Non-equilibrium steady state transport through quantum dot spin valves

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Transport through correlated nanostructures, such as quantum dots or molecules, has been under intensive research owing to the fascinating physics emerging at the nanoscale. In particular, a many-body effect resulting in an enhancement of the zero-bias conductance up to the quantum limit at low temperatures, known as the Kondo effect, is one among the main reasons for this increasing attention. Even though this effect could be theoretically explained using the Wilson's numerical renormalization group (NRG) under equilibrium, there is a need for reliable quantitative results for such systems in the non-equilibrium regime. In this communication, we theoretically investigate the non-equilibrium transport properties of a quantum dot-spinvalve, i.e., a quantum dot attached to two ferromagnetic leads, particularly focusing on the Kondo regime. We employ a hybrid NRG-time-dependent density matrix renormalization group approach that enables us to accurately resolve extremely low energy scales, while keeping the system out of equilibrium. We study the non-equilibrium steady state current, while probing the system under various parameters,such as lead spin polarization, temperature and applied magnetic field. The system when tuned to the particle-hole symmetry point, shows a finite zero-bias conductance peak, characteristic of the Kondo effect, and a reduction of the Kondo energy scale in voltage with rise in the lead spin polarization, which is quantitatively different from previous theoretical predictions for equilibrium systems. Moreover, a suppression of the Kondo resonance with increasing the lead polarization is observed when the system is detuned out of the particle-hole symmetry point, owing to the emergence of an exchange field in the system. Interestingly enough, for a particular value of applied magnetic field, the Kondo resonance can be restored. Our work provides quantitatively accurate results for nonequilibrium behavior of quantum dot spin valves that may serve as benchmark for future theoretical and experimental works.

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