The Fascination of Lanthanides as Ultracold Quantum Matter

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Ultracold atomic quantum gases have exceptional properties and offer an ideal test-bed to elucidate intriguing phenomena of modern quantum physics. The great appeal of such systems stems from the possibility to control almost on demand the interaction between the particles. This interaction is commonly isotropic and short-ranged. However, recent studies have demonstrated the power of a novel class of exotic atomic elements belonging to the lanthanides family for quantum-matter physics. Lanthanides, such as Er (erbium) that is here discussed, have more complex and rich interaction than the commonly-used alkali atoms, opening new research scenarios for scattering and many-body quantum physics.

Because of their large magnetic moment, the fundamental interaction between the atoms has a non-isotropic nature and a long-range character. In addition, in their ground-state the atoms experience a highly non isotropic orbital distribution of electrons around the atom's nucleus. This orbital anisotropy is reflected in the appearance of anisotropic van der Waal contributions to the molecular potentials. Due to these characteristics, we observe a number of novel fascinating effects from the distortion of the Fermi surface in a gas of fermions near zero temperature, to the appearance of a correlated net of Feshbach resonances in the atomic scattering.