Quantum algorithms, quantum field theory, and computational complexity

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Quantum field theory provides the framework for the Standard Model of particle physics and plays a key role in physics. However, calculations are generally computationally complex and limited to weak interaction strengths. I'll describe an extension of our quantum algorithm for computing relativistic scattering amplitudes in scalar quantum field theories to fermionic theories. The algorithms run in polynomial time and thus achieve exponential speedup over known classical methods. One of the motivations for this work comes from computational complexity theory. Ultimately, we wish to know what is the computational power of our universe. Studying such quantum algorithms probes whether a universal quantum computer is powerful enough to represent quantum field theory; in other words, is quantum field theory in BQP? Conversely, one can ask whether a given quantum field theory can implement a universal quantum computer; is quantum field theory BQP-hard? I'll describe our approach to addressing the question of BQP-hardness.