Advanced Materials Science

Otani Laboratory

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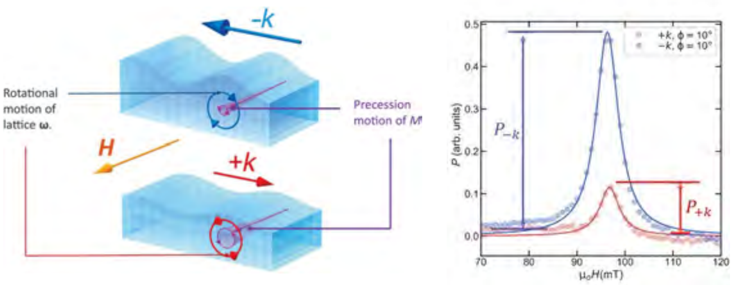
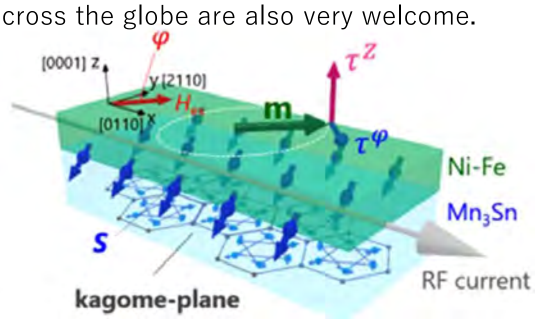
Spin current, a flow of spin angular momentum, was introduced towards the end of the twentieth century. Spintronics has evolved as a new type of electronics that successfully uses both charge and spin currents. Recently, it has been discovered that quasiparticles such as charge, spin, phonon, photon, and magnon can be converted to each other in solids through the mediation of spin. These "spin conversions" have been developed as a solid-state physics research area and are now about to blossom as ***strongly coupled spintronics***, in which coupled-quasiparticles generate a new quasiparticle. Because these phenomena frequently occur at the nanoscale at the junction interface of relatively basic different materials, they offer a wide range of applications. From the viewpoints of fundamental spin conversion and strongly coupled spintronics, our laboratory is working on developing new spin-related properties and the elucidation of their mechanisms. The following are representative research topics in our laboratory.

In recent spintronics research, antiferromagnetic materials, which have not seen the light of day compared to the more versatile ferromagnetic materials, have attracted a great deal of attention and are showing new developments as antiferromagnetic spintronics. Another important topic in spintronics is the realization of strongly coupled states, which play a vital role in the conversion between quasiparticles. At the Otani Lab, research is being conducted focusing on these two areas. We welcome anyone who wants to challenge new things with curiosity. Prof. Otani will promote a research project on magnon-phonon strong coupling spintronics as an invited professor at the CEA Spintec Institute in France for three years from 2022. In addition, we have a wide range of domestic and international collaborations, so those who wish to participate in research activities across the globe are also very welcome.



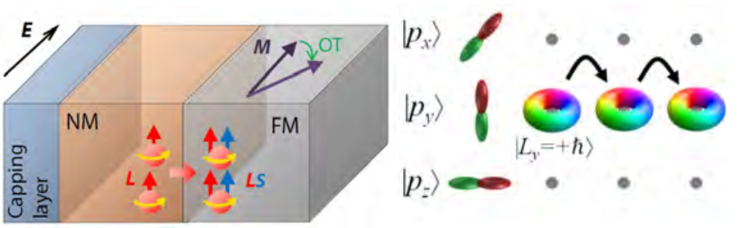
Nonreciprocal surface acoustic wave propagation via magneto-rotation coupling: The rotational lattice motion caused by surface acoustic waves couples with the magnetization. This magneto-rotation coupling induces a nonreciprocal attenuation on the surface acoustic waves.

M. Xu, *et al.* Science Advances (2020)



Spin-orbit torque via magnetic spin Hall effect in Weyl antiferromagnets: Magnetic spin Hall effect in Weyl antiferromagnets produces out-of-plane spin accumulation, which can control the magnetic state of magnetic materials. We demonstrated that the sign of the magnetic spin hall effect could be tuned by changing the direction of cluster magnetic octupole moment in the antiferromagnet.

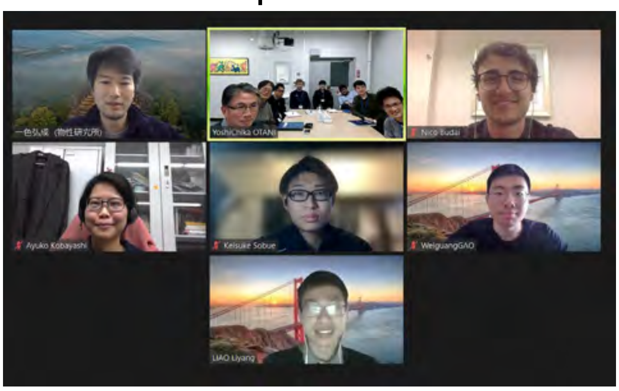
M. Kimata, *et al.* Nature (2019)
K. Kondou, *et al.* Nat. Comm. (2021)



Injection of orbital angular momentum into ferromagnet: Recent theoretical works predict that not only spin-current injection but also the orbital current, a flow of the orbital angular momentum, injection into ferromagnets can generate torque. We demonstrated Nontrivial torque generation by orbital-current injection in ferromagnetic-metal/Cu/Al_2O_3 trilayers.

J. Kim, *et al.* PRB (2021)
L. Lio, *et al.* PRB (2022)

Group Photo 2022



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