STEPS Students Report

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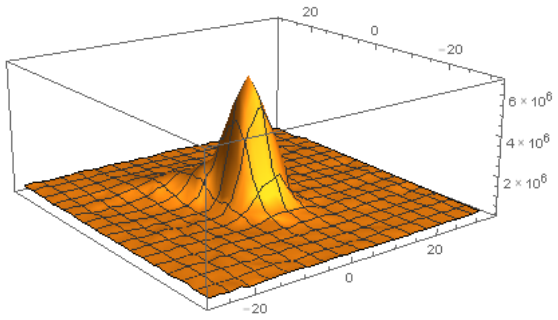
This winter I had a great opportunity to be a member of Prof. Sakai research group for a month. I would like to express the gratitude to all members of the group, especially to Sakai-sensei, Minemoto-sensei for taking me into amazing art of experiment and to Maruf Hossain for fruitful and stimulating discussions. I am also very grateful to all facilitators for making my stay comfortable.

Prof. Sakai group is doing investigations in several fields of physics, but the research I joined to is dedicated to the molecular orientation in strong non-resonant light fields. It is challenging theoretical and experimental problem, which is being solved in several groups in the world. The main aspect of such experiment is that there is a straightforward way to align molecules in a linearly polarized light but the selection of particular orientation (along the field axis or opposite to it) requires great effort. Three laser fields are involved in the process. One of them is a femtosecond field used for molecule's ionization and consequent detection. Another two are generated by the nanosecond laser and some part of the radiation is converted into second harmonics by a nonlinear crystal. These nanoseconds field create effective potential for molecules, making them orient along the field. The most important features governing quantum molecular dynamics are adiabaticity and field potential asymmetry. The adiabaticity is partially maintained by the long duration of nanosecond pulses. My aim in the investigation was to improve experimental methods in order to achieve higher degrees of orientation. There were three important parts of experiment I had to take care of.

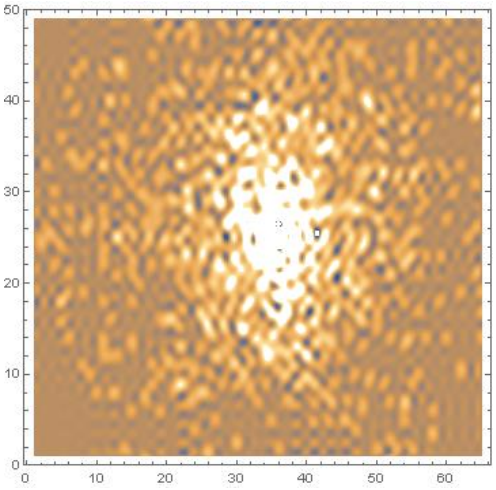
The first thing was to ensure the time stability of the laser fields. To deal with the problem Minemoto-sensei and I inspected the inside of the nanosecond laser amplifiers and changed flash bulbs in order to increase stability of modes generated and amplified in the experimental set up. We also had to conduct the adjustment of the optical elements to let the beams intersect correctly.

Another problem was connected with fields was precise tuning of beam intersection. For this purpose, I had to carry continuous iterative procedure, that would let the optical fields of nanosecond and femtosecond lasers have the same focal point and coincide in section perpendicular to beam path. Typical laser's spatial profiles that we gathered in the experiment are attached bellow, and one can notice that they are well approximated by Gaussian function.



The last problem I had to solve was the laser phase difference control, which was implemented the following way. There was a fused silica plate along the nanosecond laser propagation path that could rotate and change the beams' path inside the plate. Therefore controlling the phase difference between them. Some part of the light was decoupled from the main beam and we could observe the nanosecond's fundamental and second-harmonic interfere at the other part of the experiment. Obtained interference patterns are extremely helpful tool for calculation of the phase difference.

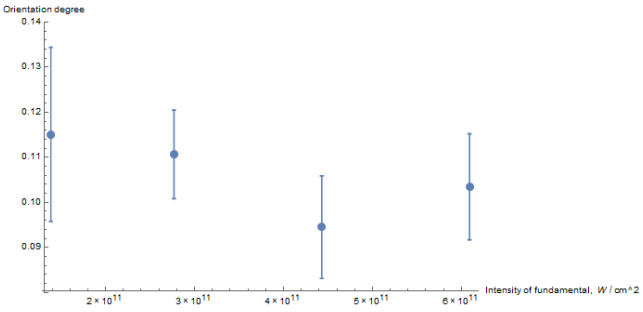
Eventual experiment let me observe molecular angular and radial distributions that were calculated from detection pattern (I attached one of them below).



One can notice that the spatial distribution is more elliptical rather than spherical. The main reason is that the alignment took place in the process and made one direction more preferable. More detailed analysis shows that the bottom areas are denser so orientation is also inherent to the picture shown above.

Higher degree of orientation is the main goal in the context of molecular orientation. It takes a lot of skill and time to get high mean value of angle's cosine, which is the numerical value of orientation. During my series of experiment, the highest value vas 0.1, which is not so outstanding comparing to the Sakai's group 0.3. Nevertheless, I

was satisfied with the result, because I could observe the effect itself, moreover the non-typical dependence of orientation on light intensity, which is one of the group's recent results. (I attached it below)



In summary, I suppose the results that I gathered for the month are satisfactory. In my opinion, the most essential effects of my stay in Japan are experience and knowledge and I would be happy to use them in my future research.