Angular dependence of the tunneling magnetoresistance in nanoparticle arrays

V. Estévez and K.Y. Guslienko

Dpto. Física de Materiales, Universidad del Pais Vasco, 20018 San Sebatian, Spain

virginia.estevez@ehu.es

Abstract

Due to the small size of the nanoparticles, the transport through metallic nanoparticle arrays is governed by the Coulomb blockade physics. To add one charge to a nanoparticle costs a finite energy, the charging energy E_c. The transport is suppressed for energies smaller than the charging energy. Once there is current through the system, it is a strongly non-linear function of the voltage because of the charging effects [1]. When the nanoparticle arrays are placed between two ferromagnetic electrodes, the interplay between the ferromagnetism and the charging effects controls the transport through the system. In the case of a single nanoparticle if the spin relaxation time is long, spin accumulation appears when the magnetic moments of the electrodes have anti-parallel orientation, but not for parallel one. In a recent paper [2], it has been showed that the interplay between ferromagnetism and charging effect has a dramatic influence on the nanoparticle arrays, leading to unexpected results. For arrays with $N \geq 3$ nanoparticles, there is a regime with large negative differential conductance and a huge enhancement of the tunneling magnetoresistance with respect to the cases of one or two nanoparticles, see Fig. 1. How these effects are affected by different factors as asymmetry, dimensionality, disorder or range of interaction have been also analyzed [3]. The works [2,3] have been done for parallel and antiparallel magnetic orientations of the electrodes. Now we want to study the case in which the magnetization directions of the electrodes are noncollinear. This means that the magnetization directions of the electrodes form an angle θ, that is different to 0 or π. For noncollinear magnetization, the spin accumulation at the nanoparticles, the flow of current and the tunneling magnetoresistance will depend on θ [4], as occurs in the case of a single nanoparticle, see Fig 2.

References

[1] E. Bascones, V. Estévez, J.A. Trinidad, and A.H. MacDonald, Phys. Rev. B, **77** (2008) 245422.
[2] V. Estévez and E. Bascones, Phys. Rev. B, **83** (2011) 020408 (R)
[3] V. Estévez and E. Bascones, Phys. Rev. B, **84** (2011) 075441
[4] V. Estévez and K.Y. Guslienko, in preparation

Figures

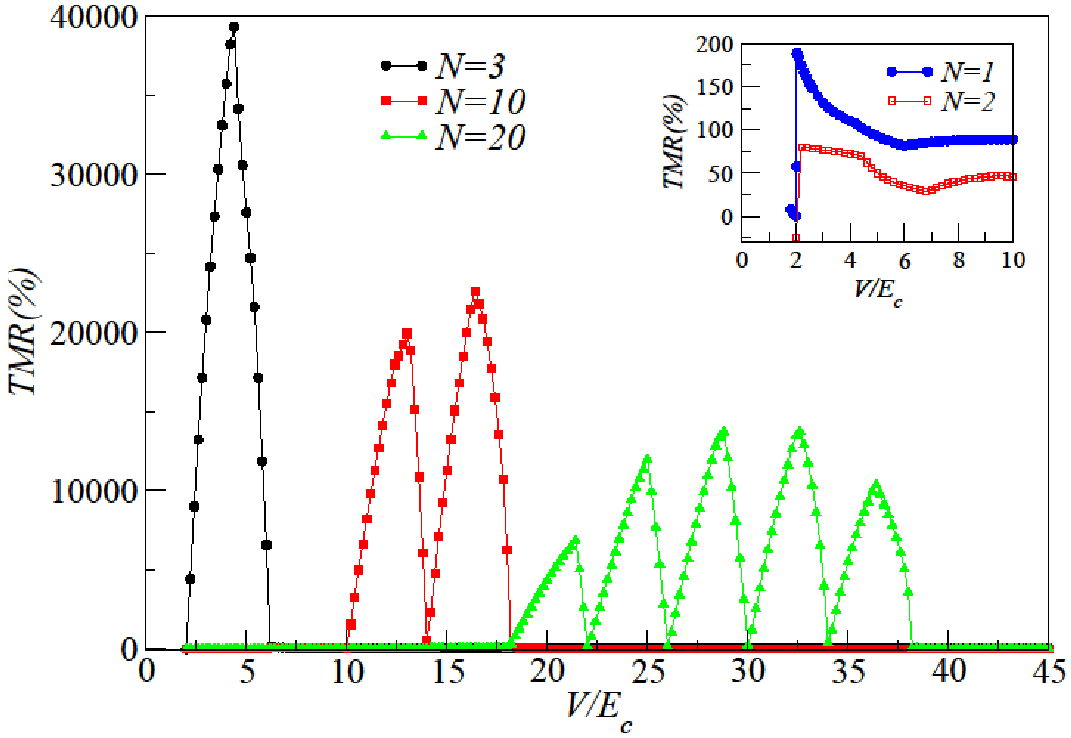

Fig 1: Tunneling magnetoresistance as a function of the bias voltage for different arrays sizes at $K_BT=10^{-4}$ E_c , and spin polarization p=0.7. Main figure: arrays of N=3,10 and 20 nanoparticles. Inset: values for one and two nanoparticles.

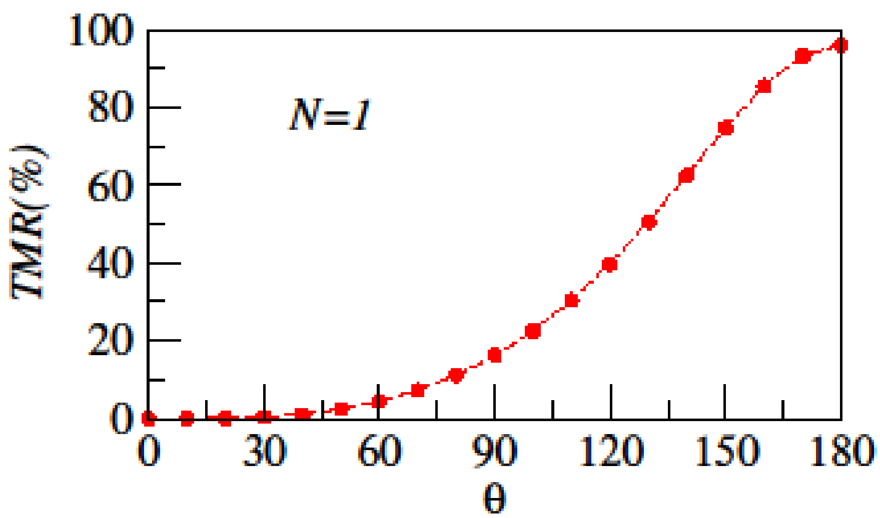

Fig 2. Tunneling magnetoresistance as a function of θ for a single nanoparticle at $K_BT=10^{-4}$ E_c , and p=0.7.