Nature Reviews Physics | https://doi.org/10.1038/s42254-019-0133-4 | Published online 3 December 2019

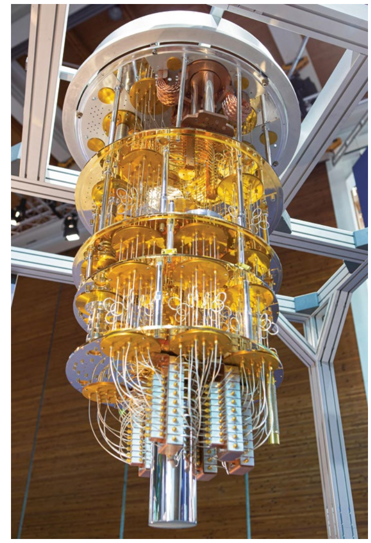
QUANTUM SIMULATION

State of the art

Recently, Google reported a demonstration of quantum supremacy with its 53-qubit digital quantum computer, in that it beat classical machines for a specific task. But quantum computers have yet to show a clear advantage in tackling practical problems, such as simulating quantum systems. Are current commercial quantum computers with tens of qubits ready to run useful quantum simulations?

Not yet. Writing in *npj Quantum Information* Adam Smith and colleagues report on a textbook example of a condensed matter system simulated on the IBM 20-qubit quantum computer (pictured). Smith et al. investigated the far-from-equilibrium dynamics of 1D spin-1/2 chains that underlie interesting physics from quantum magnetism to many-body localization. The unitary time evolution of the system is broken down into elementary operations that are the building blocks (one- and two-qubit gates) of quantum computation. An initial state is prepared, then evolved to the final state through the series of operations. From the final state quantities such as the magnetization are extracted and compared with numerical results obtained with a classical computer. The results of this digital quantum simulation show low quantitative accuracy, because the error rates of the quantum computer are still large. On the bright side, they do qualitatively reproduce the physics.

Smith and co-workers conclude that, for this type of problem, quantum simulation still "requires an order of magnitude improvement in fidelity and coherence until it will realistically outperform classical computers". Thus, dealing with errors is at the top of the agenda.



Credit: lamapress/Alamy Stock Photo

Iulia Georgescu

ORIGINAL ARTICLE Smith, A. et al. Simulating quantum many-body dynamics on a current digital quantum computer. *npj Quantum Inf.* https://doi.org/10.1038/s41534-019-0217-0 (2019)
RELATED ARTICLE Arute, F. et al. Quantum supremacy using a programmable superconducting processor. *Nature* **574**, 505–510 (2019)