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A classical-quantum approximation for bipartite quantum systems

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We derive a "classical-quantum" approximation scheme for a broad class of bipartite quantum systems. In this approximation, one subsystem's evolution is governed by classical equations of motion with quantum corrections, and the other subsystem evolves quantum mechanically with equations of motion informed by the classical degrees of freedom. Similar approximations are common when discussing the backreaction of quantum fields on curved spacetime, as in Hawking radiation around black holes or the generation of primordial perturbations in inflation. We derive an estimate for the growth rate of entanglement between the subsystems, which allows us to predict the "scrambling time": the amount of time required for the subsystems to become significantly entangled. We illustrate the general formalism by numerically studying the fully quantum, fully classical, and classical-quantum dynamics of system of two oscillators with non-linear coupling.

Keyword-1

Quantum entanglement

Keyword-2

Semiclassical approximations

Keyword-3

Quantum gravity

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