Spin Torque Shot Noise and Magnetization Dynamics

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We investigate the role of spin shot noise in the magnetization dynamics of mono-domain ferromagnets. A spin polarized current may transfer angular momentum to a ferromagnet, resulting in the celebrated spin torque phenomenon. The spin shot noise, associated with the discreteness of the spin degree of freedom, leads to a nonequilibrium stochastic force acting on the ferromagnet. We propose a stochastic version of the Landau-Lifshitz-Gilbert equation including both thermal and nonequilibrium sources of noise. By means of the Keldysh technique we derive the spin shot noise correlator in the magnetic tunnel junction setup. The correlator exhibits a dependence on the mutual orientation of the fixed and free layer's magnetizations, thus being fundamentally different from thermal noise. We solve the corresponding Fokker-Planck equation and show that the nonequilibrium noise leads to the experimentally observed nonmonotonic dependence of the precession spectrum linewidth on the current and to a saturation of the spectral linewidth at low temperatures. Finally, the role of the nonequilibrium noise in spin torque switching is investigated by applying a generalized Fokker-Planck approach that models the alteration of switching rates by a change of the effective temperature in the Arrhenius factor. We show that the spin shot noise leads to a renormalization of the effective temperature, whose details depend on the geometry of the system.