Photon Quantum Computing is More Fundamental than Qubits

Terry Bollinger
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https://youtu.be/WyZtsWN3dqY&lc=UgzWlGlxzgcRm2nSgqF4AaABAg

A Comment on the Sabine Hossenfelder post:
A New Source of Water on The Moon (Apr 5, 2023)
https://youtu.be/WyZtsWN3dqY?t=7m38s

7:38 *"If you want to compute with photons, getting them to interact would be handy. So that's why physicists are studying these bound states."* Sabine's apt assessment on this point has broad technology, cost, and energy implications for quantum computing. Photon quantum interactions are vastly more accessible and robust than atomic ones primarily due to their extremely low total energies compared to atoms and even electrons. The power of photon quantum effects shows up, in particular, in the calculation power of a single photon encountering a human-scale or larger lens since the photon can calculate the Fourier transform of that enormous room-temperature lens literally at light speed, expressing that result as a precise pinpoint of photon reception at the focus of the lens.

While QED predicts this lens effect in exquisite detail, the focus in QED is on leveraging the enormous conventional computing power to estimate the behavior of a single photon. However, the inverse relation is necessarily also true: There exist cases in which a single photon can stand in for that same enormous quantity of classical computing power. The trick is configuring that remarkable speed and efficiency into a broader calculation form.

The thing missing — and this is Sabine's and the paper's point — is the ability to transfer quantum state information between photons without reducing them to trivial classical states. If photon binding can do this, new classes of exceptionally low-power room-temperature quantum computation devices may be possible. However, such non-qubit devices would present interesting research, technology, and mathematical challenges.

One way of phrasing the problem is this: Can general-purpose quantum computation be expressed in terms of "entangled Fourier transforms" rather than qubits? While less intuitive to humans, Fourier transforms arguably are a far more natural way of expressing the kinds of transformation accomplished most easily and cheaply in quantum mechanics. In sharp contrast, qubits begin with the profoundly classical and mostly computer-inspired concept of sharply defined binary states. Almost reluctantly, the definition then adds quantum superposition at the last moment. This over-specification means that non-qubit formalisms are more likely to uncover the full power of quantum-based computation.

But why would I say qubits are more classical than quantum? After all, they are the foundation of much physics speculation and massive and well-funded quantum computation programs. Surely they must be "ideal" examples of quantum superposition?

Well… not really. The canonical example of a qubit is a fermion with the property called half spin. A half-spin electron or atom can be in only one of two states, "up" or "down." Half-spin appears to be an open-and-shut case for qubits: You assign one spin direction as 1, the other as 0, and *voila!* you have a qubit.

The problem is this: While an electron may well have only two states, the number of *orientations* of those states is infinite and itself quantum. A massive classical magnet provides an exquisitely precise up-down definition for any electrons in its fields. Those electrons *do* become qubits because they have both binary states and sufficient orientation to make that state meaningful in our classical world. As the field grows weaker — that is, as the influence of the outside classical world wanes — the certainty of the encoded bits fades until quantum computation is no longer possible. The spins remain, but the *qubits* depend on their classical hosting.

The qubit concept is better thought of as a product of the 1990s fascination with the growing power of computers and software than a direct interpretation of quantum phenomena. It is, for example, difficult to imagine a concise way to express the QED-style Fourier transformation of a photon traveling through a lens using only qubits. It's possible, but it's also not persuasive.

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