学位申請論文公開講演会

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場所：B5 講義室（B501）（コロナ感染拡大で急遽オンラインに切り替わる可能性があります。公聴会への参加を希望される方は主査(河野：kohno@st.phys.nagoya-u.ac.jp)に事前にご連絡ください。）
題目：Microscopic theory of antiferromagnetic spin dynamics
driven by magnetic field and electric current
(電流および磁場に駆動された反強磁性スピンダイナミクスの微視的理論)

主論文の要旨

Spin electronics, or spintronics for short, aims to utilize both the magnetic and electric properties of electrons to expand upon the conventional physics of electronics. So far, spintronics has proven itself useful through the discovery of the Nobel prize winning giant magnetoresistance and magnetoresistive random access memories.

Such remarkable developments were made with ferromagnets (FMs), and research in other classes of materials such as antiferromagnets (AFs) remain relatively limited. AF is another class of magnetic material that has a number of advantages over FMs, such as the robustness to magnetic perturbations, THz range spin dynamics, and absence of stray fields. Immunity to external magnetic fields and absence of stray fields are however a double-edged sword, and makes the manipulation and measurement of AFs a challenge compared to FMs. In this thesis, I theoretically explore different ways to tame AFs to our advantage.

Dynamics of magnetic domain walls (DWs) is one of the fundamental phenomena that are of interest from both theory and application perspectives. In the first part of my work, I explore the dynamics of AF DW driven by magnetic fields. By reformulating the AF spin dynamics equations, I show that the DW motion is indeed possible if the magnetic field is inhomogeneous; it is initiated by a paramagnetic response of wall magnetization, which is then driven by a Stern-Gerlach like force. The validity of the theory is backed up by atomistic simulations.

In the second part, I explore the effect of conduction electrons on AF spin dynamics, and examine current-induced DW motion and spin-wave Doppler shift. I first present microscopic calculations of various torques, which include two reactive and one dissipative spin-transfer torques (STTs), and two damping torques. Both reactive STTs are found to add up and contribute to the spin-wave Doppler shift, whereas only one of them affects DW motion. By tuning the intra- and inter-sublattice hopping parameters, a crossover of the two reactive STTs from the AF transport regime to the FM transport regime is studied. It is found that the STT responsible for the DW motion has an opposite sign to that in FMs, thus the current drives DWs in mutually opposite directions between AF and FM. This seems to explain a recent experiment on ferrimagnetic DW motion.