University Undergraduate Research Internship Programme (UURIP) 2026 – fully funded

Chasing exotic magnetic states in frustrated quantum materials

Supervisor: Dr Monika Gamza

Quantum computers and other next-generation technologies require new materials with special quantum behaviors. Some of the most promising candidates are frustrated magnets. In these materials, tiny magnetic moments cannot all align neatly, which leads to complex and highly entangled states known as quantum spin liquids. These unusual states may one day enable the storage and processing of quantum information far more reliably than current technologies.

Recent research by the Quantum Materials Group of the Jeremiah Horrocks Institute has focused on a family of frustrated magnetic semiconductors with the chemical formula $CaMn_2X_2$ (where X is a pnictogen). This work was motivated by the discovery of a rare spin-liquid state in $CaMn_2P_2$ [1] at temperatures above 68 K, followed by an unusual first-order transition to a spin-spiral state at lower temperatures [2,3].

In this project, you will study crystals of $CaMn_2P_2$ doped with arsenic using advanced experimental facilities at the University of Lancashire. Using scanning electron microscopy and X-ray diffraction, you will investigate crystal structures, microstructures and chemical compositions of phases grown from metallic fluxes. After selecting high-quality crystals with desired chemical compositions, you will perform low-temperature ac calorimetry using a newly developed experimental setup to identify the magnetic transition temperatures and map the magnetic phase diagram in detail. During the project, you will gain hands-on experience with materials characterization techniques, data analysis, and low-temperature measurements, developing practical laboratory skills that are highly valued in both academic and industrial research environments.

[1] Islam, F., Andriushin, N.D., Trevisan, T.V., Pakhira, S., Riberolles, S.X.M., Morgan, Z., Minelli, A., Johnston, D.C., McQueeney, R.J., Ye, F., Orth, P.P., and Vaknin, D. (2025), "*Spiral Spin Liquid State in the Corrugated Honeycomb Lattice of* $CaMn_2P_2$", arXiv:2501.02122.

[2] Islam, F., Trevisan, T. V., Heitmann, T., Pakhira, S., Riberolles, S. X. M., Sangeetha, N. S., Johnston, D. C., Orth, P. P., & Vaknin, D. (2023), "*Frustrated Magnetic Cycloidal Structure and Emergent Potts Nematicity in* $CaMn_2P_2$", Physical Review B, 107, 054425.

[3] Sangeetha, N. S., Pakhira, S., Ding, Q.-P., Krause, L., Lee, H.-C., Smetana, V., Mudring, A.-V., Iversen, B. B., Furukawa, Y., & Johnston, D. C. (2021), "*First-Order Antiferromagnetic Transitions of* $SrMn_2P_2$ *and* $CaMn_2P_2$ *Single Crystals Containing Corrugated-Honeycomb Mn Sublattices*", Proceedings of the National Academy of Sciences, 118(44), e2108724118.