**Excitations of emergent quasiparticles in pyrochlore magnets**

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**Abstract**

Pyrochlore compounds with general formula A2B2O7, where A is a trivalent rare-earth ion and B is a tetravalent transition-metal ion, have been extensively studied in the past few decades, and various novel magnetic behaviors have been discovered, including spin glass, spin ice, and spin liquid.

Among the titanate pyrochlore oxides, Ho2Ti2O7 and Dy2Ti2O7 have been identified as canonical spin ice materials which can be understood using a model with a <111> Ising-like anisotropy and a net ferromagnetic interaction,which lead to the four spin residing on the four corners of the corner-sharing tetrahedral two spins pointing in and two spins pointing out of the local [111] direction, the so-called ice rule. The excitation of spin ice is realized as the creations of emergent magnetic monopoles.

Yb2Ti2O7 shows ferromagnetic phase transition at *Tc* = ~0.2 K. Above *Tc*, the compound is realized to be a quantum spin ice state which exhibits two-in-two-out classical spin ice spin configuration together with the quantum fluctuation of the magnetic components perpendicular to the <111> Ising axis. Below *Tc*, Yb3+ possesses moment of ~1.3 B and points to [100] orientation. Yb2Ti2O7 undertook a Higgs mechanism from a magnetic Coulomb phase to a nearly collinear ferromagnetic long-ranged state by means of polarized neutron scattering, SR, and low-temperature magnetization measurements. These results illustrate a primary signature of the first example of a magnetic Higgs transition. By using inelastic neutron scattering techniques of time-of-flight and backscattering to reveal the low-energy quantum excitations down to tens micro electron-volt cross the transition temperature *Tc* ~ 0.19 K, we observe two low-energy magnetic excitation modes in the ferromagnetic phase of the quantum spin ice material Yb2Ti2O7. The first excitation mode is dispersive and has the energy minimum of 0.07 meV, quickly loses the intensity away from the Brillouin zone center, while the second mode is located at around ~ 0.18 meV and is nearly flat. Semiclassical analyses based on the Higgs confining phase of the *U*(1) gauge theory provide a much better explanation of the two modes than the linear spin wave theory. The first and the second modes are then interpreted as a gapped precursor photon mode with a definite helicity and a plasma oscillation mode of magnetic monopole charges.