Ian Faust, Nuclear Engineering

University: University of Michigan
Year in School: Sophomore
Hometown: Columbia, Missouri
Faculty Mentor: Dr. Keary Schoen, MU Research Reactor
Funding Source: Department of Energy's Innovations in Nuclear Infrastructure and Education Program

Flux growth of LixM2O4 spinel for use in testing the Quantum Critical Point (QCP)

Ian Faust, Keary Schoen, and Wouter Montfrooij

$Li_xM_2O_4$ is a crystal known as a spinel that has the ability to have lithium removed without affecting the structure. By varying the amount of lithium in the substance, the chemical pressure inside the crystal can be changed. This can change the ground state, which is instrumental in testing the quantum critical point (QCP). QCP is the lowest temperature point at which there a change in existence in a material, which typically occurs near absolute zero. Also, the trivalent variable element (M), can be changed to alter the nature near the QCP. These changes are observable using neutron diffraction. However, all of the current $Li_xM_2O_4$ spinels have existed in minute particle sizes, which is unusable in neutron diffraction. To create sufficiently sized crystals, a flux growth method is used. This process uses salts at very high temperatures (~1000K), which dissociate and form the spinel and byproducts ($2\ LiCl + 4\ M(NO_3)_2 = 2\ LiM_2O_4 + 8\ NO_2 + Cl_2$) By varying the time and intensity of the heating process along with the length of cooling, the production of large crystals has been optimized. The introduction of a previous crystal will induce further growth, and is known as seeding. Best results have been formed using manganese, with seeding. Further optimization in crystal size has been shown by increasing the duration of elevated temperature and by slowing the rate of cooling. Other forms of crystal using chromium and cerium have proven extremely difficult to create in significant quantities or size. Using neutron powder diffraction and x-ray powder diffraction, the structure of the created spinel has been confirmed to be that of the desired $Li_xM_2O_4$ crystal.