Experimental evidence of an Anderson-like transition of many-body localization by competing dipolar interactions

Gonzalo A. Álvarez[1], Dieter Suter[2], and Robin Kaiser[3]

[1] Department of Chemical Physics, Weizmann Institute of Science, Israel.

[2] Fakultät Physik, Technische Universität Dortmund, Dortmund, Germany.

[3] Universite de Nice Sophia Antipolis, Institut Non-Lineaire de Nice, France.

The non-equilibrium dynamics of many-body systems has many intriguing effects that are not completely understood. In particular, localization effects of many-body states can be induced either by disorder or the interplay between different interactions. We performed nuclear magnetic resonance (NMR) experiments of a many-body 3D spin-network with dipole-dipole interactions that scale with the distance between spins with $1/r^3$ and the angle between a static magnetic field and the distance vector between the spins. By controlling a perturbation interaction to a Hamiltonian that creates clusters of correlated spins which size grows with time, we observed localization effects as a function of the perturbation strength [1,2]. We used a finite-time scaling procedure [3] to study the long time regime of the evolution of the cluster size of correlated spins. We present strong evidence of a manifestation of a sharp transition on the dynamical behavior of the cluster size as a function of the perturbation strength. We interpret this critical behavior as a kind of an Anderson-like transition [3] from a non-localized to a localized regime at a finite perturbation strength. This presents new routes that can be implemented also by other communities trying to distill the physics of the many-body localization phenomena.

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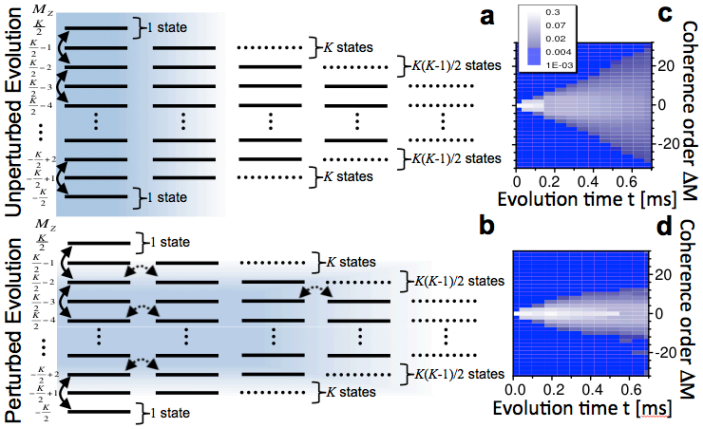

Figure: Evolution scheme on the Zeeman basis. The solid arrows represent the H_0 interactions and the dotted arrow the H_{dd} interactions. The gradient tones schematize the spreading of the initial population of the states. While in (a) the spreading is on the vertical direction, in (b) the spreading is in both directions (vertical and horizontal). (c,d) Coherence spectrum of the density matrix for the unperturbed (non-localized) and perturbed (localized) evolutions respectively.