Research team's results make development of quantum computers more realistic

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Together with a supporting research team, Kassel physicist Prof. Dr. Christiane Koch has made a discovery that is sure to attract significant attention among experts. Criteria established in the course of her research make the eventual development of the quantum computer more feasible.

Is there a flow of electrical current or not? Until now, the register of traditional bit computers can only determine between these two basic states. Complicated operations that depend on this distinction, such as the decryption of a coded message, take a correspondingly long period of time to complete. Computer scientists are hopeful that the development of quantum computers will facilitate an exponential acceleration of such processes. This would be possible because the quantum bits (or qubits) of a quantum computer can recognise multiple states at the same time, thereby making it possible for various logical operations to be executed simultaneously. This in turn would finally make it possible to handle calculations that are currently beyond the capacity of current technologies.

While the first quantum computers are indeed able to calculate very rapidly on this basis, the verification of the quantum operations has until now continued to take a large amount of time. This is mainly because the importing and exporting of the relevant information still has to take place in the tradition manner. Put simply, this means that the more qubits a quantum register has, the more time and effort is required to determine its condition following a logical operation. With the current protocols it takes several days to ascertain whether a quantum operation has been correctly executed, even with a small number of qubits. For the verification of 3 qubits, for example, 2 billion measurements are required. Even assuming that each of these measurements only lasts a microsecond, the measurement process in this instance will take an hour. In addition, with increasing numbers of qubits significantly more random checks must be undertaken, so that the verification of just 8 qubits requires a measurement time of one year.

In their study published in the prestigious journal *Physical Review Letters*, Daniel Reich, Dr. Giulia Gualdi und Prof. Dr. Koch have now shown how such operations can be verified with minimal resources. "The resources are a significant factor less than has heretofore been assumed," commented Prof. Dr. Koch, the leader of the research group Quantum Dynamics and Control at Kassel University. Through an ingenious use of the mathematical characteristics of quantum operations, the Kassel research team has demonstrated a way to achieve a considerable reduction in the necessary measurement time. For the verification of 8 qubits, only 3 days as opposed to hundreds of days will be required. "We have shown how one can best, that is to say how one can most efficiently test if the components of a quantum computer are functioning as they should," explains researcher Koch about the process. This will make it possible for designers of quantum computers to decide which protocol is most suitable for the concrete realisation of such a computer. This brings the real use of quantum computers one step closer. The Kassel research team's results will soon be tested in the context of a practical study.

More information: "Optimal Strategies for Estimating the Average Fidelity of Quantum Gates," Daniel M. Reich, Giulia Gualdi, and Christiane P. Koch *Phys. Rev. Lett.* 111, 200401 (2013).

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