52. BREAKTHROUGH IN QUANTUM COMPUTING

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The information about Majorana 1 and general information about quantum computing is presented in this paper. Physical qualities of majorana particle are described.

The biggest problem with quantum computing right now is how fragile quantum computers are. This is because any interaction with a qubit (a particle that represents 0, 1 or something in between) like a stray photon or a random temperature fluctuation sets it to either 0 or 1 or in other words collapses the wave function, which, if done prematurely, can cause errors [1]. In addition, because of that quantum computers make use of shrouding, which does several things. Firstly, it allows to suck all the air out of the chamber so that a stray air particle does not bump into the computer. Secondly, it allows for the cooling to the 0.05 K. It also shields from electromagnetism, light, RF frequencies all in an attempt to preserve this quantum state. However, it is still not enough. Moreover error correction used in usual computers cannot be applied because of the no cloning theorem, instead two physical qubits work together to create a single, logical qubit. Moreover, those error correction units require a lot of redundancy: in modern systems one logical qubit requires hundreds or even thousands of physical qubits. Considering all that, a practical quantum computer would require it to be the size of a football field.

To make a quantum computer resistant to noise mention the majorana particle needs to be mentioned. This particle was proposed by Ettore Majorana – Italian physicist working in quantum and nuclear physics. In 1937 he published his theorem describing the majorana particle. It is unique in being its own antiparticle. For decades, physicists searched for majorana particles in high energy physics, however they never found it there. Instead, it was found in condensed matter in 2012 by researchers at Del University. They showed that in a small nanowire created from the combination of semiconductor and superconducting layers at exactly the right conditions, down to the individual atoms, majorana like behaviors suddenly arose.

This wire is produced from a semiconductor material that, like any semiconductor, contains mobile electrons. Those electrons move freely and can be controlled by electric field gates to move the electrons in and out the wire. On top of this semiconductor nanowire a thin layer of superconductor is deposited. By cooing the wire down to 0.05K necessary for quantum computing, superconductor enters its superconductive state, where electrons can move up and down its length with almost zero resistance moderated by cooper pairs of electrons that move freely within a superconductor. The strange part is that some of these cooper pairs can tunnel into the semiconductor nanowire below and allow the seimiconductor to borrow superconducting properties through a process called proximity effect. Then, when a strong magnetic field is applied the electronic states within the nanowire split into two separate quantum states that exist at either of the boundary ends of the nanowire. Those are the majorana particles, each – their own antiparticles. That means that information about the electrons on these wires is now spread across the length of the wire [2].

To build a qubit you always need two distinguishable states. You can use polarisation direction of light, or the spin of a trapped aisle, and here we use number of electrons on the nanowire. There will either be even which we could call zero or odd number of electrons which we could call one. If they were just sitting on a wire it would be very easy for a stray photon to knock one of the electrons out, changing the value. But for majorana particles, which are split between the whole wire, the information is no longer localised in individual electrons, and if some external noise disturbs one end of the system, it does not immediately destroy the quantum state

[3]. This gives us world's first topological quantum cubit. This also means extinctive error correction measures are not needed, and instead of a stadium of qubits it can fit on a chip that you can hold in your hand.

Next step for Microsoft is to scale up from eight qubits to a million. They also say that potentially, practical quantum computers are years away. The reason for such a short period is that now it is an engineering problem instead of a fundamental science problem. That means that instead of reinventing science proper engineering is needed.

References:

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