Simulations of scanning gate microscopy imaging of the spin-orbit interaction in 2DEG in presence of in-plane magnetic field

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In the scanning gate microscopy (SGM) a negatively charged tip of an atomic force microscope scans the area above the sample inducing a local depletion of the two dimensional electron gas (2DEG) burried shallow beneath the surface. This depletion behaves as a movable scatterer for the Fermi level electrons which affects the conductance G of the device. By measuring \$G\$ as a function of tip parameters (position/voltage) one records conductance maps which reveal properties of the coherent charge and spin transport within 2DEG.

We investigate the possibility of mapping of the electron band structure near the Fermi level exploiting the spin-dependent backscattering induced by the tip and the resulting interference with the incident electron waves from SGM conductance maps of mesoscopic devices with quantum point contacts (QPC) [1]. For the systems with large Lande factor and in the presence of the external in-plane magnetic field the interference fringes in the conductance maps form beating pattern due to spin-dependence of the Fermi wavelengths [2], but this pattern does not depend on the magnetic field orientation, unless the spin-orbit coupling SO is present. In presence of the SO coupling the electron when scattered experiences precession of its spin due to rotation of the momentum-dependent effective magnetic field [3], and the interference potentially involve both spin branches. In case of the presence of the in-plane magnetic field and SO interaction the spin mixing becomes possible. Its consequence is an appearance of the dependence of the beating patterns on the orientation of the magnetic field. We demonstrate that the shape of the Fermi level structure can be traced back from the beatings using the Fourier transform analysis. As a result one should be able to extract the SO coupling constant from conductance mapping in the real space.

[1] M. A. Topinka, et al., Nature, 183-186. (2001)
[2] A. Kleshchonok, et al.,Phys. Rev. B 91, 125416 (2015)
[3] L. Meier, et al., Nature Phys., 650-654. (2007)