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IUPAP C10 2011 Young Scientist Prize in the Structure and Dynamics of Condensed Matter Talk: Breakdown of thermalization in finite one-dimensional systems[1]

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Little more than fifty years ago, Fermi, Pasta, and Ulam set up a numerical experiment to prove the ergodic hypothesis for a one-dimensional lattice of harmonic oscillators when nonlinear couplings were added. Much to their surprise, the system exhibited long-time periodic dynamics with no signals of ergodic behavior. Those results motivated intense research, which ultimately gave rise to the modern chaos theory and to a better understanding of the basic principles of classical statistical mechanics. More recently, experiments with ultracold gases in one-dimensional geometries have challenged our understanding of the quantum domain. After bringing a nearly isolated system out of equilibrium, no signals of relaxation to the expected thermal equilibrium distribution were observed. Some of those results can be understood in the framework of integrable quantum systems, but then it remains the question of why thermalization did not occur even when the system was supposed to be far from integrability. In the latter regime, thermalization is expected to occur and can be understood on the basis of the eigenstate thermalization hypothesis. In this talk, we utilize quantum quenches to study how thermalization breaks down in finite one-dimensional lattices as one approaches an integrable point. We establish a direct connection between the presence or absence of thermalization and the validity or failure of the eigenstate thermalization hypothesis, respectively.

References:

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