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Adelites to pyrochlores: A hydrothermal approach to single crystals of dimensional, site-ordered quantum magnets

Hydrothermal crystal growth uses an aqueous media for a slow dissolution of reactants followed by a piecewise-like nucleation of crystals. While slower than most conventional methods, this careful synthetic technique has long been known to give superior optical quality crystals of exceptional purity. Leveraging this crucial low-defect advantage, our group has long relied on a high-temperature and high-pressure hydrothermal technique to synthesize a series of dimensional quantum magnets. Unlike crystals grown via melt-based techniques, the hydrothermally prepared crystals are site-ordered and, more importantly, generally single domain. This allows relatively facile alignment of crystalline faces for anisotropic magnetization and neutron scattering experiments to probe the bulk and local magnetic phenomena. Dimensional quantum magnets rely on motifs such as linear 1D chains, trigonal 2D Kagome-like honeycombs and strips, and 3D tetrahedrons. As such, careful synthetic design and a site-ordered structure are paramount for accurate description of spin-exchange coupling interactions between magnetic centers, particularly in weakly-coupled rare-earth "liquid-like"spin systems where an unintended site defect (i.e., A-B site stuffing in pyrochlores) can induce an ordering event or inconsistent spin-exchange coupling constants. This talk will highlight the recent successes in preparing a new series of adelite-type $AB(CO_4)(OH)$ structures and a refined synthesis of mm-sized $A_2B_2O_7$ rare-earth stannate pyrochlores. The adelites, with their linear-like 1D chiral chain motif and proposed cycloidal magnetic structure, offers a marked contrast with the highly ordered 3D tetrahedral arrangement of rare-earth ions in the stannate pyrochlores. Preliminary magnetization and neutron scattering studies will be discussed. Concluding remarks will highlight additional avenues for further study and synthetic design that will allow access to new structural analogs possessing their own unique magnetic structures.

Topical Area

Hard matter: quantum, electronic, semiconducting materials

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