

Report on Visit to Queen's University Belfast by International Training Program

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In this time, I attended the International Training Program (ITP) to participate in long term exchange for two months from December 5, 2011, and I have researched at Prof. Bill Graham group in Centre of Plasma Physics of Queen's university Belfast. I will report it as follows.

I. Queen's University Belfast

Queen's University Belfast (QUB) is located in the southern district of the capital, Belfast, Northern Ireland. There are Ulster museum and Botanic Garden around the university, and the region done very in a relaxed manner. In surroundings of the botanical garden, we looked many students playing football or reading.

Centre of Plasma Physics is in Mathematics and Physics of QUB Construction. The non-equilibrium plasma is handled in Graham professor's group, and the plasma source is analyzed to simulate by the experiment when the atmospheric pressure plasma source and plasma in liquid. Moreover, most is composed of PhD and the PhD students as for the group. And British education curriculum is consisted of 3 years undergraduate course and 1 year master course, so most of the PhD students were younger than me.



Fig.1 Queen's University Belfast

II. Life in Belfast

The U.K. is located much higher latitude than Japan. So in the winter, the day length is much shorter and the climate is much colder than Japan. At 8 a.m., the sun doesn't rise yet, at 5 p.m. the sun already set. Furthermore, it frequently used to be bad weather and suddenly it started to drizzle. The British people seemed to prefer wearing hood or daring to be drenched to using the umbrella. I also accepted their style soon.

I stayed with Mr. and Mrs. Gould who lived in the house nearby QUB. They accepted lots of international students like me. Before I arrived, there was a Nigerian, and I stayed with 2 students from Spain. It took around 5 minutes from their house to QUB. There were lots of fast food shops and supermarkets, cafés nearby their house and the location was very convenient for me to live. I rented one room in their house. During Christmas vacation, I met their family and their friends. The Belfast citizen was so companionable that they talked to people even though they hadn't met each other before. Among them, there were even some people who had stayed in Japan. Once they recognized me as student from Japan, they talked to me in Japanese. It was quite surprising.

On Saturday and Sunday, there was market so-called St. George's Market in Belfast city. I could buy fresh fish and vegetables and so on. It seemed that lots of people gathered around that market. Mr. and Mrs. Gould took me to the market, I met their friends and I was introduced to them. Mr. and Mrs. Gould apparently had a wide circle of acquaintances. Since I started to live in Belfast, I mainly ate outside for lunch and supper. Thanks to high yen, I hardly mind price of food and commodity. I was able to get enough amount of food by paying 5~6 ponds. When it comes to British traditional food, I come up with fish & chips, sausage pie, mince pie, scone and pudding. These

foods were what I hadn't gone through in Japan, so they were very new for me. During Christmas vacation, I was offered that traditional pudding for many times by Gould family and I was able to see how much they loved their own traditional foods.

During off-day, I used to walk around Belfast city. The place around Belfast city hall was very civilized and there were couple of shopping malls. So, young and old people gathered that place. They seemed to enjoy window shopping and chatting. I saw some people show their performance and I found I have never got sick of Belfast city. Before Christmas, there was market in front of Belfast city hall. There were lots of branch shop that dealt exotic food and goods. Lots of people gathered there on Saturday and Sunday especially, I was able to see the Christmas was how special for them. During Christmas vacation, I was taken to several pubs by Gould's family. There were lots of people who came back to Belfast in pubs, and most of them were friends of Gould's family. They said because Belfast city was small, we became friends soon and knew each other. I understand their Irish national character is different from that of Japanese through this experience.

III. Research activity

I was lectured about the research theme given to me by Prof. Graham on the beginning of day in QUB. The research theme in Prof. Graham group was non-thermal equilibrium plasma, and Prof. Graham showed me recent progress of their research. Their research theme was oriented to medical application. The research group has studied about killing cancer cell by plasma, and the effect of plasma toward human DNA. Finally, I was lectured about progress of research theme and apparatus of plasma in liquid which was closely related to my research theme. Regarding plasma in liquid, there are still unclear mechanism of radical generation and extinction. The purpose of my theme was to analyze the mechanism by using simulation. First of all, I had to create the simulation model of OH radical generation and extinction.

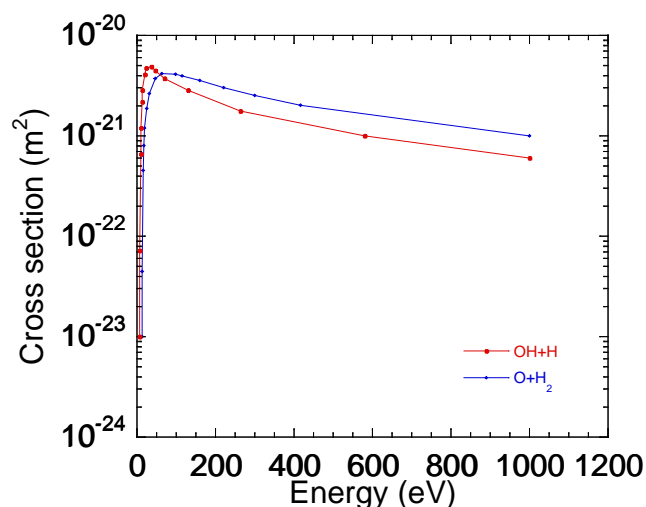
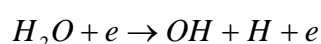


