

Dr Paul Donaldson, STFC's [Science and Technology Facilities Council's] Central Laser Facility

Better understanding the ultrafast chemical reactions within batteries and catalysts is key to improving sustainable technologies, such as renewable energy and electric vehicles. Catalysts are substances which increase the rate of chemical reactions – and have many important applications such as generating biofuels and catalytic converters for fossil fuel emissions. Paul is using new techniques with lasers to study how the chemicals within both battery electrolytes and within catalysts react and move around at the molecular level. The lasers reveal the extremely fast motions of molecules that take place in femtoseconds – a millionth of a billionth of a second – during chemical reactions. Paul will study these reactions in the laboratory and then apply these discoveries to improving the design of industrially relevant systems. Paul said: “Battery and catalysis researchers are really excited about using these new techniques at the STFC laboratory’s world-leading laser facilities, so we can develop catalysts and batteries that are more flexible and cheaper. I have support on this project from Johnson Matthey, a British multinational science and chemicals company, to enhance translation of my research into benefits for British industry and the development of more sustainable technologies.”

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Molecular stopwatch measurements of dynamics in catalysts, battery electrolytes and ionic liquids in situ.

Paul says: “For my entire career as a scientist I have always been fascinated by light and its interactions with ‘stuff’, i.e., molecules! In other words, I am a scientist specialising in spectroscopy and my passion is using spectroscopy to learn about the molecular world.

“Spectroscopy has more than a century of history of discovery under its belt and a huge range of applications across Chemistry, Physics, Biology, Materials Science, Geology and Astrochemistry to name a few. The list is endless and the community of scientists diverse and fascinating. Some of the really exciting things to me about spectroscopy are that the light sources and light detectors that we use are continuously improving, which means there are from year to year an abundance of exciting new opportunities to explore. For the last five years I have worked in the Central Laser Facility of the Rutherford Appleton Laboratory in Oxfordshire. This amazing place has some of the best lasers and detectors in the world for a spectroscopist like me. I specialise in using really

short ('ultrafast') pulses of infrared light. Really short means counting in millionths of a billionth of a second! These are the fundamental timescales of molecular motions, molecular energy transport and chemical reactions. I am determined to put these skills to use and make a difference in areas of science that are key to society. This is what the UKRI Fellowship will enable me to do. I will grow a team that will develop new instruments and techniques at the Central Laser Facility to apply ultrafast laser spectroscopy to problems focussed on the science of catalysis and the science of batteries. Catalysts to make materials we need (or break down materials we don't need) and batteries to power a more green future in transport.

“My group will be in a great position to gather important information about the fast molecular motions involved in catalysis and battery chemistry and be able to teach these new approaches to scientists working in these areas to help with efforts to make better catalysts and better batteries. Beyond the science, from my position in a UK national laboratory, I also hope to use my fellowship to learn how I can help to shape UK science's long term goals and strategies. Science operates as a special partnership between the government, society, industry and Universities. I'm keen to get out of the lab and be active in helping this partnership continue to thrive!”

See: <https://www.ukri.org/funding/funding-opportunities/future-leaders-fellowships/meet-our-future-leaders-fellows/paul-donaldson-stfcs-central-laser-facility/>.