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Controlling Dipolar Exchange Interactions in a Dense 3D Array of Large Spin Fermions

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Ultracold atoms loaded into optical lattices have developed over the last two decades into an excellent platform to study quantum many-body problems. Their high degree of isolation, purity and tunability have enabled to reach regimes, that challenge theoretical state-of-the-art tools and that are inaccessible for present supercomputers.

In my talk, I report on our joint experimental and theoretical study of large and dense quantum gases of fermionic erbium loaded into a deep three-dimensional optical lattice. The atoms posses a strong magnetic dipole moment, that allows for dipolar off-site coupling between individual atoms. Furthermore, they exhibit an internal hyperfine-manifold of 20 spin states (m_F). By combining both features, our system realizes a large-spin, long-range \textit{XXZ Heisenberg model}. Initializing the system in a target m_F state, we study the non-equilibrium, dipolar-driven spin-exchange dynamics and find a diffusion of the spin population. We demonstrate the tunability of the diffusion rate by either changing the initially prepared m_F state, or by directly tuning the orientation of the atomic magnetic moments.
Finally, we benchmark our experiment with an advanced theoretical model and find very good agreement. The theory reveals the important role of quantum dynamics (beyond the meanfield level) and shows the significance of beyond nearest-neighbor effects.

Choix de session parallèle

4.3 Simulateurs quantiques

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