Diffractive paths for weak localization in quantum billiards

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Quantum billiards are conductors which are not ruled by Ohm's law. The electron transport through quantum billiards is ruled by quantum mechanics. This fact gives rise to several quantum transport effects unexpected clasically such as weak localization. Weak localization stands for the suppresion of conductance at zero magnetic field and its increase at non-zero magnetic field. Weak localization has been ascribed to interference of classical paths within standard semiclassical appraoches. We showed that this pictures is incomplete since paths of purely quantum origin are necessary to produce weak lcoalization. We identified the origin of those paths by analyzing quantum path spectra. The paths originate in diffraction at the cavity lead junctions and their incorporation into a semiclassical theory leads to very good agreement with quantum mechanics.

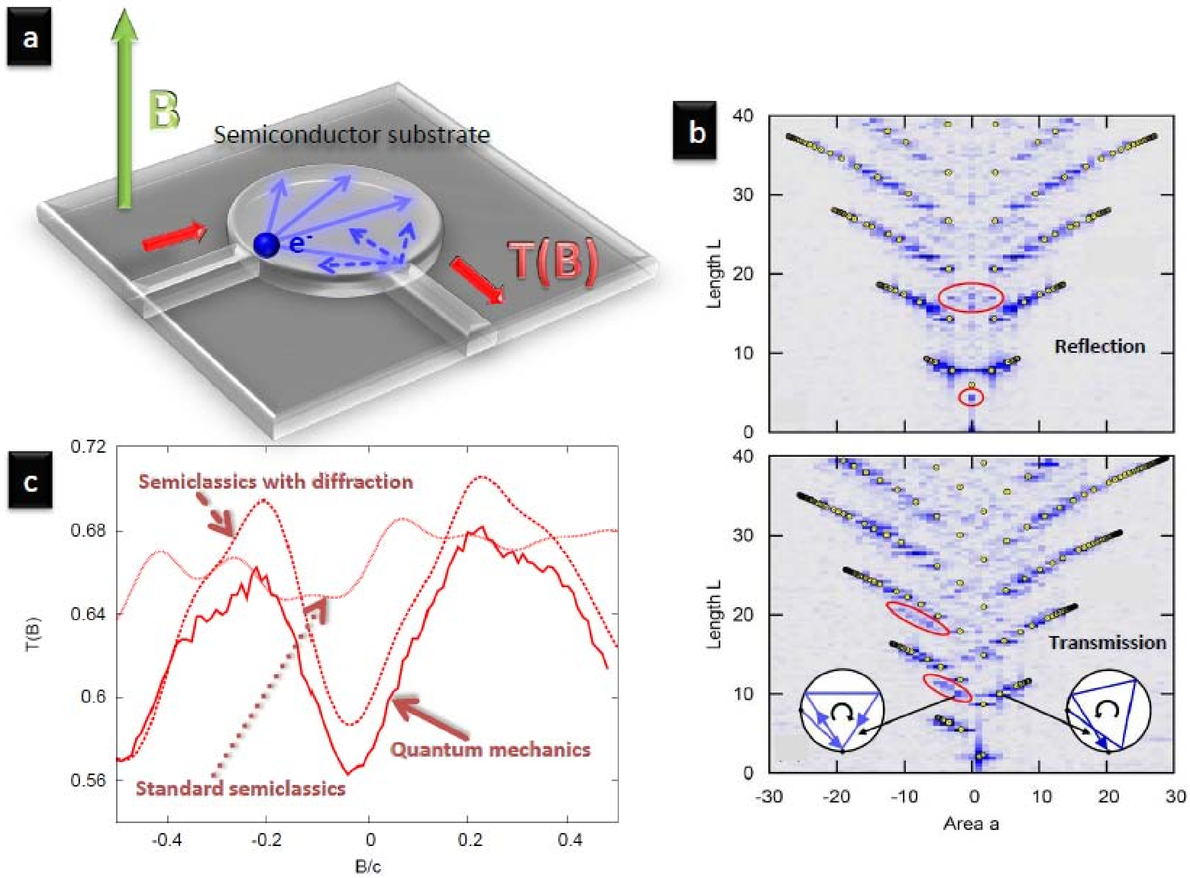

Figure:

(a) Schematic sketch of a circular quantum billiard within a semiconductor heterostructure. The conductance T(B) is measured as a function of a perpendicular magnetic field B. Within Feynman's picture of quantum mechanics the measured T(B) is the result of interference of electron paths.

(b) Spectrum of quantum paths contributing to transport through the quantum billiard. The path spectrum is obtained via Fourier transform of the scattering matrix elements for transmission and reflection. We have identified classes of non-classical paths arising from diffraction (a few of those are encircled in red). Yellow dots mark classical paths.

(c) The inclusion of diffractive paths leads to a very good agreement with quantum mechanics (QM) in contrast to the standard semiclassical theory. In the quantum and semiclassical results only paths up to a certain length have been included.