Electrical control of single-electron spin using spin-orbit effects in quantum dots

M. A. Rodriguez-Moreno[1], **L. Meza-Montes**[2], **and A. D. Hernandez**[1]

[1] *Centro de Investigaciones en Dispositivos Semiconductores, BUAP, Mexico*
[2] *Instituto de Fisica, BUAP, Mexico*

Coherent electrical control of quantum spin states has been experimentally demonstrated in nanolitographic quantum dots, showing the realization of qubits in these systems [1, 2]. Electrically-based spin manipulation and spin-orbit (SO) effects in general has been studied in semiconductor nanostructures [3]. The coupling between spin and orbital degrees of freedom induced by SO can readily be exploited by combining a static magnetic field and a time-dependent electric field. The so-called electric dipole spin resonance (EDSR) based on the SO interaction in quantum dots was theoretically analyzed within a pertubative framework [4].

In previous works we have determined stationary states and dynamical localization in double quantum dots [5]. Here we present a detailed study of the EDSR dynamics. A numerical approach is used in order to solve the time-dependent Schrödinger equation. This allows us to follow the evolution of a single-electron spin confined in a quantum dot. SO is taken into account by including the Rashba and linear Dresselhaus terms into the Hamiltonian of the system. Rabi oscillations are observed and their dependence on different parameters is studied. Comparison with theoretical results shows qualitative agreement, within the limits of the perturbative approximations.

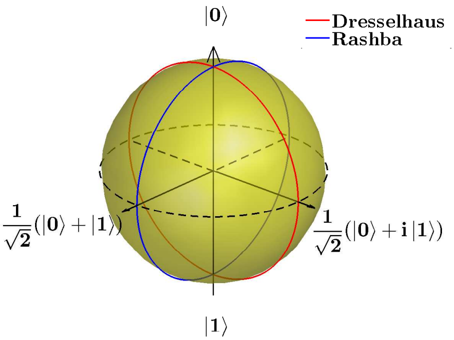

Figure 1: Spin evolution on the Bloch sphere for different SO Hamiltonians. A reference frame rotating about the z axis at the Larmor frequency of the system is used.

[1] F. H. L. Koppens, C. Buizert, K. J. Tielrooij, I. T. Vink, K. C. Nowack, T. Meunier, L. P. Kouwenhoven, and L. M. K. Vandersypen, Nature **442**, 766 (2006).

[2] K. C. Nowack, F. H. L Koppens, Y. V. Nazarov,, and L. M. K. Vandersypen, Science **318**, 1148092 (2007).

[3] E. I. Rashba and AI. L. Efros, Phys. Rev. Lett. **91**, 126405 (2003).

[4] V. N. Golovach, M. Borhani, and D. Loss, Phys. Rev. B **74**, 165319 (2006).

[5] L. Meza-Montes, Arezky H. Rodríguez, and Sergio E. Ulloa, Physica E **40**, 1226 (2008); L. Meza-Montes, Carlos F. Destefani, and Sergio E. Ulloa, Phys. Rev. B **78**, 205307 (2008).