**Probing Excitations in Pyrochlore Iridates with Resonant Inelastic X-ray Scattering**

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**Novel Physics in Pyrochlore Iridates**

- The pyrochlore iridates A₂Ir₂O₇ (A = Y or lanthanide) have attracted considerable attention due to the potential for exotic physics driven by the interplay between electronic correlations, band topology, geometric frustration, and strong 5d spin-orbit coupling [1].

- Proposed ground states for these materials include: fractional topological insulators/topological Mott insulators [2,3], topological (or Weyl) semi-metals [4-6], axion insulators [6,7], and chiral spin liquids [8].

- Previous experimental work has shown that the electronic and magnetic properties of these materials are very sensitive to A-site cation size [9-11]. Physical behaviour can be tuned via chemical composition.

**Resonant Inelastic X-ray Scattering**

- **Resonant Inelastic X-ray Scattering (RIXS) is a second-order scattering process which can be used to probe elementary excitations involving spin, orbital, charge, and lattice degrees of freedom [16].**

- **RIXS is particularly well-suited to the study of iridates (17-20).**

- **Element specific probe of magnetic and electronic properties.**

- **Small sample volumes required (<10 mg).**

- **Large resonant enhancement at hν absorption edge (2hν = δS₂ₓₓₓₓₓₓ at E = 11.21 keV).**

- **These materials are not amenable to conventional inelastic neutron scattering due to strong neutron absorption across section and difficulty of growth.**

- **In hν-edge RIXS measurements carried out using the Advanced Photon Source at Argonne National Lab.**

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**d-d Excitations in A₂Ir₂O₇ (A = Y, Eu, Pr)**

- **Compare experimental data with ab initio calculations by L. Hsieh et al [12].**

- **Multiconfiguration self-consistent field (MCSCF) and multiconfiguration interaction (MCI) calculations performed on finite cluster (6 adjacent IrO₆ octahedra and neighbouring A-site cations).**

- **Good agreement between experimental and theoretical values.**

- **Model Eₗ and Eₜ with simple single-ion Hamiltonian: Hₑ = 3Jₑₛ – δₓ².**

- **Obtain reasonable values for spin-orbit coupling (δ), but surprisingly large trigonal crystal field splitting (Δ).**

- **A remains large, even for calculations with idealised crystal structure/no distortion of IrO₆ octahedra.**

- **A must originate from long-range anisotropy – trigonal field produced by neighbouring A-site ions and IrO₆ cations.**

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**Magnetic Excitations in A₂Ir₂O₇ (A = Eu)**

- **Investigate low-lying inelastic scattering in single crystal Eu₂Ir₂O₇ using high-resolution experimental set-up (U ~ 35 meV).**

- **Temperature dependence, incident energy dependence, and Q-dependence indicate that this feature is magnetic in origin.**

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