What Will Limit the Quantum Computers of the Future?

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Computers will soon reach the limit of their speed and quantum computers are seen as a way to increase that limit further. I have shown that there are unavoidable limits to the speed of quantum computers as well, though they are much higher.

Quantum computers are the next step of the evolution of the computer. While there's still a few years left until a consumer ready quantum computer is made, it's a very lively field of research. There are many different ways to realise the illusive quantum computer and the scientific community has yet to find a definitive approach. One thing that is common for all implementations is the need for a qubit.

A bit is how computers handle information, and it's the smallest building block of computers. Quantum computers also need to be able to handle information, so the name of the quantum equivalent of a bit is called a qubit.

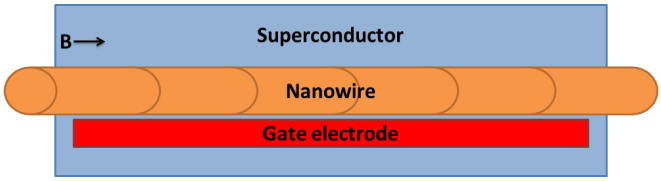

Figure 1: *Model of the qubit.*

In Figure 1, you can see a model of the qubit that I've worked with. It's basically a very small wire, only 2 µm long, made of semiconducting material. Such wires can be made using nanotechnology. The working parts of the qubit is created inside the wire. First it is connected to a superconducting material and electrodes. The qubit is then created using a combination of a magnetic field and a voltage applied through the electrodes.

The results were found by simulating this qubit. In order to simulate something, a model must be created to express the system, like a blueprint for a house. The model used for the simulation started very simple. It was later improved by adding more complex parts as needed.

The main result boils down to a set of energy plots. For an ideal qubit, these energy plots will be constant. Some of these plots had dips in energy for certain electrode voltages as can be seen in Figure 2. These dips will cause disturbances, which means that the system will need to be designed in a way that avoids them.

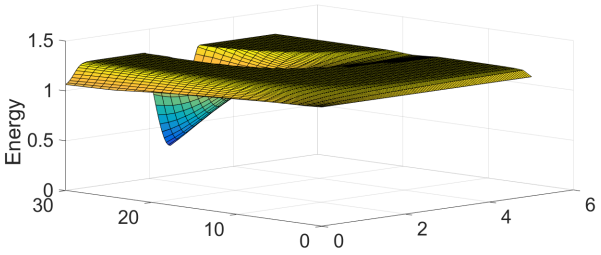

Figure 2: *Energy plot with a dip.*

Another result was finding a limit of the speed of operations for the qubit. The speed of operations will determine how fast the computer can work. This was once again found by analysing the energy plots. The limit that was found was on the magnitude of picoseconds, meaning 10^{-12} s. If operations were faster than this limit, the qubit would break. This is a very small and not currently achievable speed of operation. It's nonetheless a fundamental limit and could become a problem in the future.