Quantum magnetism with a Bose-Einstein Condensate

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Ultra-cold atomic gases are attracting considerable interest thanks to the many opportunities they provide to explore novel domains in quantum physics. Physicists from various disciplines gather to explore problems at the interfaces of AMO physics with condensed matter and statistical physics. Magnetic high-spin atoms such as chromium provide a test-bed to study the effects of long-range interactions in quantum many-body problems as well as the interplay between internal and external degrees of freedom. We report on two series of experiments using a spin-3 chromium Bose-Einstein condensate. In a first series, we demonstrate the stabilization of this quantum gas against dipolar relaxation loss processes by transferring the BEC in a 3D optical lattice. We also demonstrate how dipolar relaxation then acquires a resonant character as a function of the ambient magnetic field [1]. In another series of experiments, we observe for the first time magnetic dipolar interaction driven spin dynamics [2]. Starting from a Mott state, spin exchange oscillations are observed on two distinct timescales. Rapid oscillations result from contact interactions between atoms located in the same lattice sites. Slow oscillations result from dipolar interactions between atoms sitting at different sites of the lattice. Our work pioneers the experimental realization of quantum magnetism where dynamics is driven by long-range spin-spin interactions between distant lattice sites.

References

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