

Report: Long-term overseas dispatch

Department of Physics, Nobuyuki Okuma

I stayed in Prof. Allan H. MacDonald's group for three months since Sep.28, 2015. I performed a collaborative study with Massoud Ramezani and Allan H. MacDonald. Our theme is "Microscopic theory of spin orbit torque". In this study, we microscopically derive a spin-charge coupled Boltzmann equations of multi-band systems by using the quantum kinetic equation. We also evaluate the magnitude of the spin orbit torque for some examples.

One of the important ways of thinking in theoretical physics is to make a theory for the simplest model at first. We start from the two-dimensional Dirac Hamiltonian. The two-dimensional Dirac Hamiltonian is a model of a topological insulator. We choose this Hamiltonian, which apparently is a specific model. However, this Hamiltonian is one of the simplest models that describe the spin orbit interaction, which breaks the $SU(2)$ symmetry in spin space. This is because the number of the band degrees of freedom is the same as the number of spin degrees of freedom, two, and the number of Fermi surface is only one. We derive the spin-charge coupled Boltzmann equations and solve them for specific case analytically. Then we generalize this procedure for non-degenerate two-band models. Our goal is to generalize this procedure for the N -band systems. To do this, we use the knowledge of the $su(N)$ Lie algebra and show that spin, which is a vector in three-dimensional space, is naturally generalized to a vector in N^2-1 -dimensional space. We also perform numerical calculations for various cases in the surface state of a topological insulator. Now we write a paper about our results.

In this stay, I discussed with prof. MacDonald about twice a week. I also discussed with Massoud Ramezani frequently. Although I had experiences of English discussions before this stay, I had no experience with discussing with the researchers who are the collaborators. I felt a difficulty in discussing. I had to tell the collaborators about my research perfectly because I cannot make any mistakes in the collaborative study. Now I recognize the importance of English skills and feel that I should study English harder.

In this stay, I had other fruitful experiences. This stay was the first long-term stay in abroad. It took one month to get used to daily lives. I had roommates and talk with them just before going to bed. I could make a lot of friends, e.g. a Japanese who want to study in other field and a Vietnamese who study English for enrolling in a college in America.

Acknowledgement: I acknowledge many fruitful discussions with Allan H. MacDonald and Massoud Ramezani. I also acknowledge the financial support from MERIT. I would like to thank my friends.

