Seminar organized by Graduate Program in Spintronics

GP Spin

"Magnetic domain walls in thin-film nanostructures: statics, dynamics, and emerging applications"

Speaker: Professor Geoffrey Beach (Massachusetts Institute of Technology)

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16:00-17:30

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(Katahira campus)

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Magnetic domain walls in thin-film nanostructures:

Statics, dynamics, and emerging applications

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Domains of opposing magnetization direction in a ferromagnet are separated by narrow transitions called domain walls. Ferromagnetic nanowires provide a well-defined conduit for domain walls, which may be manipulated by magnetic fields or electric currents and used in a variety of information storage and processing schemes [1]. This seminar will describe the static and dynamic properties of domain walls, their interactions with spin currents, and how these properties can be engineered in nanoscale materials and device geometries.

In thicker magnetic films the magnetostatic energy dominates: domains lie in the plane and the structure and dynamics [2] of nanowire-guided domain walls are dictated principally by the geometry. In this case the domain walls are typically quite wide, and while they can be driven by current through bulk spin-transfer torques [3,4], the high critical currents and low velocities present a challenge to eventual applications. In ultrathin films, broken symmetry and spin-orbit coupling (SOC) at interfaces can give rise to an interfacial contribution to the magnetic anisotropy that can dominate if the film is sufficiently thin, pulling the magnetization out of the plane and leading to domain walls with a width of just a few nm. While the influence of interfacial SOC on magnetic anisotropy has been recognized for decades, the impacts on spin transport and spin textures in ultrathin-film heterostructures have only recently to come to light. In nonmagnetic heavy metals such as Pt and Ta with strong SOC, conduction elecrons exhibit a left-right scattering asymmetry such that spin "up" and spin "down" electrons pile up on either side of a material when a charge current flows through it. This spin Hall effect can be used to create pure spin currents at the interface that can efficiently drive magnetization switching and domain wall motion in an adjacent ferromagnetic film [5,6]. At the same time, broken inversion symmetry and spin-orbit coupling can lead to an antisymmetric exchange interaction known as the Dzyaloshinskii-Moriya (DM) interaction, which competes with the usual Heisenberg exchange to generate nonuniform spin textures with a preferred chirality [6]. This seminar will describe the origin and consequences of this interaction on domain walls and their dynamics [6,7], as well as other topologically nontrivial textures such as magnetic skyrmions that have very recently been observed at room temperature [8].

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