Local magnetic fields to explore novel behaviors in frustrated and quantum magnetism

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The complexity embedded in condensed matter fertilizes the discovery of new states of matter, enriched by ingredients like frustration, low-dimensionality or quantum fluctuations. Illustrating examples in magnetic systems are quantum spin liquids in spin chains or 2-dimensional frustrated materials or spin ices in 3-dimensional pyrochlore compounds. They support fractionalized excitations, for example the magnetic charges in spin ices, also called monopoles, or the spinons in quantum spin liquids. To explore the phase diagrams of this rich physics, external parameters are commonly used such as magnetic or electric fields, pressure or doping effects.
Here I will take an alternative route with two selected studies where another driving parameter, a local staggered field, can change drastically the properties of the systems. The first example deals with spin ice physics in a pyrochlore iridate material where the local field is created by one magnetic sublattice on the other one. This well-defined non-collinear field leads to a fragmentation of the magnetization, a new state of matter where the magnetic moment fragments into an ordered part and a persistently fluctuating one [1]. The second example concerns a spin chain compound with anisotropic magnetic moments. In this case, an internal staggered field is generated from the anisotropic response of the magnetic moments to the application of an external uniform magnetic field. This staggered magnetic field produces a quantum phase transition where the magnetic excitations characterizing the ordered phases on both sides of the transition are two different types of competing topological objects [2].

[1] E. Lefrançois et al., Magnetic charge injection in spin ice: a new way to fragmentation, Nature Communications **8**, 209 (2017)

[2] Q. Faure, et al., Topological quantum phase transition in the Ising-like antiferromagnetic spin chain $BaCo_2V_2O_8$, to appear in Nature Physics