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Magnetic equivalent of the Seebeck effect.

SYLVAIN BRECHET, EPFL

Spin caloritonics seeks to investigate the effect of a thermal gradient on the electronic charge and spin degrees of freedom. In a conductor, a thermal gradient leads a transport of the conduction electrons that in turn generate an electric field along the temperature gradient, which is the well-known Seebeck effect. In an insulator, there are no conduction electrons. Thus no electronic charge transport takes place. However, the electronic spins can reorient themselves in the presence of a temperature gradient as they precess around an external field oriented along the temperature gradient. In fact, the temperature gradient generates a magnetic induction field in the plane orthogonal to the temperature gradient. The effect is the magnetic analog of the Seebeck effect and is thus refered to as the magnetic Seebeck effect. It has been observed for the propagation of spin waves along and against a temperature gradient in a YIG slab. The propagation of spin waves against the temperature gradient lead to a positive thermal damping and the propagation along the temperature gradient leads to the opposite effect, namely a negative thermal damping. Thus, the magnetic Seebeck effect generate of heat driven spin torque that can generate a positive or a negative thermal damping. The magnetic Seebeck effect has been recently established using a fundamental variational approach.In many experimental situations, the system can be treated as a classical continuum with magnetisation on the scale of interest where the quantum fluctuations average out and the underlying microscopic structure is smoothed out. For the propagation of magnetisation waves in a stationary state, the system is slightly out of equilibrium but the magnetic kinetic energy is constant. In such a case, the action of the system is a functional of the magnetisation and the magnetisation current. Since the magnetisation is a function of the temperature, the action variation yields an explicit expression for the magnetic induction field generated by the temperature gradient. This field lead to a heat driven spin torque that has the same geometry in an insulator than the spin transfer torque proposed by Berger and Slonczewski in a conductor.