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An active role for quantum computation in exploration seismology

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Summary

Quantum computation has been developed as a computationally efficient paradigm to solve problems that are intractable with conventional classical computers. Quantum computers have the potential to support the simulation and modeling of many complex physical systems, not just quantum ones, significantly more rapidly than conventional supercomputers.

The increasing demand for computational resources in a variety of disciplines in science, based on this promise, motivates the development of quantum computers in addition to that of classical supercomputers. Recent advances in quantum computer hardware and software have led to a jump in the number of discipline areas of pure and applied science identifying themselves as stakeholders in quantum computation technology. Areas such as chemistry, biology, machine learning and finance are clearly on this list, and it is the purpose of our research to advocate that geophysics should be too.

In seismology, simulation is critical; ultimately, we would like to use quantum computation for numerical modeling of seismic wave propagation for earthquake modeling and reservoir characterization**.** Seismic exploration and monitoring practitioners and researchers in particular stand to gain an enormously powerful tool when quantum computers come online. Meaningful advances in seismic exploration methods depend on progress in computer hardware and software technology. In our view, it is essential for geophysicists to start to become familiar with the ideas and the potential within the computers and algorithms in the quantum regime, in order to properly take advantage of these tools as they become available. In this reswearch, the effectiveness in principle of quantum algorithms for seismic wave modeling and seismic imaging is discussed, at the same time introducing in geo-scientific terms the opportunities and challenges of quantum computation. We examine the extent to which quantum computer will be able to solve both the seismic modeling and imaging problems, by exploiting quantum algorithms such as quantum linear systems of equations, quantum Fourier transform and quantum database search.

The idea of using quantum computation in seismology should be very exciting to both physicists and seismologist. Researchers in quantum computation are looking for new quantum algorithms to demonstrate the substantial speed-up over the classical counterparts. At the present, the interplay between quantum theory and geophysics remains unexplored. However, we believe that quantum computation shows a significant potential to deal with the large-scale modeling and inversion problems geophysicists currently encountered.

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