New simulator is next step on the road to developing quantum computers

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Scientists have proven theoretically a novel way to build a simulator that can recreate the way atoms and particles behave in a quantum system, says research published today. The proposed simulator is unique because it could let researchers control how individual particles move and interact with each other. This ability to control individual parts of a quantum system is key to the development of powerful quantum computers in the future.

The term 'quantum system' is used to describe a system which is governed by the laws of quantum mechanics, as opposed to being governed by the classical laws of physics such as mechanics, gravity and Einstein's general theory of relativity. Quantum mechanics comes into play when systems are the size of atoms or smaller, because on this very small scale the conventional laws of mechanics no longer apply. Quantum computing devices of the future, which have not yet been successfully created, will rely on scientists harnessing quantum behaviour to create systems that can far exceed the speed and processing capabilities of current silicon-based computers.

The study, published in *Nature Physics*, shows that a device can be built which is able to simulate the behaviour of atoms and other particles according to the laws of quantum physics. The proposed simulator would consist of atoms and photons – particles of light – in an array of very small silicon cavities, measuring just 50 micrometres across. The researchers show that the atoms and photons inside the cavities would form a strongly-interacting many-body system, with photons jumping

from cavity to cavity, and at the same time being scattered off each other – all examples of quantum behaviour.

Dr Michael J Hartmann, who led the study along with his colleagues Mr. Fernando Brandão and Professor Martin Plenio from Imperial College London's Department of Physics and Institute for Mathematical Sciences, said: "Our research has successfully shown that it is possible to create a simulation of a system governed by the laws of quantum physics, in which scientists could have control of individual particles. This is a key theoretical discovery because in order to build the quantum computers of the future - which harness the power of atoms to perform calculations billions of times faster than normal computers – we will need to be able to manipulate quantum systems in this way."

Professor Plenio adds: "In the short term the simulator could be used to test the capabilities of materials at the atomic and sub-atomic level when quantum physics governs atoms' behaviour. In the very long run we anticipate that these kinds of simulators could potentially be used to create new materials with capabilities and characteristics which do not occur naturally."

Citation: "Strongly Interacting Polaritons in Coupled Arrays of Cavities", *Nature Physics*, 26 November 2006.

Source: Imperial College London