Condensed Matter/Bio Physics Seminar

Department of Physics

Date: Thursday, October 30, 2014

"Electric Manipulation of Spin Textures"

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Abstract: The imminent breakdown of Moore's law due to the heat management bottleneck drives the search for alternative approaches for power-efficient information encoding and processing. Towards this end, temporal and spatial magnetic spin textures have received increased interest, since their dynamics can occur with minimal dissipation. Typical examples of temporal spin textures are spin waves, or magnons, which are the fundamental dynamic excitations of a magnetically ordered system. Spatial spin textures that have received recently increased attention are magnetic skyrmions. These are spin structures that are stabilized by their distinct topology, and therefore can behave as independent quasi-particles. The high interest in skyrmions arises from the fact that they can be manipulated very efficiently with electric currents with ultra-low threshold current densities.

In this presentation I will discuss two recent examples of electrically manipulating these spin textures. First, I will show how local Oersted magnetic fields from charge currents can manipulate the propagation of spin waves. This can be used for guiding spin waves through curved waveguides, where otherwise the spin wave propagation is suppressed by the inherently anisotropic spin wave dispersion in thin films [1]. This same concept can be further generalized for switching spin waves between multiple waveguides [2].

Second, I will discuss how magnetostatically stabilized skyrmion structures, magnetic bubbles, can form in magnetic thin films with perpendicular magnetic anisotropy. By adding an additional layer with strong spin-orbit coupling to the ferromagnet, it is possible to generate an interfacial chiral Dzyaloshinskii Moriya interaction, which stabilizes the skyrmion spin structure in the magnetic bubble domain wall. Using spin Hall effects [3] these magnetic skyrmion bubbles can then be electrically manipulated. This is demonstrated for completely metallic systems, where we can generate skyrmions through inhomogeneities of electric charge currents in a process that is remarkable similar to the droplet formation in surface-tension driven fluid flows. This provides a practical approach for skyrmion formation on demand. From an applied point of view skyrmion structures in ferromagnetic insulators are of even higher interest due to their extremely low magnetization damping. However, the large charge gap makes direct electric manipulation in these materials impossible. Nevertheless, we show that even in these systems electrical manipulation of the skyrmions is possible by utilizing again spin Hall effects. In these measurements, we observe different behaviors for individual skyrmions, which can be understood in terms of different topological charges.

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References

1. K. Vogt, *et al.*, Appl. Phys. Lett. **101**, 042410 (2012).
2. K. Vogt, *et al.*, Nature Commun. **5**, 3727 (2014).
3. A. Hoffmann, IEEE Trans. Magn. **49**, 5172 (2013).

The seminar will be held at 10am in 2214 SES.

UIC Physics Department/SES is located at 845 W. Taylor Street, Chicago, IL, 60607