JSPS Fellow Experience: ***Time-Resolved Photoelectron of DNA Bases in a Liquid Microjet***

Host Institution: Kyoto University

Host Professor: Professor Toshinori Suzuki

JSPS Fellow: Rebecca Ingle (rebecca.ingle@bristol.ac.uk)

Research Project

Each time DNA absorbs UV light, there is a small risk that this will lead to potentially carcinogenic damage to the DNA strands. Fortunately, this risk is very small, as DNA is incredibly efficient at converting this light energy into heat via its photoprotection mechanisms.

However, particularly in the biologically relevant solution phase, there is still a far from complete understanding of how this photoprotection mechanism works in both DNA and the individual DNA bases. A complete understanding of this mechanism is one of the major contemporary challenges in physical chemistry and could potentially lead to a better understanding of the underlying causes of skin cancers.

At Kyoto University, experimental techniques involving the use of ultrafast laser systems are being developed to study the very rapid steps involved in these photoprotection mechanisms. In particular, Professor Suzuki's group have pioneered a technique called time-resolved photoelectron spectroscopy (TR-PES) which is capable of tracking how the electronic energy that is introduced into a molecule upon absorption of a photon of light is distributed within the molecule and how this distribution evolves with time.

This work was a continuation and a major development of the TR-PES experiments I started in Kyoto in summer 2014 (supported by the Bristol-Kyoto Strategic Fund) that had revealed a possible pathway for incredibly rapid energetic deactivation in pyrazine, a small molecule with many structural features in common with the DNA bases. By utilising novel techniques for the generation of high energy UV photons, the study I undertook with JSPS support in the summer of 2015 offers what is arguably the most complete picture of the ultrafast dynamics in pyrazine obtained to date.

This fellowship was a fantastic opportunity to gain more hands-on experience of working with femtosecond laser set-ups – such as that shown in figure 1 – and with emerging techniques for generating high energy (vacuum-UV) light, such as high harmonic generation and plasma filamentation. Use of these techniques in UK chemistry laboratories is, as yet, rare. I also had the chance to participate in regular group seminars in both Japanese and English and learn a great deal about data analysis techniques which are highly relevant to my research in the UK.

Figure 1: The femtosecond lasers used in one of the TR-PES experimental set-ups in Kyoto.

Wider Impact

During my time in Japan, I also had the opportunity to visit several other prominent scientists and their groups. JSPS gave me the opportunity to visit Professor Satoshi Maeda's group at Hokkaido University, who are developing a novel computational code with applications highly complementary to the experimental work we do at Bristol University. This visit was fundamental in fostering a continuing collaboration between the groups that has already resulted in one joint publication. I was also able to present this work at the international iCOMET meeting in Chengdu, China and was awarded the prize for best student oral presentation.

I also visited Dr Taro Sekikawa's laboratory at Hokkaido University, Professor Takao Fuji's group at the Institute of Molecular Science in Okazaki and Professor Keiji Morokuma's group at the Fukui Institute for Fundamental Chemistry. This gave me the opportunity for some very fruitful scientific discussion on several of my research projects as well as insight into the cutting-edge research happening in Japan.

Life in Japan

The research group in Kyoto were fantastic hosts and colleagues and made the whole process, from sorting out the visa application to daily working in the lab, as smooth and easy as possible. I enjoyed having the opportunity to practice my Japanese with them as well as helping some of the students who were giving their first conference talks in English. Knowing some Japanese was definitely beneficial but everyone was very patient with any communication issues.

As well as working in the lab, I joined the university weightlifting club and tried my hand at some traditional Japanese handicrafts. Kyoto University has a fantastically well-equipped weightlifting club and I was able to receive some excellent coaching and make some great friends there. The advantage of joining a club is that you already have one universal language in common. Kyoto is also famous on account of its numerous world class attractions (see figure 2) and as a centre for both traditional and modern Japanese crafts which offer plenty of opportunities to try traditional weaving, dyeing and embroidery techniques.

Figure 2: The grounds in Okochi Sanso, Arashiyama, Kyoto