Nonlinear Transport in Ballistic Mesoscopic Systems: B-field Symmetry

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We study the conductance through ballistic mesoscopic devices beyond the linear response regime. By using non-equilibrium Green's functions we obtain a general expression for the current. This expression is manifestly gauge invariant and depends in a self-consistent way on the charge distribution in the device. To compare our findings with recent non-linear transport experimental results, our calculations are specialized to two terminal devices. The current is expanded in powers of the applied bias, which allows us to identify the nonlinear conductance terms. We study their symmetry with respect to the magnetic field and observe that they violate the Onsager relations. We identify the first correction to the linear conductance with the nonlinear conductance obtained by Büttiker and collaborators using the S-matrix formulation [1]. One of the advantages of our approach is that it can easily be extended beyond the first order correction. To quantitatively study the non-linear conductance we consider a simple model, namely, a single-channel quantum ring attached to two leads. In the S-matrix theory, this model allows us to compute the characteristic potentials, injectivity, and the first non-linear conductance term in a Thomas-Fermi approximation. The properties of these quantities under magnetic field inversion agree with recent experimental results [2].

[1] T. Christen, and M. Büttiker, Europhys. Lett. 35 (7), 523 (1996).

[2] R. Leturcq, D. Sánchez, G. Götz, T. Ihn, K. Ensslin, D.C. Driscoll, and A.C. Gossard, Phys. Rev. Let. 96, 126801 (2006).

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