Quantum Mechanics Literature Search I

Gabriel M Steward

Quantum Computers

There are a large number of articles on Quantum Computers available, but this one talked about actual quantum engineering related to it, so I selected it.

<https://news.mit.edu/2020/explained-quantum-engineering-1210>

Quantum computers are a technology that’s talked about often, but only recently has it become possible to actually build things based on the theory. In essence, a quantum computer is any device that takes advantage of quantum phenomena to run calculations faster than the traditional method of compounding ones and zeroes. Quantum computers take advantage of things called qbits that can exist as either zero, one, or a superposition of both states—and, as a bonus, the qbits can be subject to quantum entanglement, ensuring that two different qbits have related states no matter what the distance.

The actual physical construction of a qbit can be any number of things. There is the standard “spin up or spin down” electron illustration, but they can be built out of superconductors as well as entire atoms. In theory, these constructs can be wired together much like a traditional computer to perform calculations exponentially faster than the current technology allows. However, there is one major problem with relying on quantum effects in designing technology: decoherence. Both superposition and quantum entanglement rely on the wave nature of matter to function. However, any time a particle is “observed” the wave function that defines it collapses to a single point, which removes the superposition and severs entanglement. There is a serious problem in keeping qbits isolated while traveling so environmental effects won’t interfere with them, destroying their computing power. While a particle can act like it is in two states or positions at once, the moment anything forces it to be in one place or another, it stops acting as such—and the effects we seek to exploit are ruined. Furthermore, the electromagnetic fields used to guide qbits through to their destinations sometimes collapse the wave function all their own. It’s a complex problem.

This is a particularly large problem in superconductor qbits, since they are so large. A single superconductor-based qbit is a tenth of a millimeter wide, which is small on our scale, but on the quantum level a millimeter is an eternity of opportunities for the wave function to collapse. (Not to mention the inherent difficulties present in getting superconductors to work in the first place.) The good side is that it’s easy to manipulate to alter calculations.

Another qbit construction method is to use ionized atoms. They exhibit quantum behavior readily (though not as much as individual electrons) and are easy to manipulate due to their charge. Altering voltage allows for these qbit ions to stay in place or move around at will, solving many of the problems the superconductor qbits have. However, a new problem arises: controlling the ionic qbits while keeping their properties.

Commercial application of these qbits is still years if not decades away, but they exist and we have built several of them. Modern scientists and engineers are testing for the best possible qbit construction methods, of which superconductors and ions are just a small sampling.