Large voltage-tunable spin valve based on a double quantum dot

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In this communication the theoretical study of spin-dependent transport properties of a spin valve based on a double quantum dot setup is described. In the considered device each quantum dot is strongly coupled to a separate ferromagnetic lead, while the coupling between the dots is assumed to be weak. Using perturbation theory in the hopping between the dots, we have determined the current flowing through the system, its spin polarization and the tunnel magnetoresistance associated with the change of magnetic configuration of the leads from the parallel to antiparallel one. To calculate the spectrum of a quantum dot-ferromagnetic lead subsystem in most accurate manner, we have used the numerical renormalization group method. We show that the spin-resolved transport strongly depends on the magnitude and sign of the exchange field, which splits the double dot levels. Such a field, which can be controlled by gate voltages applied to the dots, plays a role similar to a local magnetic field. We demonstrate that in the linear response regime both positive and inverse tunnel magnetoresistance can be obtained. Moreover, in the nonlinear response regime, we predict a perfect spin polarization of the current and a greatly enhanced tunnel magnetoresistance. These effects can be observed when the exchange field is of opposite sign in each dot, which can be obtained by appropriate tuning of gate voltages. Our work reveals thus that double quantum dots strongly attached to external ferromagnetic leads can serve as efficient voltage-tunable spin valves characterized by high output parameters.

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