Capturing Ultrafast Dynamics in Energy Materials using X-ray Free Electron Lasers

Funding availability: The studentship is normally only available to home (UK) students, but there is a good possibility to extend it to an EU/international student.
Start date: October 2025 (some flexibility)
Duration: 4 years
Deadline: Applications will be considered on a rolling basis until the post is filled. Final deadline 1st May 2025.

Project Description
The motion of atoms/electrons underpins both the entire biosphere *via* photosynthesis and many technologies paramount to modern life *e.g.*, catalysts, batteries, computing materials, *etc*. Hence, capturing and understanding atomic/electronic dynamics is essential for both fundamental understanding, and designing new technologically important systems.

Ultrafast laser spectroscopies allow us to watch atomic/electronic motion on its natural femtosecond (million-billionths of a second) timescale, but often lack spatial resolution. Recently, with the advent of new laser sources in the X-ray wavelength range (X-ray free electron lasers; XFELs), this problem has been overcome and we can start to capture atomic/electronic motion not only with femtosecond (and faster) time resolution, but with also truly nanoscopic spatial resolution.

The goal of this fully funded PhD is to develop and push new ultrafast spectroscopies both in the lab and at XFELs for the spatio-temporal study of energy materials (oxides used in batteries and ferroelectrics). The work will be in the groups of Raj Pandya (https://www.iccd-lab.com/) and James-Lloyd Hughes (https://tinyurl.com/yzcapws2) at Warwick University with joint supervision from Chris Milne at European XFEL in Hamburg (https://tinyurl.com/4xd9ep7b). Work will be primarily experimental (and be based at Warwick), with some coding/modelling components, and focus around:

(1) Novel lab-based ultrafast experiment construction (especially with strong THz pulses that can be used to 'drive' atoms and control chemical reactions like electron-transfer).
(2) Steady-state and time-resolved X-ray experiments at synchrotrons and free-electron lasers using novel excitation sources (*e.g.*, in the THz) or geometries *e.g.*, to examine ultrafast correlations between atoms.
(3) Modelling of ultrafast X-ray observables for capturing dynamics like ion-hops in battery materials. This may also include designing methods to handle large XFEL data sets and signal processing.

While some of the above is set out there will also be a lot of room to develop the project in the areas that excites you. There is also generally significant scope for travel (with a secondment to EuXFEL in Hamburg) and to beamlines internationally.

You will be able to learn a wide range of technical and transferable/sought-after skills in non-linear optics, ultrafast X-ray science, materials chemistry, coding and project management, with access to unique tools and world-class facilities.

We offer an international, diverse, inclusive and fun environment with lots of energy and time to help you learn and develop. In addition, Warwick University sits in central England, in an area with some of the best value and quality for living within the UK.

References: [1] Pandya et al. Nat. Commun. 12, 6519 (2021) [2] Pandya et al. Nat. Nanotechnol. 18 1185-1194 (2023) [3] Bressler Science 323 (5913), 489-492 (2009)

Requirements: Applicants should have an honours degree (at least 2.1 or equivalent) in physics, chemistry, materials science, electrical engineering or mathematics. No prior expertise in ultrafast optics/X-rays is required.

How to apply: To make an informal enquiry or to discuss projects in more detail, please contact Raj Pandya (raj.pandya@warwick.ac.uk) James Lloyd-Hughes (j.lloyd-hughes@warwick.ac.uk) or Chris Milne (christopher.milne@xfel.eu) in the first instance. The formal application can be made here: http://www.go.warwick.ac.uk/pgapply/research
Applications will be considered on a rolling basis until the post is filled.