OVERHAUSER FIELD-INDUCED ELECTRON TRANSPORT THROUGH WEAKLY COUPLED DOUBLE QUANTUM DOTS.

C. López Monis*1*, J. Inarrea*1,2*, G. Platero*1* and Allan H. McDonald[3].

*1*Instituto de Ciencia de Materiales(CSIC), Cantoblanco, Madrid, Spain.

*2*Escuela Politecnica Superior,Universidad Carlos III,Leganes,Madrid,Spain.

[3]Department of Physics, University of Texas at Austin.Austin, Texas 78712

Recent transport experiments in double quantum dots show that Pauli exclusion principle plays an important role [1-5] in current rectification. Thus these devices could behave as externally controllable spin-Coulomb rectifiers with potential application in spintronics as spin memories or transistors.
We analyze the electronic transport through a double quantum dot in the regime where spin blockade occurs as a function of a DC magnetic field. We have developed a model where the Overhauser interaction between both electronic and nuclear spins and their interplay with the external magnetic field are proposed to lift spin blockade regime. Our results indicate that the current leakage experimentally observed in the spin blockade region [1], occurs mainly due to the latter spin-flip processes, affecting the electrical response and properties of the potential current rectifying device.

Triplet states, in the double quantum dot, are responsible for spin blockade. This blockade is lifted by a electron spin flip to a singlet state generating a leakage current. In our model we consider both, interdot (1,1) and intradot(0,2) singlet states, which hybridize due to singlet-triplet exchange interaction. In this scenario, two opposite flip-flop processes can occur, one gives rise to a nuclear magnetic field which supports the external one, meanwhile the other counteracts the external magnetic field. Thus the leakage current obtained strongly depends on the external magnetic field and also on the Coulomb interaction, the interdot tunneling and the level detuning between the two dots. Transport experiments at the spin blockade region show strongly non linear behavior of the leakage current as a function of the applied magnetic field including instabilities and hysteretic behavior [2-5].
Our model consists on rate equations for the charge occupations and nuclei spin polarizations in the quantum dots in the presence of Hyperfine interaction assisted by phonons, which are selfconsistently solved. We analyze the current through a double quantum dot in a static magnetic field at different level detunings. The external field produces singlet-triplet crossings which increase abruptly the current due to electron-nucleus spin flip flop, giving rise to abrupt steps in the current, as experimentally observed [2,4]. The calculated current as a function of magnetic field, presents hysteresis which is explained in terms of the induced dynamical nuclear polarization by Hyperfine interaction.

References:
[1] K. Ono, et al., Science, **297**, 1313 (2002).
[2]K. Ono et al., Phys. Rev. Lett., **92**, 256803 (2004).
[3] F.H.L. Koppens et al., Science, **309**, 1346 (2005).
[4] S. Tarucha et al., Phys. Stat. Solid (b) **243**,14, 3673, (2006).
[5]A. Pfund et al., cond-mat 0701054.