Electron momentum spectroscopy and dissociative electron attachment studies of complex interstellar molecules

**Principal supervisor** Kate Nixon (School of Life, Health and Chemical Sciences)

**Co-supervisor** Sam Eden (School of Physical Sciences)

**Location** The Open University, Milton Keynes, United Kingdom

**Duration & Funding** Full-time, 3 year 3 month studentship from October 2024 as part of EPSRC Doctoral Training Partnership; Stipend £18,622 per annum; Training grant £4,500

**Application due date:** January 26, 2024

**Notification of shortlisting:** February 9, 2024

**Interview:** week commencing Feb 19, 2024 on Microsoft Teams

**Final Funding Decision:** April 2024. This is part of a pooled EPSRC-DTP process, so the selected applicant will be put forward to a reviewing panel in March for final decisions. Applicants will be notified if they are selected, and will be informed of the panel decision afterwards.

**Start date:** October, 2024

**Science-related enquiries:** kate.nixon@open.ac.uk and sam.eden@open.ac.uk

**Process-related enquiries:** stem-lhcs-phd@open.ac.uk

**Research area/keywords:** Dissociative electron attachment, electron momentum spectroscopy, interstellar molecules

**Project highlights:**

- A recently developed laser-based desorption method will enable novel DEA and EMS experiments on complex gas-phase molecules.
- DEA experiments on complex molecules observed or predicted in the interstellar medium can provide new insights into the possible origins of key biological building blocks.
- EMS experiments will determine the wavefunctions of the isomers and tautomers in the laser-desorbed targets. This information will be critical for high-level electron scattering and quantum chemical calculations to interpret the DEA results.
- The project will involve collaborations with leading theoreticians and experimentalists.
Project description:
The discovery of diverse complex molecules in the interstellar medium in recent years, notably polycyclic aromatic hydrocarbons [1] and nitrogen-containing aromatic species [2], has inspired numerous laboratory studies aimed at understanding their possible roles in extra-terrestrial radiation chemistry. The great goal of such studies is to obtain insights into the molecular origins of life. As the most abundant products of ionizing radiation, low-energy electrons play a critical role in radiation chemistry, particularly through dissociative electron attachment (DEA) [3]. However, DEA experiments on complex molecules are generally limited by (i) the difficulty of bringing complex neutrals into the gas phase without thermal decomposition, and (ii) the tendency for gas-phase targets of complex molecules to contain a combination of different isomers and tautomers. This programme of DEA and electron momentum spectroscopy (EMS) experiments will address both of these challenges.

The student will exploit a new DEA facility in the Molecular Clusters Group led by Sam Eden at the Open University. This is the first DEA experiment to feature a laser-based thermal desorption source [4] which has been demonstrated to be extremely efficient at producing intense intact targets of thermally labile molecules such as nucleosides. The student will also use a new EMS experiment in Kate Nixon’s laboratory at the OU. EMS is a powerful method to directly measure the wavefunction of a molecule, and this is unique to its isomeric / tautomeric form. By installing a laser-based thermal desorption source in the EMS experiment, the student will be able probe the same targets by EMS and DEA. The EMS data will be invaluable for benchmarking theoretical methods applied to complex molecules, and the student will have the opportunity to work with our collaborator Darryl Jones (Flinders University, Australia) on the supporting calculations. Furthermore, the EMS experiments will reveal the populations of different molecular structures in the DEA experimental targets. This information will be critical for high-level calculations by our collaborators (notably Jimena Gorfinkiel and Sean Mutter at the OU) to support our interpretations of the DEA results. By extending the current experimental limits of both DEA and EMS, the project provides an exceptional opportunity to gain new insights into the radiation response of complex molecules in space.

References:
Eligibility

1. Applicants will ideally have a First Class or Upper Second undergraduate degree or Masters degree (or equivalent experience) in Physics, Chemistry, or a related discipline.
2. the student should have strong practical skills and enthusiasm for experimental work. A solid undergraduate-level knowledge of physical chemistry or atomic and molecular physics is important.
3. The student would be required to live in the UK and within commuting distance to The Open University in Milton Keynes.

We are committed to widening participation and awarding PhD studentships to a diverse community of applicants. We particularly welcome applications from under-represented groups. Equal Opportunity is University policy.

How to apply

Please check this page for application entry requirements:
https://www.open.ac.uk/postgraduate/research-degrees/degrees-we-offer/doctor-of-philosophy-phd
Please submit to stem-lhcs-phd@open.ac.uk an:

- application form, and
- 2-page (A4) personal statement outlining your suitability for the studentship, what you hope to achieve from the PhD and your research experience to date

You do not need to submit a research proposal.
Information and the application form is found here:
https://www.open.ac.uk/postgraduate/research-degrees/how-to-apply/mphil-and-phd-application-process. Note that as part of the application form, you will be asked to submit further documents (CV, degree transcripts, etc.)