Frustrated Magnetism Meets Electric Bands Topology: Case of Pyrochlore Iridates

Natalia Drichko

Johns Hopkins University

October 13, 2023

One of the aims of condensed matter research is a search for new states of matter. We already know that one way to achieve those is a coupling of different degrees of freedom (electrons, spins, lattice) in a solid. Pyrochlore iridates present a unique interplay of magnetic frustration, electron correlations, and spin orbit coupling. A topological state called Weyl semimetal state was suggested in these materials when the quadratic band touching splits into Weyl nodes as a result of time reversal symmetry breaking by the all-in-all-out (AIAO) ordering of the Ir moments. We show that not only Nd2Ir2O7 is the best candidate to live up to these theoretical expectations, but due to both A (Nd) and B (Ir) sites of the pyrochlore lattice of this material being magnetic, it demonstrates a unique way to enhance magnetic interactions in the Nd pyrochlore lattice. Using Nd2Ir2O7 as an example, I will discuss how we can use polarized (inelastic) Raman scattering spectroscopy to probe electronic and magnetic excitations in solids. We detect magnon response from the ordered in AIAO configuration moments of iridium below TN(Ir)=33 K, and AIAO ordered Nd moments below 14 K. We show that the presence of Ir results in the renormalization of magnetic interactions between Nd moments: Below TN(Ir)= 33 K spin ice fluctuations of Nd magnetic moments are detected through an observation of a collective mode at 15 meV. A step-like change of the electronic scattering at TN(Ir)= 33 K is interpreted as a signature for the splitting of quadratic band touching into Weyl nodes.