Ac-driven few-electron double quantum dots operated as spin pumps and bipolar spin filters

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ABSTRACT

The field of spintronics aims at creating devices that utilize the spin degree of freedom of electrons. In one approach, a spin-polarized current is injected from a ferromagnetic material into a metal or a semiconductor. Alternatively, a spin filter can be built *without ferromagnetic leads* by using quantum dots with pulsed gate voltages, as recently shown experimentally in [1].

In this work we propose an alternative approach which uses ac driven double quantum dots as spin filters. In particular, we demonstrate the possibility of pumping spin polarized electrons, namely a *spin polarized current*, without a net dc voltage across the double dot device. Furthermore, our proposal allows to control the spin polarization of the current by changing the frequency of the applied ac signal (in the range of GHz). In particular, the use of an ac signal allows fast switching of the polarization of the current from 100% spin up to fully spin down polarization.

Our results are based on simulations of the dynamics of the full reduced density matrix of the problem by using a Markov master equation approach. The behavior of the pumped current through the double-dot is studied as a function of the parameters of the ac field and as a a function of the coupling to the leads. Spin relaxation and decoherence effects are also studied.

[1] R. Hanson, L. M. K. Vandersypen, L. H. Willems van Beveren, J. M. Elzerman, I. T. Vink and L. P. Kouwenhoven, cond-mat/0311414.