Quantum to classical computability transition via negative Markov chains formalism

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In this talk I will present a recently introduced representation of quantum dynamics based on negative Markov chain processes. By introducing particles and antiparticles, this formalism enables the mapping of generic quantum dynamics onto a Markov process defined over an exponentially large configuration space. Within this framework, quantum complexity arises from the proliferation of stochastic particles, which ultimately renders classical simulation intractable beyond a certain timescale. In the presence of noise, we demonstrate that for any unitary evolution generated by a linear combination of local or pairwise interactions, there exists at least one noise channel that effectively classicalizes the system by suppressing the growth of stochastic particles. As a corollary, we show that for this class of unitaries, the dynamics of an open quantum spin chain subject to depolarizing noise undergo an exact transition to classical simulability once the noise strength exceeds a critical threshold.