Exploring the electronic structure and superconductivity of quantum materials under strain

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This project will investigate the response of quantum materials, especially iron-based superconductors, to applied lattice strain. The fundamental reason to do this is that in these materials there are many electronic processes that occur simultaneously, which can be difficult to disentangle when looking at the unstressed system alone. One can gain much more information by understanding how elastic lattice distortion, applied through hydrostatic, biaxial, or uniaxial stress, affects the electronic properties of a material. For example, lattice strain may be used to suppress an electronic instability, or to enhance one or more of the processes in the material. One major area of interest in the iron-based compounds, which is likely to be a key part of this project, is electronic nematicity, a form of electronic order which breaks rotational but not translational symmetries. Nematicity may play an important role in high-temperature superconductivity. Uniaxial stress can be used to increase nematic polarisation in a material, by adding to the orthorhombic lattice distortion associated with nematic order.

Measurements to be performed may include quantum oscillations in high magnetic fields of up to 45T and potentially angle-resolved photoemission at the Diamond Light Source. The project also involves the development of high-precision, piezoelectric-driven stress apparatus, for example of a miniaturised stress cell that fits into a high-field magnet and therefore is suitable for students who want to develop their engineering skills along with their scientific skills. A suitable candidate should have a good understanding of condensed matter physics, good experimental and computing skills, and an ability to work well in an experimental team. This project will be jointly supervised by Amalia Coldea at Oxford University, and by Clifford Hicks and Andrew Mackenzie at the Max Planck Institute for Chemical Physics of Solids, in Dresden, Germany. The student will be expected to spend approximately half of the time in Oxford and half in Dresden.