UNL Department of Physics and Astronomy presents:

Spin Dynamics in Soft Magnetic Microstructures

PRESENTED BY

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VIA ZOOM

ABSTRACT

Magnetization reversal in soft magnetic materials occurs via motion of domain walls that separate regions (domains) of uniform electron spin orientation. This presentation describes research carried out at The University of Texas by Erskine's group and collaborators (2000-2010) that addresses magnetic-field and electric-current driven domain-wall motion. A brief introduction covering selected properties of magnetic materials relevant to domain formation and magneto-optical effects in magnetic materials is provided to review the underlying physical phenomena and the primary experimental tools used in the research [1]. Early experiments that motivated the development of a high-speed high-spatial-resolution magneto-optic Kerr effect polarimeter [2] are described including the related initial studies of Barkhausen effects and magnetic energy-loss scaling in Permalloy microstructures [3]. Refinements of the instrument and technique development for fabricating thin-film-based Permalloy nanowire structures are described that provided the basis for new experimental studies of magnetic-field [4] and electric-current [5] driven domain-wall dynamics. These experiments tested decade-old analytical models and numerical simulations. Topics include: 1) Simulation of magnetic domain structures and wall types in rectangular cross-section Permalloy nanowires, 2) A discussion of the one-dimensional model of domain-wall motion including predictions of two wall-motion regimes separated by a critical (Walker) field - a linear mobility regime characterized by a simple transverse-wall structure and a higher drive field regime involving complex vortex wall structures and negative differential mobility. 3) Time-of flight measurements of the domain-wall velocity as a function of applied field that verify one-dimensional model predictions including the breakdown field and the oscillatory nature and negative differential mobility of vortex structure propagation. Modifications in methodology are described that extend the time-of-flight mobility curve measurements to include study of spin-torque mechanisms that permit electric current in the nanowire to drive domain-wall motion. Experiments that probe the spin-torque efficiency parameter and other features of spin-transfer torque mechanisms are described. General reciprocity arguments suggested that current-induced domain-wall forces should be accompanied by a voltage produced by a magnetic-field propelled domain wall. This mechanism (proposed by Berger and called the magnetic Josephson Effect due to the universal nature of the generated EMF) is detected [6] using methodology developed for the domain-wall dynamics experiments.

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