Nano-Arc Aharonov-Bohm Interferometer with Scatterers

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The Aharonov-Bohm effect has become famous in mesoscopic physics, where it causes the resistance of micron-sized metallic and semiconducting cylinders and rings to oscillate as a function of the strength of an applied magnetic field. The study of transport through mesoscopic interferometers continue in interest at present [1-4]. The construction of an interferometer is usually a ring with conductors attached to it at opposite sides, but at present a series of investigations was also realized in Aharonov–Bohm quantum interferometers of other constructions.

We propose a one-dimensional model for a broad class of Aharonov-Bohm interferometers formed by two nanoarcs with or without scattering centers, connected to current leads and subjected to an external uniform magnetic field. The scatterers on the arcs are approximated by δ-potentials, and may be chosen as attractive or repulsive. To our knowledge similar geometry was not investigated before. The explicit formulae for transmission probability of the class of nanodevices are obtained. The asymptotics for the transmission coefficient in some special cases as a symmetric ring with two leads connected diametrically, an Aharonov-Bohm ring with leads connected at one point are found.

In the case of ballistic symmetric Aharonov-Bohm ring the simplest expressions for the conditions of high and zero conductivity in the nanodevice are found. For ballistic Aharonov-Bohm ring with difference Δ in arc length so called π-phase shifts of the transmission probability on the magnetic flux are investigated. It is shown that variation in electron wave number \( k \) on \( \pi/\Delta C \), were \( C \) is circumstance of the ring, leads to phase shift of transmission coefficient on \( \pi \) in magnetic flux. Our results are in a good agreement with experimental and theoretical investigations, and they allow estimating the length difference in the ring arcs from conductance measurements. Thus the indirect method for the estimation of arc length difference from magnetoconductance measurements is proposed.

The appearance of sharp resonances (which are similar to impurity levels in momentum-energy diagram) for the transmission probability of Aharonov-Bohm ring with scatters is presented. The dependence of the sharp resonance location in energy on the scatterer positions on the ring arms is studied and expressed in simplest relations. The influence of the scatterer potentials with regards to the electron energy on the shape of "impurity levels" is investigated. The possibility of frequency doubling of the Aharonov-Bohm oscillations in the rings with scatterers, and formation of wide plateaux on the transmission probability in the ring with different scatterers on two arcs is shown.

We propose also different models of the Aharonov-Bohm arcs based on graphene nanoribbons. The work is partially supported by the RFBR Grant № 08-02-01096.

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