Fractional conductance oscillations in the charged two-terminal semiconductor quantum ring

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We study the single electron transport through the two-dimensional quantum ring which additionally confines one or two electrons in the Aharonov-Bohm regime. For that purpose we simulate the many-particle wave-packet for a few hundreds of picoseconds by solving the time dependent Schrödinger equation in which the interparticle correlations arising due to electrostatic interaction are taken into account exactly. For an ideal quantum ring we have found that the conductance oscillates depending on magnetic field strength with a period $\Phi = \Phi_0/N$, where $\Phi_0 = h/e$ is the magnetic flux quantum and N is the total number of electrons forming the transient few-particle system in the ring. This fractional periodicity is noticeable if the subsystem of $(N-1)$ electrons originally confined in the ring, i.e. spatially separated from the incoming electron, is in the ground state. This finding is consistent with the fractional conductance oscillations measured by Keyser et al. [1] and also with previously predicted fractional oscillations of persistent currents in the closed quantum rings [2]. The amplitude of these oscillations strongly depends on the ring channels widths since an uneven injection of electron wave packet to both arms of the ring driven by magnetic (Lorentz) force effectively suppresses the quantum interference at its output[3]. We also analyze the conductance oscillations for the ring with disorder in confinement potential which even for $N = 1$ may lead to a fractional periodicity ($\Phi = \Phi_0/2$) due to Altshuler-Aronov-Spivak effect [4]. In that case, the contribution to the conductance oscillations from mods oscillationg with period $\Phi = \Phi_0/N$ are distinctly diminished[5].

[1] U. F. Keyser, C. Fühner, S. Borck, R. J. Haug, M. Bichler, G. Abstreiter, W. Wegscheider, Phys. Rev. Lett. **90**, 196601 (2003).
[2] T. Chwiej, B. Szafran, Phys. Rev. B **78**, 245306 (2008).
[3] T. Chwiej, K. Kutorasiński, Phys. Rev. B **81**, 165321 (2010).
[4] A.G. Aronov, Y.V. Sharvin, Rev. Mod. Phys. **59**, 755 (1987).
[5] D.-I. Chang,G. L. Khym, K. Kang, Y. Chung, H.-J. Lee, M. Seo, M. Heiblum, D. Mahalu, V. Umansky, Nat. Phys. **4**, 205 (2008)