ESR of a single spin in quantum-dot spin valves

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We discuss the possibility to generate, manipulate, and probe single spins and their dynamics in single-level quantum dots (QDs) or single molecules coupled to ferromagnetic leads. We develop a theory of electron transport through QDs that are weakly coupled to ferromagnetic leads taking non-collinear magnetization of the leads into account, and allows for an externally-applied magnetic field [1, 2]. The spin-polarized current flowing between dot and electrodes leads to a non-equilibrium accumulation of spin on the dot. Both the magnitude and the direction of the dot's spin depend on the magnetic properties of leads and their coupling to the dot. They can be, furthermore, manipulated by either an externally applied magnetic field or an intrinsically present exchange field that arises due to the spin-polarized tunnel coupling of the strongly-interacting-QD states to ferromagnetic leads. The exchange field can be tuned by both the gate and bias voltage, which, therefore, provide convenient handles to manipulate the quantum-dot spin. Since the transmission through the QD spin valve sensitively depends on the state of the QD spin, all the dynamics of the latter is reflected in the transport properties of the device.

We suggest a series of transport experiments on spin precession in QDs coupled to one or two ferromagnetic leads. An applied magnetic field gives rise to the Hanle effect [3]. Recent experiments fit well to our predictions [4].

We study also frequency-dependent current noise of this system. We show that the noise spectrum displays a resonance at the Larmor frequency, whose line-shape depends on the relative angle of the leads' magnetizations. One can thus use the current noise as a tool to detect the electron spin resonance (ESR) from a single spin [5, 6].

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