How quantum physics could make 'The Matrix' more efficient

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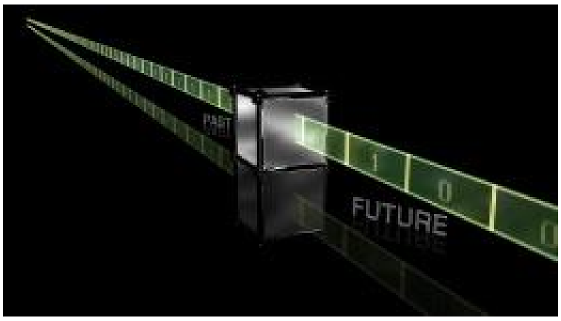

Quantum simulations need to store less information to predict the future than do classical simulations. The finding applies to phenomena described by stochastic processes. Credit: Mile Gu / Center for Quantum Technologies at the National University of Singapore

Researchers have discovered a new way in which computers based on quantum physics could beat the performance of classical computers. The work, by researchers based in Singapore and the UK, implies that a Matrix-like simulation of reality would require less memory on a quantum computer than on a classical computer. It also hints at a way to investigate whether a deeper theory lies beneath quantum theory. The finding is published 27 March in *Nature Communications*.

The finding emerges from fundamental consideration of how much information is needed to predict the future. Mile Gu, Elisabeth Rieper and Vlatko Vedral at the Centre for Quantum Technologies at the National Univesity of Singapore, with Karoline Wiesner from the University of Bristol, UK, considered the simulation of "stochastic" processes, where there are several possible outcomes to a given procedure, each occurring with a calculable probability. Many phenomena, from stock market movements to the diffusion of gases, can be modelled as stochastic processes.

The details of how to simulate such processes have long occupied researchers. The minimum amount of information required to simulate a given stochastic process is a significant topic of study in the field of complexity theory, where it is known in scientific literature as statistical complexity.

Researchers know how to calculate the amount of information transferred inherently in any stochastic process. Theoretically, this sets the lowest amount of information needed to simulate the process. In reality, however, classical simulations of stochastic processes require more storage than this.

Gu, Wiesner, Rieper and Vedral, who is also affiliated with the University of Oxford, UK, showed that quantum simulators need to store less information than the optimal classical simulators. That is because quantum simulations can encode information about the probabilities in a "superposition", where one quantum bit of information can represent more than one classical bit.

What surprised the researchers is that the quantum simulations are still not as efficient as they could be: they still have to store more information than the process would seem to need.

That suggests quantum theory might not yet be optimized. "What's fascinating to us is that there is still a gap. It makes you think, maybe here's a way of thinking about a theory beyond quantum physics," says Vedral.

More information: For further details, see "Quantum mechanics can reduce the complexity of classical models" *Nature Communications*, 3, 762 (2012). www.nature.com/ncomms/journal/ … full/ncomms1761.html

A preprint is available at arXiv:1102.1994 arxiv.org/abs/1102.1994

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