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"Listening" to the spin noise of electrons and holes in semiconductor quantum dots[1]

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The coherence and dynamical properties of spins in semiconductors are usually studied with powerful techniques based on optical pump-probe or spin resonance methods. Such methods are necessarily perturbative, in that one measures the (dissipative) response of the spins resulting from an external drive or excitation field (*eg*, free-induction decays). However, in accord with the fluctuation-dissipation theorem, the intrinsic fluctuations of the spin system - if experimentally measurable - can also reveal the same dynamical properties (such as g-factors and 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 [1]. 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 acquire noise spectra from 0-1 GHz in real time with picoradian/root-Hz sensitivity. In doped (In,Ga)As/GaAs quantum dots, 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. A large, energy-dependent anisotropy of in-plane hole g-factors is clearly exposed, reflecting systematic variations in the average confinement potential. In contrast with conventional pump-probe studies, noise signals increase as the probed volume shrinks, suggesting possible routes towards non-perturbative, sourceless magnetic resonance of few-spin systems.

[1] PRL **104**, 036601 (2010); PRB **79**, 035208 (2009).

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