Simulations of Photon-Assisted Tunneling in Carbon Nanotube Double Quantum Dots

Edyta N. Osika, and Bartłomiej Szafran

AGH University of Science and Technology,
Faculty of Physics and Applied Computer Science,
al. Mickiewicza 30, 30-059 Kraków, Poland

One of the obstacles for quantum information processing on spins of the carriers confined in III-V quantum dots is the dephasing in the nuclear spin field. For that reason, novel materials are investigated to minimize the influence of the environment on the quantum state of the system. In particular, several recent experiments focus on carbon nanotube quantum dots, since the nanotubes provide nearly nuclear-field free environment for spin qubits. Special attention is paid to purely electrical manipulation of the carbon nanotube qubit, which can be achieved by e.g. electric dipole spin resonance (EDSR) or photon-assisted tunneling (PAT) [1].

We report on simulations of PAT in double quantum dots defined electrostatically in carbon nanotubes [2]. Since graphene-based materials do possess additional degree of freedom apart from spin – the valley – dynamics of both, spin and valley state of the qubit has to be taken into account. We investigate resonant excitations resulting in charge tunneling through the double quantum dot system – either spin-valley-conserving or spin- or valley-flipping transitions are considered. We report on appearance of both single and few photon resonances driven by microwave electric field. For high amplitudes of the electric field the Landau-Zener-Stueckelberg interference [3] is observed in the system. We indicate that in double quantum dots in which the spin-valley Pauli blockade appears, the spin-valley conserving resonances can not enable charge tunneling, therefore only PAT events accompanied by spin or valley flips can be observed experimentally. On the contrary, systems with no Pauli blockade show a very strong signal for transitions which conserve both spin and valley state of the system. We propose a way to achieve spin-valley resolved PAT by adjusting the microwave electric field frequency or the magnitude of constant external magnetic field.

[1] A. Mavalankar, T. Pei, E.M. Gauger, J.H. Warner, G.A.D. Briggs, and E.A. Laird, *Phys. Rev. B* **93**, 235428 (2016).
[2] E. N. Osika, and B. Szafran, arXiv:1702.08802
[3] S. N. Shevchenko, S. Ashhab, and Franco Nori, *Phys. Rept.* **492**, 1 (2010).