Understanding electron-induced damage in complex biomolecular systems

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Description:
As the most abundant products of ionizing radiation, low-energy electrons play a critical role in biological radiation damage, notably through dissociative electron attachment (DEA) and neutral electronic excitation. Both of these processes have been investigated extensively in small biomolecules such as DNA bases that can be brought into the gas phase by simple heating [1-3]. This approach enables many fundamental mechanisms to be identified unambigiously but represents a poor approximation of biological material. The aim of this PhD is assess the applied relevance of specific low-energy electron driven damage processes by looking for their signatures in sequentially more complex biomolecular systems.

The student will use two methods to increase biomolecular complexity in a controlled and step-wise manner. Firstly, clusters of molecules will be studied, providing insights into how the condensed environment modifies radiation damage pathways. *Stark deflection* of supersonic beams in inhomogenous electric fields will enhance our control over the specific cluster configurations in our targets [4]. This will enable detailed comparisons to be carried out with electron scattering calculations carried out by Jimena Gorfinkiel. Secondly, *laser induced acoustic desorption* (LIAD) will be used to bring large biomolecules such as oligonucleotides (short strands of DNA) into the gas phase without thermal damage. The student will use high-resolution electron beams and tuneable UV lasers to initiate DEA and neutral electronic excitation, respectively.

The integrated research programme will help to bridge the *complexity gap* between understanding radiation-induced processes in small gas-phase biomolecules and in multimolecular systems, with applications in modelling and potentially modifying biological damage on the nanoscale.

References:
[1] I.I. Fabrikant, S. Eden, N.J. Mason, J. Fedor, *Advances in Atomic, Molecular, and Optical Physics* 66 (2017) 545.

[2] K. Kleinermanns, D. Nachtigallova, M.S. De Vries, *Int. Rev. Phys. Chem.* 32 (2013) 308.

[3] B. Barc, M. Ryszka, J. Spurrell, M. Dampc, P. Limao-Vieira, R. Parajuli, N.J. Mason, S. Eden, J. Chem. Phys. 139 (2013) 244311.

[4] S. Trippel, Y.-P. Chang, S. Stern, T. Mullins, L. Holmegaard, J. Kupper
Phys. Rev. A 86 (2012) 033202.

Qualifications required:
Applicants must have graduated (or be about to graduate) with an honours degree in Physics, Chemistry, or a related discipline. Furthermore, the student should have strong practical skills and enthusiasm for experimental work. A solid undergraduate-level knowledge of atomic and molecular physics (or physical chemistry) is important.