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MAX PLANCK LECTURE ON NON-EQUILIBRIUM QUANTUM PHENOMENA

To thermalize or not to thermalize?

We will discuss two experiments designed to investigate how integrable quantum many-body systems do or do not thermalize in the presence of integrability breaking perturbations.

In the first experiment, a quantum Newton's cradle is set in motion under different strengths of a magnetic interaction among the dysprosium atoms in an ultracold 1D gas. Rotating the dipoles tunes the strength of the integrability-breaking perturbation. Surprisingly, we are able to predict the strong thermalization rate dependance on dipole angle with a simple expression.

We then discuss how we have created novel nonthermal "quantum many-body scar" states in the same 1D gas of dysprosium. Even more surprisingly, we find that these same integrability-breaking dipolar interactions *stabilize* a super-Tonks-Girardeau gas against collapse and thermalization regardless of contact interaction strength. This enables us to cycle contact interactions from weakly to strongly repulsive, then strongly attractive, and finally weakly attractive. We show that this quench cycle is an unusual energy-space topological pump due to a quantum holonomy in the underlying Hamiltonian. Iterating this cycle offers an unexplored topological pumping method for creating a novel hierarchy of increasingly excited prethermal scar states.

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https://www.mpsd.mpg.de/neqp-lecture#lev