The need for fast and easy access to facilities for quantum computation/simulations

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Quantum Information Science (QIS) is at the heart of important problems at the frontier of our understanding of high-energy physics (HEP). These include consistent formulations of quantum gravity, the evolution of the early universe, dealing with fermions with a sign problem and real-time calculations for strongly interacting particles.

As we gain better control of the manipulation of small quantum systems, the idea of using physical quantum systems to study theoretical quantum models [1] has generated many exciting developments. General arguments [2] show that for local interactions, using quantum versions of the bits used by usual computers (qubits for quantum computing), could drastically reduce the computational effort for problems involving local quantum field theory.

In this rapidly evolving landscape at the interface between HEP and QIS, it is important for the HEP theory community to identify optimal ways to have access to state of the art programmable quantum computers or quantum simulation experiments. In the coming years, being able to use multiple platforms (e.g. superconducting devices, Rydberg atoms, trapped ions, cavities, etc.) which would each be the most suitable to particular problems will allow rapid progress on those specific problems. In practice this access could be through existing experimental setups, either from labs located in Universities or by contracting private companies such as IBM, ION-Q, and QuERA.

One successful model for how this might work is to look to USQCD which is a meta collaboration of all US lattice gauge theorists. This collaboration solicits proposals for members for computing time on dedicated hardware and also makes community wide bids for time on leadership class hardware managed by the DOE. One could envisage a collaboration of US HEP-QIS theorists who's main goal would be to evaluate individual proposals and coordinate access to different hardware platforms available at national labs or commercial sites. It would also facilitate communication between people developing QC hardware and the needs of the theorists developing algorithms and software for HEP applications. USQCD has been very successful having a collaborative Algorithm Development team feeding into independent and basically competing individual groups. It is like a “virtual US lab” that could be emulated for the QIS community.

It is also important to identify the most pressing needs of the potential users. For these reasons, we need to enhance the communication between the HEP researchers and experimentalists developing new computational platforms. It is expected that the HEP effort will have serendipitous beneficial effects on QIS and other areas of research such as nuclear and condensed matter physics.

References

[1] R. P. Feynman. Simulating Physics with Computers. *International Journal of Theoretical Physics*, 21:467–488, June 1982.

[2] Seth Lloyd. Universal quantum simulators. *Science*, 273(5278):1073–1078, 1996.