

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 $\text{Li}(\text{Mn},\text{Fe})\text{PO}_4$ series were measured at room temperature, base temperature, and in five-degree increments around the magnetic ordering temperatures. Patterns of the $\text{Li}(\text{Mn},\text{Co})\text{PO}_4$ 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.

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