Contribution ID: **128** Type: **Plenary**

Probing ultrafast structural and electronic dynamics in the condensed phase using X-ray free electron lasers

Wednesday, 7 September 2022 09:00 (45 minutes)

X-ray spectroscopy and scattering allow a unique combination of electronic and structural information to be obtained from a variety of different types of samples in many different forms (solid, liquid, gas). The extension of these methods into the time domain has allowed measurement of dynamic processes, for example the tracking the photoinduced charge carriers in a functional material[1],[2] or following the photocycle in a light activated protein[3],[4]. In recent years X-rays have started to become routinely used to measure light-activated processes using a pump-probe scheme, where the sample is photoexcited with light and then probed after a variable time delay using an X-ray pulse. These methods can measure dynamics over a broad range of timescales, allowing them to probe everything from protein dynamics to ultrafast electronic spin-state changes in molecular systems. With the recent development of X-ray free electron lasers (XFELs)[5], time-resolved X-ray techniques have moved into the ultrafast regime, where the timescales of electron and nuclear motion can be accessed using the femtosecond X-ray pulses available from these facilities.[6]
This talk will present an overview of how X-ray techniques are being used at XFELs and the type of information the measurements can provide. The talk will introduce the European XFEL[7], a brand-new, high-repetition rate XFEL facility located in northern Germany, and its'Femtosecond X-ray Experiments (FXE) instrument[8],[9] which is focussed on measuring ultrafast dynamics in the condensed phase. Finally the lecture will present some examples of the types of measurements XFELs can perform and the scientific questions that can be answered using ultrafast X-ray techniques.

1. Penfold, T. J. *et al.* Revealing hole trapping in zinc oxide nanoparticles by time-resolved X-ray spectroscopy. *Nat Commun* 9, 478 (2018).
2. Rittmann-Frank, M. H. et al. Mapping of the Photoinduced Electron Traps in TiO2 by Picosecond X-ray Absorption Spectroscopy. *Angewandte Chemie Int* Ed 53, 5858–5862 (2014).
3. Bacellar, C. et al. Spin cascade and doming in ferric hemes: Femtosecond X-ray absorption and X-ray emission studies. *P Natl Acad Sci Usa* 117, 21914–21920 (2020).
4. Kinschel, D. et al. Femtosecond X-ray emission study of the spin cross-over dynamics in haem proteins. *Nat Commun* 11, 4145 (2020).
5. Barletta, W. A. et al. Free electron lasers: Present status and future challenges. Nuclear Instruments & Methods In Physics Research Section A-Accelerators Spectrometers Detectors And Associated Equipment 618, 69–96 (2010).
6. Seddon, E. A. et al. Short-wavelength free-electron laser sources and science: a review*. Rep Prog Phys 80, 115901 (2017).
7. Decking, W. et al. A MHz-repetition-rate hard X-ray free-electron laser driven by a superconducting linear accelerator. Nat Photonics 14, 391–397 (2020).
8. Galler, A. et al. Scientific instrument Femtosecond X-ray Experiments (FXE): instrumentation and baseline experimental capabilities1. *Journal of Synchrotron Radiation* 26, 1–16 (2019).
9. Khakhulin, D. et al. Ultrafast X-ray Photochemistry at European XFEL: Capabilities of the Femtosecond X-ray Experiments (FXE) Instrument. emphasized text*Appl Sci* 10, 995 (2020).

Would you like to participate in the Poster Prize competition?

No

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Session Classification: XFEL I