Quantum tunneling of atomic magnetic moments

The (quantum) tunneling of the magnetization is a fascinating process that allows a spin reversal without climbing the energy barrier separating opposite orientations. This effect has been extensively studied in single molecule magnets (SMMs) that are built from magnetic clusters embedded in a complex, non-magnetic host. The implications range from basic research on resonant tunneling and topological interference to potential applications in quantum computing and data storage.

In iron-doped lithium nitride, $Li_2(Li_{1-x}Fe_x)N$, the basic magnetic unit is not a cluster but the magnetic moment of single, isolated iron atoms, which are embedded in the non-magnetic lithium nitride matrix [1]. This novel model system shows an extremely large magnetic anisotropy and allows to study quantum tunneling of the magnetization in a rather simple, inorganic material. At the origin of the outstanding properties is the special geometry that the iron finds itself in: the linear coordination between two nitrogen atoms is not subject to a Jahn-Teller distortion and gives rise to an unquenched orbital moment. Accordingly, this rare-earth-free material shows a huge hysteresis with coercivity fields of more than 11 Tesla.

Recently we have found an extreme field dependence of the tunneling in dilute iron-doped Li_3N [2]. The spin-flip probability strongly increases in *transverse* magnetic fields that proves the resonant character of this tunneling process. Applied *Longitudinal* fields, on the other hand, lift the ground-state degeneracy and destroy the tunneling condition. An increase of the relaxation time by four orders of magnitude in applied fields of only a few milliTesla reveals exceptionally sharp tunneling resonances. Therefore, it is possible either to freeze the orientation or to promote the flip of a spin-state by tiny applied fields. The up and down states of the iron atom's spin have been made switchable and provide an 'atomic quantum bit' at easily accessible liquid helium temperatures.

[1] A. Jesche *et al.* Nat. Commun. 5:3333 (2014) doi: 10.1038/ncomms4333

[2] M. Fix, J. H. Atkinson, P. C. Canfield, E. del Barco & A. Jesche Phys. Rev. Lett. 120, 147202 (2018)