Thermalisation of a quantum system from first principle

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Abstract

How does a quantum system reach thermodynamical equilibrium? Answering such a question from first principles is, perhaps surprisingly, still an open issue (Popescu Nat. Phys. 2006, Goldstein PRL 2006, Genway PRL 2013). We present here a new model comprising an arbitrary quantum system interacting with a large arbitrary quantum environment, both initially prepared in a quantum pure state. We then demonstrate that thermalisation is an emergent property of the unitary evolution under a Schrodinger equation of this large composite system. The key conceptual tool of our method is the phenomenon of "measure concentration" appearing with functions defined on large dimension Hilbert spaces, a phenomenon which cancels out any effect of the microscopic structure of interactionHamiltonians. Using our model, we first characterize the transient evolution or decoherence of the system and show its universal character. We then focus on the stationary regime and recover the canonical state well known from statistical thermodynamics. This finding leads us to propose an alternative and more general definition of the canonical partition function, that includes, among other things, the possibility of describing partial thermalisation.

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