University at Buffalo *The State University of New York*

Department of Physics

239 Fronczak Hall, Buffalo, NY 14260-1500 • Telephone (716) 645-2017 • FAX (716) 645-2507

ANNOUNCEMENT

COLLOQUIUM

"Listening" to the Spin Noise of Electrons and Holes in Semiconductors

Dr. Scott A. Crooker

National High Magnetic Field Laboratory, Los Alamos

Abstract:

Not all noise in experimental measurements is unwelcome. Certain fundamental noise sources contain valuable information about the system itself – a notable example being the inherent voltage fluctuations (Johnson noise) across any resistor, from which temperature can be determined. In magnetic systems, fundamental noise can exist in the form of random spin fluctuations. For example, statistical fluctuations of N paramagnetic spins should generate small noise signals of order $\sqrt{N}$ spins, even in zero magnetic field. In accord with the fluctuation-dissipation theorem, the spectrum of these fluctuations – if experimentally measurable -- can reveal the dynamical properties of the spins (such as g-factors and spin decoherence times) without ever perturbing the spin ensemble from thermal equilibrium.

This talk describes how we measure electron and hole spin dynamics in semiconductors by passively "listening" to these small spin noise signals. We employ a spin noise spectrometer based on a sensitive optical Faraday rotation magnetometer that is coupled to a digitizer and field-programmable gate array (FPGA), to measure and average noise spectra from 0-1 GHz continuously in real time (no experimental dead time) with picoradian $/\sqrt{\mathrm{Hz}}$ sensitivity. This approach, applied originally to paramagnetic atomic vapors [1], is now being used to measure spin noise from electron Fermi seas in n-type GaAs [2] and, very recently, from electron and hole spins that are localized in self-assembled InGaAs quantum dot ensembles [3]. Both electron and hole spin fluctuations generate distinct noise peaks, whose shift and broadening with magnetic field directly reveal their g-factors and dephasing rates. These noise signals increase as the probed volume shrinks, suggesting possible routes towards non-perturbative, sourceless magnetic resonance of few-spin systems.

[1] Nature **431**, 49 (2004); [2] Phys. Rev. B **79**, 035208 (2009); [3] Phys. Rev. Lett. **104**, 036601 (2010).

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