Theoretical analysis of shot noise suppression in chaotic cavity in the presence of a magnetic field

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We present a theoretical investigation of shot noise suppression in chaotic cavities in the presence of an orthogonal magnetic field, focusing on the specific device that has been experimentally investigated by Oberholzer et al. (Nature, v. 415, 765 (2002)). Due to the relatively large size of the cavity (5 x 8 microns) and to the large value of the magnetic field, the problem is very challenging from a numerical point of view: we have adopted an approach based on the recursive combination of elementary scattering matrices and on the evaluation of the transverse wave functions based on the technique introduced by Tamura and Ando (Phys. Rev. B, v. 44, 1792 (1991)). Such wave functions are strongly distorted with respect to those without magnetic field, and therefore a very large basis (of the order of 700 elements) is needed for their proper representation.

We observe that, as the magnetic field B is increased, conductance quantization, which with B=0 vanishes as a consequence of the chaotic behavior of the cavity, is recovered, due to the formation of edge states crawling along the walls and crossing the device without significant scattering. This has an effect also on the noise power spectral density, which, in the case of a symmetric cavity, drops below the value expected for B=0, corresponding to 1/4 of the full shot noise, and vanishes for a sufficiently large magnetic field.

While Oberholzer et al. propose an explanation of the behavior of the Fano factor (the ratio of the noise power spectral density to the full shot value predicted by Schottky's theorem) that is based on the reduction of the cavity area available for electron motion for increasing magnetic field, and the associated reduction of the dwell time of the electrons in the device, we suggest a more intuitive argument based on the ratio of the cyclotron radius for the electrons to the width of the apertures defining the cavity. Finally, we show that such an argument is well supported by an analysis of our numerical results.