Simulating complex, non-Markovian processes with quantum physics

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Abstract:

Stochastic processes are as ubiquitous throughout the quantitative sciences as they are notorious for being difficult to simulate and predict. Weather patterns, stock prices, and biological evolution are just some of the most prominent examples.
In the last decades a sophisticated framework, called 'computational mechanics', has been developed that studies the complexity of such processes in terms of the minimal memory required for their simulation. More recently, it was discovered that this memory requirement for simulation may be further reduced by using a quantum instead of a classical memory substrate. Based on these results, we have developed a generic method for constructing a unitary quantum simulator for a large class of stochastic processes. Unlike previous works which were focused on fundamental aspects of statistical complexity our construction opens the door to experimental implementation by providing a construction which is both simple and practical.
In this talk I will give a brief an introduction to computational mechanics and statistical complexity as well as their extension to quantum memory. I will then describe a proposal for the construction of a unitary quantum simulator which is applicable to a large class of stochastic processes.