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Quantum simulations for dipolar spin systems in optical lattices

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We study spin systems made of large number of spin 3 chromium atoms loaded in 3D optical lattices. We both study out-of-equilibrium spin dynamics from a high energy initial state, and how to reach the ground state of a textbook spin Hamiltonian. Experimental results are compared with different approximated quantum models.

Out-of-equilibrium spin dynamics follows a collective rotation of an initially polarized ensemble, with respect to the external magnetic field.
In deep optical lattices, with unit filling, the pure dipolar spin dynamics is benchmarked by comparison with an improved numerical quantum phase-space method. Although isolated from environment, the many body state reaches an equilibrium at long dynamics time, which is described by a thermal distribution. Our system provides an example of quantum thermalization, where evolution towards a thermal-like state is tied to the growth of entanglement entropy [1].
When varying the lattice depth, we explore regimes where spin dynamics is also due to tunneling and super exchange processes. We compare our results with approximated models, i.e. the Gutzwiller approach.

We also present preliminary results about the experimental realization of an XXZ transverse spin Hamiltonian. By ramping the transverse field, we are able to produce non trivial spin states, and investigate a phase diagram which can be compared to both mean field and quantum simulations.

[1] Lepoutre et al, accepted at Nature Communication

Choix de session parallèle

4.3 Simulateurs quantiques

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