

A Comparison of the Magnetic Structures of Candidate Ferrotoroidic Olivine Materials

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The iron and cobalt analogs of lithium phospho-olivine materials are recognized candidates for ferrotoroidicity. This is a theorized fourth class of the primary ferroics in which the magnitude and direction of a net toroidal moment can be controlled by external fields. While there is no detailed chemical model, the magnetic structure requires even multiples of spin moments arranged head-to-tail. A toroidal moment would form perpendicular to the ring of spin moments. While this effect is permitted in the iron and cobalt analogs (point group = mmm'), it is not for the manganese analog ($m'm'm'$).

To understand the onset and orientation of these magnetic structures, neutron powder diffraction studies were performed on hydrothermally-prepared solid solutions of $\text{LiMn}_x\text{Fe}_{1-x}\text{PO}_4$ ($x = 0.3, 0.5, 0.7$) and $\text{LiMn}_x\text{Co}_{1-x}\text{PO}_4$ ($x = 0.3, 0.5, 0.7$). Time-of-flight diffraction patterns of the $\text{Li}(\text{Mn,Fe})\text{PO}_4$ series were measured at room temperature, base temperature, and in five-degree increments around the magnetic ordering temperatures. Patterns of the $\text{Li}(\text{Mn,Co})\text{PO}_4$ series were measured on a constant-wavelength diffractometer at room temperature and above and below the ordering temperatures. A comparison of the magnetic structure refinements will be presented and examined with respect to the effect on the predicted toroidal moment for these materials.

- (1) Spaldin, N. A.; Fechner, M.; Bousquet, E.; Balatsky, A.; Nordström, L. *Phys. Rev. B* **2013**, 88, 1–13.

Acknowledgements: Funding for this project was provided by a grant from the U.S. DOE Office of Science (Grant #:DE-SC0016434). We acknowledge the support of the National Institute of Standards and Technology, U. S Department of Commerce, and the Spallation Neutron Source, a DOE Office of Science User Facility operated by Oak Ridge National Laboratory, for providing the neutron facilities used in this work.