Ultracold dipolar quantum gases with atomic erbium

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In the field of ultracold quantum gases, only recently non-alkali-metal atoms have become of central interest thanks to their special properties that open novel fascitating frontiers in quantum physics. Species with multiple unpaired valence electrons, such as lanthanides, have a very rich atomic energy spectrum and provide exceptionally large magnetic moments. The interaction between strongly magnetic lanthanides is dominated by long-range magnetic dipole-dipole forces and the study of unexplored dipolar phenomena, e.g. crystal phase, super-solid phase or p-wave pairing, is accessible.

In our experiment in Innsbruck we have produced the first Bose-Einstein condensate (BEC) of ^{168}Er and could demonstrate the dipolar-induced d-wave collapse of the superfluid. One of the key ingredients for this experiment is the magnetic tunability of the contact interaction exploiting so-called Feshbach resonances. In quantum gas experiments the contact interaction can easily be controlled by changing an external magnetic field.

For various Erbium isotopes we found a much richer resonant interaction spectrum as compared to alkali quantum gases. Taking advantage, these resonances allow to magnetically associate atoms and to form dipolar Er_2 molecules at ultralow temperatures of around 100nK. The molecules have large magnetic dipole moments of up to 12μB - almost two times larger than for atoms. In molecule-molecule collisions the effect of the dipolar interaction is already comparable to the interaction of heteronuclear systems such as ground state RbK molecules. With erbium molecules a collisionally stable system can be realized.