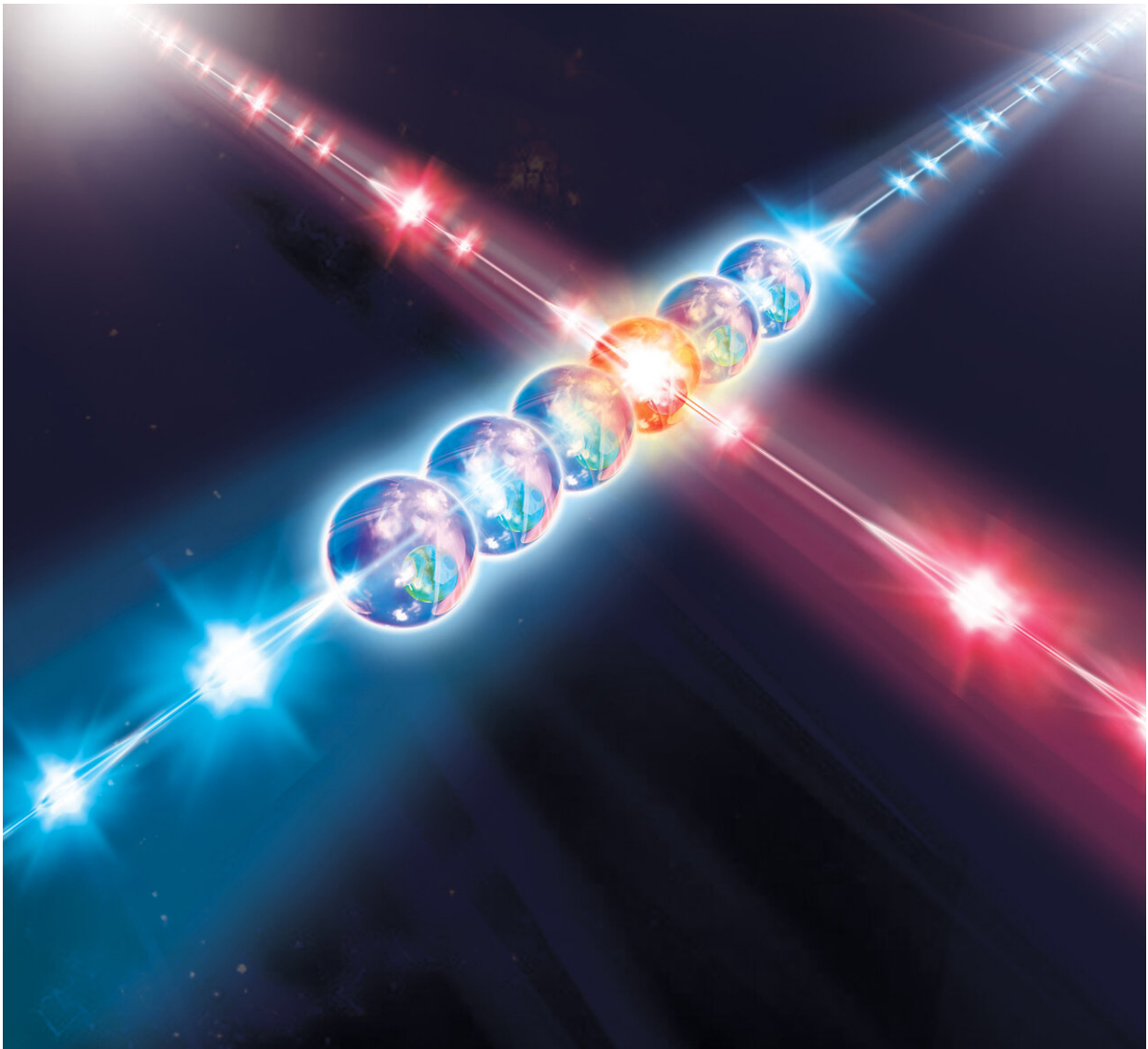


Quantum simulation more stable than expected

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Digital quantum simulation is intrinsically much more robust than what one might expect from known error bounds on the global many-body wave function.

Credit: IQOQI Innsbruck/Harald Ritsch

A localization phenomenon boosts the accuracy of solving quantum many-body problems with quantum computers. These problems are otherwise challenging for conventional computers. This brings such digital quantum simulation within reach using quantum devices available today.

Quantum computers promise to solve certain computational problems exponentially faster than any classical machine. "A particularly promising application is the solution of quantum many-body problems utilizing the concept of digital quantum simulation," says Markus Heyl from Max Planck Institute for the Physics of Complex in Dresden, Germany. "Such simulations could have a major impact on [quantum chemistry](#), [materials science](#) and fundamental physics."

Within digital quantum simulation, the [time evolution](#) of the targeted quantum many-body system is realized by a sequence of elementary quantum gates by discretizing time evolution, a process called Trotterization. "A fundamental challenge, however, is the control of an intrinsic error source, which appears due to this discretization," says Markus Heyl.

Together with international colleagues, they showed in a recent *Science Advances* article that quantum localization by constraining the time evolution through quantum interference strongly bounds these errors for local observables.

More robust than expected

"Digital quantum simulation is thus intrinsically much more robust than

what one might expect from known error bounds on the global many-body wave function," Heyl says. This robustness is characterized by a sharp threshold as a function of the utilized time granularity measured by the so-called Trotter step size. The threshold separates a regular region with controllable Trotter errors, where the system exhibits localization in the space of eigenstates of the time-evolution operator, from a quantum chaotic regime where errors accumulate quickly rendering the outcome of the quantum simulation unusable.

"Our findings show that digital quantum simulation with comparatively large Trotter steps can retain controlled Trotter errors for local observables," says Markus Heyl. "It is thus possible to reduce the number of quantum gate operations required to represent the desired time evolution faithfully, thereby mitigating the effects of imperfect individual gate operations." This brings digital quantum simulation for classically challenging quantum many-body problems within reach for current day [quantum](#) devices.

More information: "Quantum localization bounds Trotter errors in digital quantum simulation" *Science Advances* (2019). [DOI: 10.1126/sciadv.aau8342](#) , [advances.sciencemag.org/content/5/4/eaau8342](#)

Provided by University of Innsbruck

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