Are there applications of ultrafast spectroscopy in the analytical sciences?

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Ultrafast spectroscopies with sub-picosecond time resolutions allow for real-time measurement of many of the fastest processes in chemical dynamics, including bond breaking and formation, charge redistribution and energy transfer.[1-3] These spectroscopies have revolutionised our understanding of how molecules interact with light and how chemical reactions occur at the atomistic level as well as how fast.

Most ultrafast experiments are performed in a pump-probe configuration, where an ultrashort pulse photoexcites the sample. Then, a second pulse, the probe, is used to record a spectrum at varying time delays to map out the reaction of the molecule and how fast it occurs. The advantage of pump-probe schemes is that they are highlight flexible – the probe could be a broadband white light continuum for absorption spectroscopy, or a highly energetic X-ray pulse for performing time-resolved X-ray emission measurements. However, many of these techniques face a number of experimental challenges that mean they are far from being standard analytical measurement tools.

In this talk, I will give an overview of some of the state-of-the-art methods in ultrafast spectroscopy and present some of the challenges of these techniques, both in terms of experimental implementations and data analysis. I will then show some applications of transient electron absorption spectroscopy and its use for materials design and development and some of our work and future possibilities of bringing these methods towards robust analytical tools.

[1] J. S. Beckwith, C. A. Rumble and E. Vauthey, *Int. Rev. Phys. Chem.*, 2020, **39**, 135–216.
[2] A. J. Orr-Ewing, *Struct. Dyn.*, 2019, **6**, 010901.
[3] R. Berera, R. van Grondelle and J. T. M. Kennis, *Photosynth. Res.*, 2009, **101**, 105–118