Lorentzian and non-Lorentzian spin noise: what the lineshape tells us about the physics?

EVGENY SHERMAN*

Department of Physical Chemistry, University of the Basque Country UPV/EHU and IKERBASQUE, Basque Foundation for Science, Bilbao, Spain

Spectroscopy of noise is a powerful tool to study condensed matter phenomena, including spin dynamics of quantum and semiclassical electrons in solids [1]. Spin noise spectra contain valuable information about spin fluctuations and subsequent spin relaxation at the equilibrium state of a macroscopic system. Here we present theoretical analysis of spin noise in two qualitatively different systems such as: (1) hopping electrons in semiconductor nanowires and (2) strongly light-matter coupled states represented by polaritons in optically driven microcavites.

We begin with semiconductor nanowires considered as prospective elements for spintronics and realization of the Majorana states. Here we concentrate on the spin dynamics and noise caused by the interplay of electron hopping between large-radius one-site localized states and the hyperfine interaction of electron and nuclear spins. At a sufficiently low density of these sites the hopping rates have an exponentially broad distribution resulting in slow spin relaxation and anomalous ¨non-Lorentzian low-frequency noise similar to the $1/f$ "flicker" behavior [2].

Next, we consider (pseudo)spin fluctuations of excitons-based polaritons in a driven microcavity. This noise is determined by the occupation of the ground state, Bose statistics of polaritons, and interactions between them. Its spectrum becomes very narrow in the lasing regime due to formation of a polariton condensate. The shape of the spectral line becomes non-Lorentzian due to the interaction-induced spin decoherence [3].

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*evgeny.sherman@ehu.es

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