Non-equilibrium quantum magnetism in a dipolar lattice gas

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Résumé

Research on quantum magnetism with ultra-cold gases in optical lattices may open fascinating perspectives for the study of fundamental problems in condensed-matter physics. In this seminar I will describe an experiment where a Bose-Einstein condensate of Chromium atoms is loaded into deep 3D optical lattices. Due to their large magnetic dipole moment, Chromium atoms interact at long distance via dipole-dipole interactions. These interactions provide intersite spin-spin interactions without relying on super-exchange energies, which constitutes a great advantage for the study of spin lattice models. I will show that a chromium gas in a 3D lattice thus realizes a lattice model resembling the celebrated t-J model. In our experiment, this is characterized by a non-equilibrium spinor dynamics resulting from inter-site Heisenberg-like spin-spin interactions provided by non-local dipole-dipole interactions. I will also describe the complex spin dynamics which arises in presence of doubly-occupied sites. We observe an interplay between short-range contact interactions and long-range dipolar interactions, which further reveals the interest of chromium lattice gases for the study of quantum magnetism of high-spin systems. Finally, I will show that the anisotropy of dipolar interactions introduces the possibility of magnetization changing collisions. In a lattice, these collisions may resonantly happen when the energy released in a dipolar relaxation event (the Larmor energy, tuned by the magnetic field) matches the energy for band excitation. Dipolar interactions thus introduce an intrinsic non-linear spin-orbit coupling which may qualitatively modify the study of quantum magnetism.

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