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In the past year, we've seen Google's first demonstration of 'quantum supremacy'. To achieve supremacy, a quantum computer needs to perform any computation which for all possible purposes, a conventional computer cannot. But before we get to quantum supremacy, let us see what a quantum computer is. All conventional computers work with quantum mechanics because their elements rely on quantum behaviour, but the operations that they perform are not quantum. Conventional computers store and handle information in form of bits that can take either of two values, 1 and 0. A quantum computer, on the other hand, stores information in the form of quantum-bits or q-bits, which can store any combination of 0 and 1. Operations on a quantum computer can then entangle the q-bits, which allow the quantum computer to solve certain problems much faster than a conventional computer. In principle, properties like conductivity, rigidity, or even colour, can be calculated from the atomic build-up of a molecule. But solving them with conventional computers would take too long. To truly realise the potential of quantum computing, consider this scenario - A quantum computer can be reproduced on a conventional one just by numerically resolving the equations of quantum mechanics. If successful, the computational complexity of the computer increases exponentially with the number of q-bits that are reproduced. On a personal computer, 2 or 4 q-bits might be feasible. For 50 q-bits, a group of supercomputers will be requisite and anything beyond that cannot presently resolved at present, at least not in any suitable amount of time. ## So what exactly is Quantum Supremacy? Quantum supremacy is the event in which a quantum computer outperforms the best conventional computers at a particular task. It needs to be a specific task because quantum computers are actually special-purpose machines designed to facilitate specific computations. This gives rise to the question - How do we test for quantum supremacy? Scott Joel Aaronson, a professor of computer science at the University of Texas proposes that we let a quantum computer do what it does best – be itself. If set up in a suitable way, the quantum computer will produce probabilistic distributions of measurable variables. Replicating the same on a conventional computer would take an inconveniently long amount of time. So by letting a conventional computer battle with a quantum one, we can demonstrate proof of quantum supremacy. The exact point at which quantum supremacy will be declared is a bit ambiguous, because one can always argue that better conventional computers could be used, or better algorithms could be developed. But for practical purposes, this really doesn't matter all that much, since quantum computers supersede conventional computers in terms of computational efficiency. ## The Future of Quantum Supremacy The motivation to build quantum computers stems from the fact that most molecules have quantum processes that surpass the computational limits of present-day supercomputers. And while quantum supremacy sounds like a very promising solution, the creation of random variables that can be used to confirm quantum supremacy fails to generate any useful results. Does that imply that quantum computers are really just new toys for scientists? And what would it take to calculate anything useful with a quantum computer? Estimates vary between half a million and a billion q-bits; depending on the subjectivity of what is deemed 'useful', and improvements in algorithms for quantum computers. And when will we get to see such a quantum computer? At present, no one knows. Most dominant approaches, like superconducting q-bits and ion traps are unlikely to scale. In neither case is there any development to get beyond a few hundred. To oversome the obstacles ahead effort is required on two fronts - research in engineering and bringing down cost of manufacture. And this is why, in recent years, there has been a lot of talk in the community about NISQ computers, which are 'noisy intermediate-scale quantum computers'. This actually is a term invented to make investors believe that quantum computing will have practical applications in the next few decades or so. The trouble with NISQs is that while it is likely that the will soon be practically feasible, no one knows how to calculate something useful with them. Personally speaking, I am not very optimistic that quantum computers will have practical applications any time soon. I share the same scepticism for quantum computing as I do for nuclear fusion; that it will remain forever promising but never quite work. Nonetheless, quantum supremacy is surely do for nuclear fusion, that it will remain forever promising but never quite work. Nonetheless, quantum supremacy is surely going to be super exciting.

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