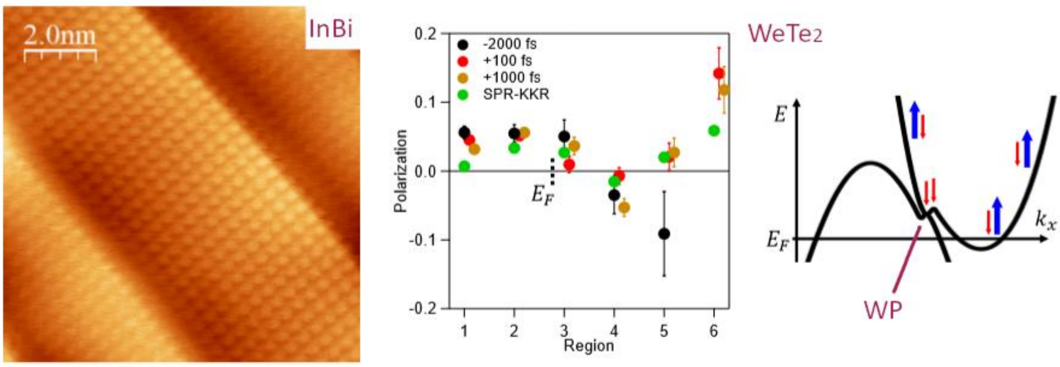
Electronic structure of epitaxial topological materials

- A EUTOPIA Ph.D. project joint University of Warwick (UK) and CY Cergy Paris University
- Supervisors Dr. Gavin Bell (Warwick), Professor Karol Hricovini (Paris)
- Experimental condensed matter & surface physics
- Combined laboratory and synchrotron-based work (UK, France, Italy)
- Based in Warwick, minimum 1 year in Paris, plus synchrotron radiation (SR) experiments
- Application for full EUTOPIA funding ongoing, available also to self-funded students

Materials with topologically non-trivial band structures have enormous potential for spintronics, thermoelectrics and other advanced technologies. In order to integrate such materials with the infrastructure of modern electronics, it is desirable to fabricate thin epitaxial films on conventional semiconductor substrates. Growth by molecular beam epitaxy (MBE) also allows manipulation of crystal orientation, strain and interface structures, and the growth of heterostructures (layered "sandwiches" of different materials) in order to optimise the properties of the materials. The key technique for studying the electronic band structure is angle resolved photoemission spectroscopy (ARPES). In this project you will combine advanced MBE and ARPES methods to fabricate and study both 2D and 3D topological materials. Two-dimensional materials such as WTe_2 have mostly been studied by "exfoliation" – physically peeling thin layers from bulk crystals – but in this project you will use MBE to grow highly controlled films (down to monolayer thickness) on selected substrates. These materials are usually semimetallic but can become insulators at monolayer or bilayer thicknesses, allowing their topological surface and interface states to dominate conduction. Similarly, 3D materials such as InBi are typically semimetallic but can be grown by MBE in ultra-thin film form in order to expose and manipulate topologically protected states.



Left: STM image of the surface of a tetragonal InBi nano-crystal on InAs(111)A substrate. Centre: time- and spin-resolved ARPES data from exfoliated WTe2 showing evidence for unusual spin dynamics. Right: the spin dynamics can be explained by spin-down accumulation at the Weyl point(s) of WTe_2.

The MBE-grown films will be analysed by in situ surface-sensitive methods such as scanning tunnelling microscopy (STM). You will be fully trained in these techniques and underpinning ultra-high vacuum (UHV) technology. Analysis of the electronic structure will exploit ARPES, including advanced time-resolved and spin-resolved methods, both lab-based and at SR facilities methods. Samples will be transferred to the different ARPES systems using UHV "suitcases", or in some cases grown in situ, to ensure we work on pristine surfaces. We aim to obtain both state of the art thin-film material and world-leading ARPES results in this exciting area of condensed matter physics.