MICROREVERSIBILITY BREAKING IN MESOSCOPIC SYSTEMS COUPLED TO NONEQUILIBRIUM ENVIRONMENTS

David Sánchez[1] and Kicheon Kang[2]
1. Departament de Física, Universitat de les Illes Balears, E-07122 Palma de Mallorca, Spain
2. Department of Physics, Chonnam National University, Gwangju 500-757, Korea

The Onsager-Casimir symmetry relations [1,2] are crucial to understand the transport properties of mesoscopic conductors. These symmetries are fundamentally a consequence of microreversibility of the scattering matrix that describes the conductance of a phase-coherent conductor, dictating that the two-terminal linear conductance G must be symmetric under reversal of the external magnetic field B. However, breakings of this symmetry may take place. For instance, magneto-asymmetries were predicted to arise in the nonlinear regime of mesoscopic transport [3,4], this effect originating from the charge response of the system. For an experimental verification, see, e.g., Refs. [5,6].

Here, we discuss the developement of magneto-asymmetries already in the *linear* regime of mesoscopic transport when the system interacts with an environment which is driven out of equilibrium [7]. Our theory confirms why magnetic-field symmetries are preserved in existing experiments on two-terminal conductors despite the fact that they cannot avoid interactions with its environment.

We consider a mesoscopic conductor in close proximity with a second conductor, which acts an a tunable enviroment. There exists a Coulomb interaction coupling conductor and environment electrons but no particle exchange is permitted between the two subsystems. Experimentally, the environment can be a quantum point contact, a quantum Hall bar or any other system whose electron states depend on the electronic trajectory across the conductor. For instance, we consider resonant tunneling through a quantum dot which is capacitively coupled to the top edge of a quantum Hall conductor. We observe that the conductance G through the dot differs for opposite B orientations. The reason for the asymmetry is uniquely due to the asymmetry of the screening potential ΔU arising from the asymmetry of the Hall bar injectivity. The magneto-asymmetry is larger for stronger interaction coupling (C_μ) to the edge state. We recover the Onsager result for vanishing voltage bias across the Hall conductor, as expected. Importantly, we predict that the asymmetry is a function of the two-particle scattering matrix.

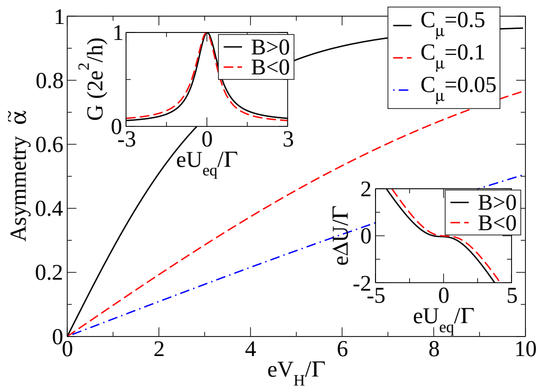

Fig. 1 Magnetic-field asymmetry of G through a quantum dot interacting with a quantum Hall bar. The asymmetry is stronger for larger voltages applied to the bar (V_H) and enhances for increasing values of the interaction coupling between the two conductors (C_μ).

We have also examined the case of a partinioned edge state and predict a magneto-asymmetry of *dephasing* when a quantum point contact is inserted in the Hall bar. In this case, dephasing in the dot is related to the possibility of extracting charge state information from the relative phase shift between the transmitted and reflected beams at the point contact.

References

[1] L. Onsager, Phys. Rev. **38**, 2265 (1931); H.B.G. Casimir, Rev. Mod. Phys. **17**, 343 (1945).
[2] M. Büttiker, Phys. Rev. Lett. **57**, 1761 (1986).
[3] D. Sánchez and M. Büttiker, Phys. Rev. Lett. **93**, 106802 (2004).
[4] B. Spivak and A. Zyuzin, Phys. Rev. Lett. **93**, 226801 (2004).
[5] R. Leturcq *et al.*, Phys. Rev. Lett. **96**, 126801 (2006).
[6] D. M. Zumbühl *et al.*, Phys. Rev. Lett. **96**, 206802 (2006).
[7] D. Sánchez and K. Kang, Phys. Rev. Lett. **100**, 036806 (2008).