Investigating Kosterlitz-Thouless physics in the triangular lattice antiferromagnet TmMgGaO$_4$

Benjamin A. Frandsen$^1$, Zhiling Dun$^2$, Raju Baral$^1$, Martin Mourigal$^2$

$^1$Department of Physics and Astronomy, Brigham Young University, Provo, Utah, U.S.A.  
$^2$School of Physics, Georgia Institute of Technology, Atlanta, Georgia, U.S.A.  
benfrandsen@byu.edu

The transverse-field Ising model on a triangular lattice is predicted to support a topological Kosterlitz-Thouless (KT) phase at nonzero temperature through a mapping of the Ising spins to a complex order parameter defined for each triangular unit. Recently, the triangular lattice antiferromagnet TmMgGaO$_4$ has emerged as a candidate material to realize this theoretical scenario. Through the complementary use of neutron diffraction and magnetic pair distribution function (mPDF), we have quantitatively investigated the spin correlations in TmMgGaO$_4$ in the temperature region of interest, tracking their evolution across the proposed transitions into and out of the KT phase. We confirm the presence of the three-sublattice order predicted for the ground state and show that the local magnetic structure undergoes distinct changes in the temperature range expected for the KT phase. Modeling the real-space mPDF reveals a preferential tendency for the system to form bound vortex-antivortex pairs, the hallmark of the KT phase, precisely in the expected temperature range [1]. These findings constitute promising evidence for the KT phase, potentially establishing TmMgGaO$_4$ as a rare platform for studying KT physics in a dense spin system.


Keywords: triangular lattice; antiferromagnet; Kosterlitz-Thouless; neutron diffraction; magnetic pair distribution function