

CONDENSED MATTER SCIENCES SEMINAR

Dr Yoshitomo Kamiya

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Host

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Title

Designing Magnetoelectric Effects Using Organic Quantum Spin Trimers

Friday, April 24th, 2026

1st Floor – B101

15:00-16:00

Abstract

An equilateral spin trimer composed of three $S = 1/2$ spins is known to host both magnetic and electric dipole moments at low energies, the latter arising from virtual charge fluctuations akin to ring exchange. A weakly coupled trimer system is therefore expected to exhibit magnetoelectric (ME) effects through the interplay between emergent electric dipoles and other low-energy degrees of freedom associated with each trimer. We present a materials design strategy to realize this concept using organic chemistry, which offers flexible synthetic routes. In particular, we have synthesized single-crystalline TNN·CH₃CN, an organic quantum spin trimer antiferromagnet composed of TNN, a perfectly C_3 -symmetric molecular magnet, and the observed ME effects, revealed by thermodynamic, magnetic, and dielectric measurements, point to a rich multiferroic phase diagram. On the theoretical side, we derive low-energy effective models and perform semiclassical CP2 and CP3 Monte Carlo simulations for different magnetic field regimes, identifying rich ME phenomena arising from trimer-based degrees of freedom, such as a linear ME effect due to spin-orbital entanglement, orbital ferroelectricity, and a novel kinetic ME effect, as captured by effective Kugel-Khomskii, compass, and bosonic t - J models, respectively. These results demonstrate a bottom-up pathway for designing multiferroics and ME effects based on quantum spin trimer systems.