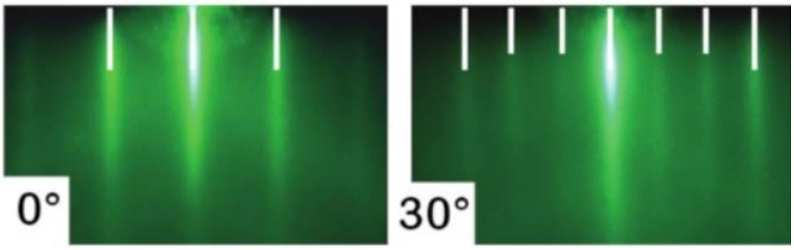
PhD Project Outline – Department of Physics – University of Warwick

Altermagnetic heterostructures

Altermagnetism is a new classification of magnetic order encompassing various forms of unconventional antiferromagnetism [1]. An altermagnetic material has no net magnetic moment, like any antiferromagnet, but can lift the Kramers degeneracy even in the absence of strong spin-orbit coupling, like a ferromagnet. This combination of properties is extremely promising for spintronic devices, where a spin-momentum link is required. Since an altermagnet lacks a net magnetisation, no stray field is generated (hence devices could be packed at high density) and sensitivity to external magnetic fields is minimised. CrSb has recently been identified as a canonical altermagnet. We have grown high quality CrSb on MnSb (itself a ferromagnetic weak metal) and explored its surface reconstructions [2]. More recently we have grown MnSb-GaSb heterostructures, GaSb being a conventional III-V material used extensively the compound semiconductor industry. This provides a flexible platform for studying altermagnetic heterostructures with control down to atomic layer thicknesses.



The (√3 × √3)R30° surface reconstruction of MBE-grown CrSb(0001) revealed by reflection high energy electron diffraction (RHEED).

Heterostructures are single-crystal layers of different materials stacked on top of each other, and the materials platform enables fundamental investigations into thin-film altermagnetism and, eventually, fabrication of spintronic devices. The MBE systems in Warwick allow in situ analysis of films as they grow, by electron diffraction, XPS and scanning tunnelling microscopy. This enables efficient optimisation of MBE growth. We can also transfer samples by UHV suitcase to other analysis facilities. The project will involve MBE growth of CrSb heterostructures, including investigating novel (Mn,Cr)Sb alloyed layers and their magnetic order. You will also take part in advanced analysis by methods such as neutron reflectometry and synchrotron X-ray diffraction. As well as travelling to central facilities such as ILL / ESRF in Grenoble, France, for experiments, we will collaborate with groups at UCL (London) and NTU (Pilsen, Czech Republic).

Extensive hands-on training and support in MBE growth and surface science will be provided along with a range of taught postgraduate modules tailored to your needs, as well as support and training in analysing advanced “neutron + X-ray” reflectometry data.

For further information and to apply, please contact Gavin Bell gavin.bell@warwick.ac.uk and Physics Postgraduate Admissions.

The project will suit candidates with a strong background in experimental physics, physical chemistry or materials engineering. Experience with any of the following would be advantageous: ultra-high vacuum (UHV), epitaxial growth, surface science, or X-ray photoelectron spectroscopy (XPS).

[1] L. Bai et al. Advanced Functional Materials (2024) 2409327 https://doi.org/10.1002/adfm.202409327

[2] C.W. Burrows, J.D. Aldous and G.R. Bell, Results in Physics 12 (2019) 1783.