at:

https://www.printables.com/model/1913894

SPOOKY action at a distance qubits



Individual qubits are nice for explaining ***superposition***, but how do you graphically explain ***entanglement***?

Einstein didn't like the "spooky action at a distance" aspect of operations on entangled qubits. It seemed unreasonable that an operation on one qubit could instantaneously change the state of another qubit. SPOOKY mechanical qubits implement what appears to be the same phenomenon, making coordinated changes to the state of multiple SPOOKY qubits that have no apparent connections to each other.

Of course, SPOOKY qubits are not really entangled, but simulate spooky action at a distance using 2.4GHz 802.11 WiFi to coordinate battery-powered qubits. A pair of 28BYJ-48 stepper motors controlled by a RISC-V (ESP32-C3) processor rotate the two axes as commanded via a simple wireless HTTP interface. A C++ program that can easily run on a laptop performs the simulated execution of arbitrary quantum programs and sends HTTP commands to move the physical qubits. Parts cost for building your own SPOOKY is under $30/qubit. See:

https://www.instructables.com/SPOOKY-Action-at-a-Distance-Qubits

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University of Kentucky

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