Ferromagnetism in an atomic quantum spin mixture

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Abstract: At CNR-INO lab in Trento we realize highly tunable quantum spin mixtures of sodim atoms, exhibiting magnetic properties. Such an experimental platform is extremely versatile and can be exploited as quantum simulator of different phenomena.

Laser cooling allows to bring dilute gases to such low temperatures that internal and external atomic degrees of freedom can be highly controlled. Their extreme tunability favours the implementation of diverse configurations which mimic the behaviour of other systems in nature, characteristic of different fields and scales, from solid state to cosmology, to name a few.

At CNR-INO lab in Trento, we routinely produce superfluid gases of bosonic sodium atoms and allow them to populate just two specific internal spin states. Such a quantum mixture [1], in the presence of a coherent coupling between two spin states, and in an ultrastable magnetic field environment [2,3], exhibits magnetic properties. We investigated the transition from paramagnet to ferromagnet measuring the full phase diagram, observing the characteristic bifurcation and hysteresis and showing the possibility to create magnetic domain walls [4] on demand.

Lately, we investigated the spontaneous decay mechanism of an extended metastable (spin up) system to the ground state (spin down) through the formation of macroscopic spin bubbles. Using a field theory approach on the field describing our coherently-coupled spin mixture, it is possible to estimate the characteristic time associated to such a decay process. We experimentally verified the exponential dependence of the timescale on the distance from critical point [5] and are currently investigating how the system temperature affects the timescales.

Figure 1 shows the spatial distribution of spin up (above) and spin down (below) of a ferromagnetic superfluid sodium system, trapped in a flat potential. Starting from a uniform metastable configuration with all spins up, spin-down bubbles spontaneously formed in random locations.

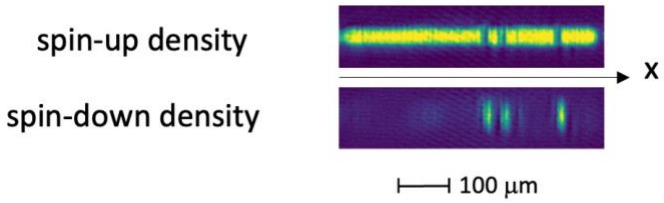

Fig. 1 Spin bubbles spontaneously formed in a metastable ferromagnetic superfluid mixture.

References

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