

Large spin atoms in optical lattices

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Our experimental projects at the Laser Physics Institute (North Paris University) aim at characterizing entanglement for many-body systems made of large spin atoms. For this, we developed two experimental set-ups: one with large-spin strontium fermionic atoms, with spin-independent contact interactions; one with large-spin chromium bosonic atoms, with spin-dependent long-range dipole-dipole interactions.

I will first briefly describe our first measurements of the spin distribution of the $SU(N)$ Fermi gas made of strontium atoms. For this, we used a spin-orbit coupling scheme, where a retroreflected laser beam selectively diffracts two spin components in opposite directions. Spin sensitivity is provided by sweeping through a magnetic-field sensitive transition while dark states ensure that spontaneous emission remains low.

On the chromium machine, we investigated the spin dynamics and quantum thermalization of a macroscopic ensemble of $S = 3$ spins initially prepared in a pure coherent spin state. The experiment uses a unit-filled array of 10 thousand chromium atoms in a three dimensional optical lattice. Atoms interact at long distance under the effect of magnetic dipole-dipole interactions, realizing the spin-3 XXZ Heisenberg model with long-range couplings. We investigated the build-up of quantum correlations in this many-body system. For this, we measured collective properties such as the total population in the seven different Zeeman states, or the collective spin length. We also found that the measurement of magnetization fluctuations provides direct quantitative estimates for two-body correlations.