Nebraska Center for Materials and Nanoscience

2020 Spring Seminar Series

Professor Xin Fan

Assistant Professor of Physics
University of Denver

Transverse Spin-Orbit Effects in Magnetic Materials

The anomalous Hall effect, discovered by Edwin Hall in 1880, describes a phenomenon that an electric current perpendicular to magnetization of a magnetic material can produce a charge accumulation in the direction orthogonal to both electric current and magnetization. Through century-long theoretical and experimental efforts, it is now understood that the anomalous Hall effect arises from the spin-orbit coupling. The understanding of the anomalous Hall effect has also led to the discovery of new spin-orbit effects, such as the spin Hall effect, where an electric current generates spin accumulations in nonmagnetic materials. However, despite the comprehensive understanding, I will argue that the anomalous Hall effect is incomplete in describing the spin-orbit coupling-induced phenomenology in magnetic materials. There exist a group of spin-orbit effects associated with transverse spins – spins polarized perpendicular to the magnetization, which have been previously overlooked. We refer to this group of spin-orbit effects as transverse spin-orbit effects in magnetic materials. In my talk, I will discuss our experimental observations of two unique transverse spin-orbit effects: (1) spin-to-charge interconversion with unconventional spin rotation symmetry and (2) the generation of anomalous spin-orbit torque in a single layer magnetic film – a hidden counterpart to the anomalous Hall effect.

[1] Humphries, A. M., Wang, T., et al. Observation of Spin-Orbit Effects with Spin Rotation Symmetry, Nature Communications, 8, 911 (2017)

[2] Aljuaid, W. S., Allen, S. R., Davidson, A., Fan, X., Free-layer-thickness-dependence of the spin galvanic effect with spin rotation symmetry, Applied Physics Letters 113, 122401 (2018)

[3] Wang, W., Wang, T., et al. Anomalous Spin-orbit Torques in Magnetic Single-layer Films, Nature Nanotechnology, 14, 819-824 (2019)

[4] Davidson, A., Amin, V. P., Aljuaid, W. S., Haney, P. M., Fan, X., Perspectives of Electrically Generated Spin Currents in Ferromagnetic Materials, Physics Letters A 126228 (2020)

Xin Fan received his B.S. in Physics from University of Science and Technology of China in 2004, and Ph.D. in Condensed Matter Physics from University of Delaware in 2010. His advisor is Prof. John Xiao. After graduation, Xin stayed in the same group as a postdoc fellow. He joined the faculty of University of Denver in 2014, and is currently an assistant professor in Physics at DU. His current interests include magnetization dynamics and spintronics.

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February 26, 2020 | 4 p.m. | 136 Jorgensen Hall
Refreshments in 1st floor vending area at 3:45
Host: Kirill Belashchenko
Department of Physics & Astronomy