Interaction of microwaves with backscattering orbits in open quantum dots

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Recently, there has been much interest in the physics of open quantum dots regarding the cross-over from the classical to the quantum-mechanical regime. An interesting aspect focuses on the question whether discrete energy levels survive in open dot systems, although the coupling to the two-dimensional reservoirs is strong, and whether magnetoresistance experiments can elucidate the problem. There is some theoretical support for the existence of the discrete levels [1-3]. From estimates of the energy level spacing in a closed dot one can expect that transitions between discrete levels occur in microwave fields. Due to the smallness of the dot a transmission experiment is not practicable. We have already shown that peaks in the low-field magnetoresistance which are attributed to backscattering trajectories are very sensitive to microwave radiation [4]. In the present contribution we demonstrate that this response of the backscattering peaks can be used for a sensitive detection of the microwave excitations of the open quantum dot.

The dot system is defined using finger-gate structures on top of a 2DES in an AlGaAs/GaAs heterostructure (n_s= 2.3 x 10^{11} cm^{-2} , μ= 1.2 x 10^6 cm^2/Vs). The size of the dot is 280nm and the width of the constriction is 70nm. The experiments are performed at temperatures between 0.3 K and 1.5 K. The microwave frequency range is 30 – 60 GHz. The magnetoresistance as well as its change due to microwave irradiation, ΔR, are recorded at low and medium magnetic fields. At low fields the backscattering peaks appear, at medium fields Shubnikov-de-Hass oscillations. The damping of the latter ones under microwave irradiation is used as a monitor for the microwave power. Our main experimental results are:

- The backscattering peaks in the dc resistance show a strong response to microwave radiation at temperatures where their height is independent of temperature.
- The microwave induced ΔR peaks are observed within the width of the backscattering peak. Their magnetic-field positions differ from the dc peak position and are weakly frequency dependent.
- For certain frequencies the ΔR peak splits into two peaks.
- The ΔR peak heights show a strong frequency dependence in the range 30 – 60 GHz.

These findings indicate that the microwave response is a genuine high-frequency effect and not just due to electron heating. The frequency dependence of ΔR suggests the existence of discrete energy levels in the dot. For a detailed discussion we assume an anisotropic parabolic confinement potential. Then, the trajectories of the classical treatment can be associated with discrete states at the Fermi energy and the microwave response with transitions to a higher energy state. Thus the backscattering condition is destroyed and the backscattering peak lowered causing the ΔR signal.

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