DC and microwave investigations of open quantum dots

F.Kuchar R. Brunner, R. Meisels,

Department of Physics, University of Leoben, A-8700 Leoben, Austria,
`kuchar@unileoben.ac.at`

The study of transport through open dots has received much attention in recent years, and one important aspect of this research focuses on the use of such structures to probe the connection between semiclassical physics and quantum mechanics. In large quantum dots effects have been observed which can be described by a classical behavior of electron trajectories, e.g. leading to backscattering peaks in the low-field magnetoresistance [1]. As one example, an electron following a quasi-triangular trajectory, QTT, after two bounces in the dot, can exit the dot at its entrance causing a backscattering peak in the resistance at a certain magnetic field. Theoretically, the problem has been studied by semi-classical and quantum mechanical methods and by numerical simulations [2]. Open dots are coupled to reservoirs by constrictions which support several propagating modes. A crucial question is whether their transport properties can only by fully explained by assuming that a subset of the closed-dot eigenstates survive despite the strong coupling.

The purpose of our work is to tackle this question by investigating, for the first time, the response of the backscattering peaks in AlGaAs/GaAs dots to microwave (MW) irradiation (26.6 - 40 GHz). MW frequencies are well suited since they are of the order of the cyclotron resonance frequency in low magnetic fields and the confinement frequency [3]. Without MW irradiation the DC data exhibit backscattering peaks at fields of a few tenth of a Tesla with the field positions depending on dot size which is of the order of a few 100 nm. Shubnikov-de-Haas (SdH) oscillations appear above 0.5 T. While the SdH oscillations show the usual temperature dependence, the backscattering peaks are temperature independent up to 2.5 K. Under MW irradiation both the QTT peak and the SdH amplitude are reduced. Considering the temperature dependence the QTT peak reduction cannot simply be attributed to electron heating. This conclusion is supported by the observation of a strong frequency dependence which suggests the presence of a discrete density of states associated with the QTT orbit.

The backscattering will be discussed within a classical trajectory model, which assumes a parabolic potential within the dot in a perpendicular magnetic field and allows to calculate the DC resistance. For interpreting the frequency dependence we have to allow for a strong asymmetry of the potential. Then, energy level splittings of the order of magnitude of our MW frequencies are obtained suggesting excitations out of a state connected with a backscattering orbit, thus increasing the transmittance/conductance of the dot.

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[2] T. Blomquist, I.V. Zozoulenko, Phys. Rev. B **64**, 195301 (2001) and refs. therein; R. Akis et al., Appl. Phys. Lett. **81**, 129 (2002); N. Mori et al., Physica E **13**, 667 (2002).
[3] R. Brunner et al., Proc. ICPS-26, Edinburgh (2002).

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