Figure 2. Example of electron and H₂O impact cross-section

The theme I was given was creating radical generation model of plasma in liquid at atmospheric pressure by using Bolsig+ and other calculation tools. The student who helped me was Andrew and Colm. They also had the experience of creating radical generation model. Andrew was using Bolsig+ and tried to create simulation of other substance reaction. Colm had completed simulation of reaction between He and O₂. What I did was using Bolsig+ and imputing cross-section data of atoms, molecules and so on, and solving Boltzmann equation by using Bolsig+. By using Bolsig+ calculation, I got electron mobility, diffusion coefficient, the reaction coefficients, EEDF (Electron Energy Distribution Function). And by imputing them into other calculation tools, I created simulation. In order to create simulation, I had to search for papers and studied what reaction would occur through electron-H₂O molecule collision. And I also gathered cross-section data of those reactions. This research theme focused on reactive species "OH radical" produced by plasma in liquid. This following reaction equation was considered.



However electron-water molecule collision also occur H₂O molecule excitation, ionization in addition to dissociation. So I had to study other possible reactions as

well. Moreover, I had to take account for other reaction and search for those cross-section data. And after imputing those data, I distinguished what chemical reaction was important, what wasn't important. From obtained cross-section data, I chose several high rate cross-section data for radical generation model. By defining the temperature and energy for plasma in liquid, I obtained data of mobility and diffusion coefficient of electron and reaction coefficients dependence on energy. I calculated approximate formula from obtained data and put them into other calculation tool, defined boundary condition, finally the simulation was completed. That was how I created OH radical generation simulation model.

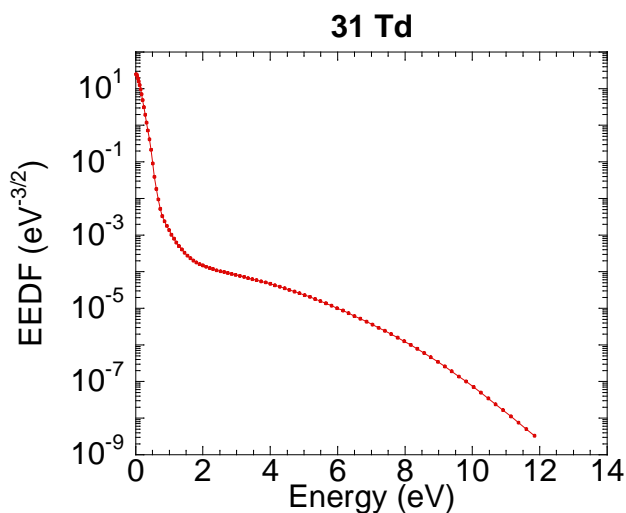


Figure 3. Example of EEDF

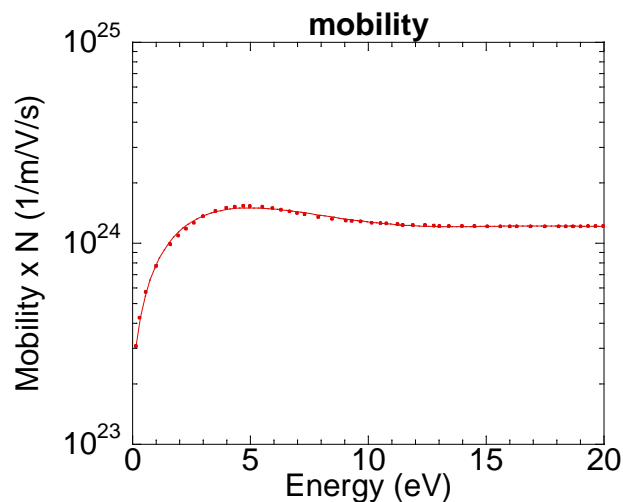


Figure 4. Mobility of electron

IV. Life in CCP

The meeting of research group was held every Tuesday. One or mostly two students were appointed to give their presentation what they had done in those days. They had about 20 minutes to give the presentation in each and the active discussion was held involving professors and PhD students. They asked about and remarked data in the presentation slide. In addition, students who didn't give the presentation also reported their progress situation of research, and what they planned to do. I could see how close the relationship between professor and students was. And the office for students was used by various research group members. I had seen the interaction among them for many times. Some students ate lunch they brought from their houses, other students went out for lunch and bought and carried them to the office. They seemed to prefer having lunch in their office. I used to have brought my lunch and joined their luncheon party. They talked about their off-day and their recent affair jestingly. I could see how similar their regular life to that of Japanese students.

V. What I have learned

From this International Training Program which I lived 60 days in Belfast, I considerably felt different culture which I hadn't gone through in Japan. Especially British country is quite far from Japan, there is little connection even between

British and Japan companies. So living in British country is at most one time experience in the life. I think that this exchange for two months was invaluable to me. In addition, there are lots of people who are not good at English. Therefore still more Japanese students must go abroad for global society and learn to see with wider vision.

From this International Training Program I lived 60 days in Belfast, because this is expected to develop research activities in the future and trigger understanding each other's culture between Japan and the U.K. through the modeling the plasma reaction in liquid, exchange of students and professor in QUB, and living abroad, and two months so it was quite invaluable to me. Though it was first experience for me to stay long in foreign country, I tried not to be afraid of failing and spontaneously tried to do lots of thing, the stay in Belfast was quite massive. Hereafter I am positively going to contact foreign people and keep in touch with them, I want to strengthen gradually relationship between foreign country and Japan.

Finally I would like to express my gratitude to Professor Graham, all CPP members who welcomed me warmly and ITP staffs who gave me this beneficial opportunity.