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Integrability versus Thermalizability in Isolated Quantum Systems[1]

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The purpose of this presentation is to assess the status of our understanding of the transition from integrability to thermalizability in isolated quantum systems. In Classical Mechanics, the boundary stripe between the two is relatively sharp: its integrability edge is marked by the appearance of finite Lyapunov's exponents that further converge to a unique value when the ergodicity edge is reached. Classical ergodicity is a universal property: if a system is ergodic, then every observable attains its microcanonical value in the infinite time average over the trajectory. On the contrary, in Quantum Mechanics, Lyapunov's exponents are always zero. Furthermore, since quantum dynamics necessarily invokes coherent superpositions of eigenstates of different energy, projectors to the eigenstates become more relevant; those in turn never thermalize. All of the above indicates that in quantum many-body systems, (a) the integrability-thermalizability transition is smooth, and (b) the degree of thermalizability is not absolute like in classical mechanics, but it is relative to the class of observables of interest. In accordance with these observations, we propose a concrete measure of the degree of quantum thermalizability, consistent with the expected empirical manifestations of it. As a practical application of this measure, we devise a unified recipe for choosing an optimal set of conserved quantities to govern the after-relaxation values of observables, in both integrable quantum systems and in quantum systems in between integrable and thermalizable.

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