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Dynamical properties of disordered Heisenberg spin models realized with Rydberg atoms

Abstract: Understanding the relaxation dynamics of closed quantum systems far from equilibrium is one of the major unresolved problems in quantum physics. Non-integrable disordered systems in 3D are expected to relax to a thermal state. The dynamics of this relaxation process, however, can show a wide variety of phenomena ranging from exponential relaxation to kinetic arrest and prethermal states known from spin glass physics. We use Rydberg excited atoms to implement a Heisenberg spin model (XXZ model) with tunable disorder. The decay of the magnetization of an initially spin polarized ensemble shows a stretched exponential behavior. The exponent characterizing this decay is constant over a wide range of disorder strengths. Applying various numerical techniques to reproduce the experimental observation we find that while a simple mean field treatment fails completely a semiclassical approach performs surprisingly well.