# Entanglement and the foundations of statistical mechanics

SANDU POPESCU[1,2], ANTHONY J. SHORT[1]* AND ANDREAS WINTER[3]

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Statistical mechanics is one of the most successful areas of physics. Yet, almost 150 years since its inception, its foundations and basic postulates are still the subject of debate. Here we suggest that the main postulate of statistical mechanics, the equal *a priori* probability postulate, should be abandoned as misleading and unnecessary. We argue that it should be replaced by a general canonical principle, whose physical content is fundamentally different from the postulate it replaces: it refers to individual states, rather than to ensemble or time averages. Furthermore, whereas the original postulate is an unprovable assumption, the principle we propose is mathematically proven. The key element in this proof is the quantum entanglement between the system and its environment. Our approach separates the issue of finding the canonical state from finding out how close a system is to it, allowing us to go even beyond the usual boltzmannian situation.

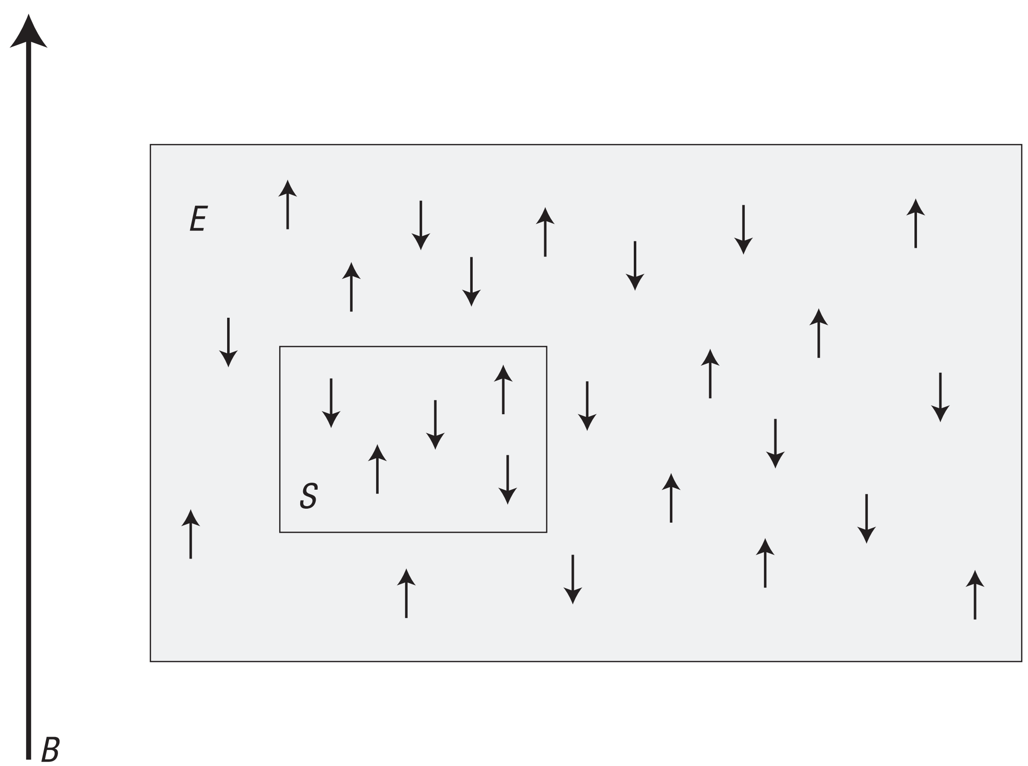


**Figure 3 Example: A system of spins.** As a concrete application of our theorem, consider a set of $n$ spin-1/2 systems in an external magnetic field $B$, where a

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# Thermalization and its mechanism for generic isolated quantum systems

Marcos Rigol[1,2], Vanja Dunjko[1,2] & Maxim Olshanii[2]

**An understanding of the temporal evolution of isolated many-body quantum systems has long been elusive. Recently, meaningful experimental studies[1,2] of the problem have become possible, stimulating theoretical interest[3–7]. In generic isolated systems, non-equilibrium dynamics is expected[8,9] to result in thermalization: a relaxation to states in which the values of macroscopic quantities are stationary, universal with respect to widely differing initial conditions, and predictable using statistical mechanics.**

**for the outcomes of relaxation in such systems. Here we demonstrate that a generic isolated quantum many-body system does relax to a state well described by the standard statistical-mechanical prescription. Moreover, we show that time evolution itself plays**

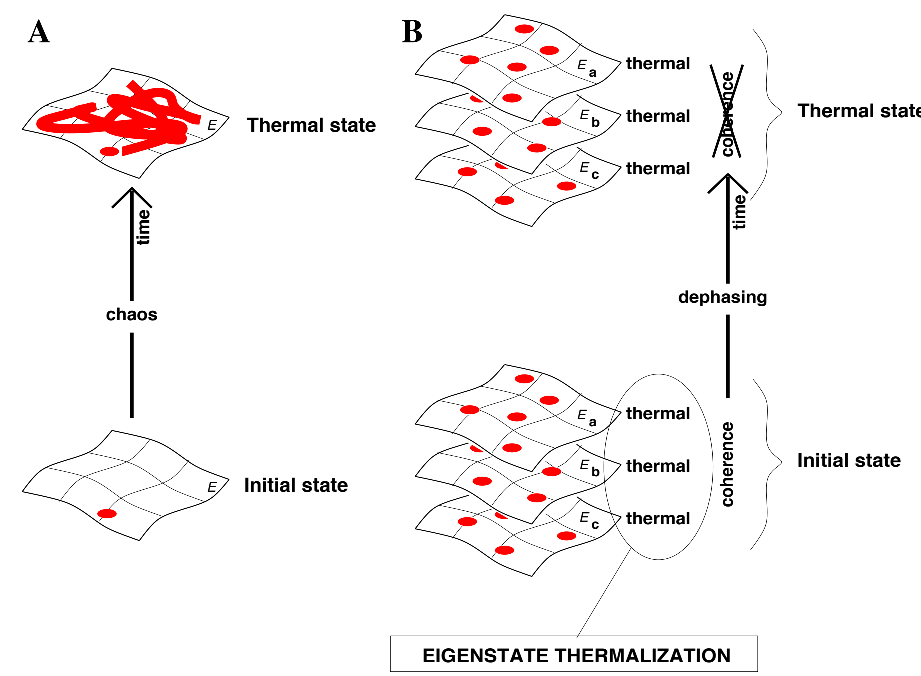


FIG. 2: **Thermalization in classical vs quantum mechanics**. **a**, In classical mechanics, time evolution constructs the thermal state from an initial state that generally bears no resemblance to the former. **b**, In quantum mechanics, according to the eigenstate thermalization hypothesis, every eigenstate of the Hamiltonian always implicitly contains a thermal state. The coherence between the eigenstates initially hides it, but time dynamics reveals it through dephasing.