Interplay of the Kondo effect and ferromagnetism in molecular spintronics devices

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We study the Kondo effect in a quantum dot (QD) or a single molecule, which is coupled to ferromagnetic leads, and analyze its properties. Based on a scaling analysis [1] we first show that a splitting of the Kondo resonance similar to the usual magnetic-field-induced splitting will appear due to exchange interaction with leads. The most important result is that this splitting can be fully compensated by an appropriately tuned external magnetic field and the strong coupling limit of the Kondo effect can be restored. The value of the Kondo temperature decreases with increase of the spin polarization and is suppressed to zero for the full spin-polarized system [1, 2]. We adapt the NRG method [2, 3] to the case of a QD coupled to ferromagnetic leads. We show that the Kondo effect in the presence of ferromagnetic leads has unique properties such as a strong spin polarization of the density of states at the Fermi level. In addition, we find, surprisingly, that even in the presence of strong spin asymmetry in the QD spectral function at the Fermi level, the ground state of the system has a fully compensated local spin and displays Fermi liquid behavior. Electronic transport is investigated in the unitary limit at $T = 0$, and we find that the system has the same conductance $G = e^2/h$ for each spin channel, despite of the strong spin asymmetry in the spectral density at the Fermi level. We also analyze the nonlinear transport through the QD [1, 4]. We find that for parallel alignment of the lead magnetizations the zero-bias anomaly is split. This splitting can be removed by appropriately tuning of a magnetic field. In the antiparallel configuration of the lead magnetizations and symmetric coupling no splitting occurs. New experimental results for single C_{60} molecules and carbon nanotubes attached to ferromagnetic leads [5] confirm our theoretical predictions.

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