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Magnetic structures and anisotropic excitations in Tb2Ti2O7 spin liquid

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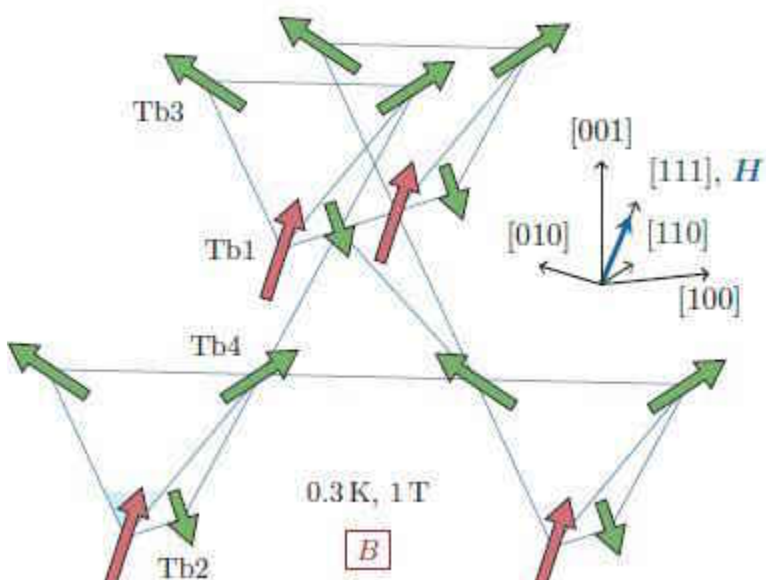
Geometrical frustration in the pyrochlore lattice of corner sharing tetrahedra yields exotic short range ordered ground states known as spin liquids or spin ices. Among them, Tb2Ti2O7 spin liquid (also called quantum spin ice) remains the most mysterious, in spite of 15 years of intense investigation. Our recent single crystal experiments using neutron diffraction and inelastic scattering down to 50 mK yield new insight on this question. By applying a high magnetic field along a [111] anisotropy axis [1], the Tb moments reorient gradually without showing the magnetization plateau observed in classical spin ices. Quantitative comparison with mean field calculation supports a dynamical symmetry breaking akin to a dynamic Jahn-Teller distortion, preserving the overall cubic symmetry. In the non-Kramers Tb ion this induce a quantum mixing of the wave-functions of the ground state crystal field doublet enabling the formation of a spin liquid, viewed as a non-magnetic two-singlet ground state in this mean-field picture [2]. The spin lattice coupling also shows up in the spin fluctuations in zero field [3]. Dispersive excitations emerge from pinch-points in the reciprocal space, with anisotropic spectral weight. This is the first evidence of them in a disordered ground state. They reveal the breaking of some conservation law ruling the relative orientations of the fluctuating magnetic moments in a given tetrahedron, as for the monopole excitations in classical spin ices. The algebraic character of the correlations shows that Tb2Ti2O7 ground state is akin to a Coulomb phase. Finally, the first excited crystal field level and an acoustic phonon mode interact, repelling each other. The whole results show that the magnetoelastic coupling is a key feature to understand the surprising spin liquid ground state. They call for an interaction between quadrupolar moments, whose Jahn-Teller distortion is the first (single site) approximation.

***[1]** A. Sazonov et al PRB 88, 184428, (2013) ; P. Bonville et al to appear in PRB (2014)., **[2]** P. Bonville et al PRB 84, 184409 (2011), **[3]** S. Petit et al PRB 86, 174403, (2012) ; S. Guitteny et al PRL 111, 087201 (2013);T. Fennel et al PRL 112, 017203 (2013)*



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