M2 Internship proposal 2023
Centre de Physique Théorique – Nanophysics team
Département de Physique, Aix Marseille Université

Name of the laboratory: Centre de Physique Théorique CNRS UMR 7332
http://www.cpt.univ-mrs.fr/
Nanophysics team E6 Internship

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Title: Delta-T noise in an electronic Fabry-Perot interferometer

Description:

The nanophysics team of the CPT has an established expertise in the study of electronic transport in nanoscopic and mesoscopic systems. Transport is achieved by putting the system out-of-equilibrium, for example by applying a voltage bias. The study of the electronic current and its fluctuations (the current noise) gives valuable informations on the properties of the system, like the charge of the effective carriers. This charge can be non-trivial for interacting systems, like the fractional quantum Hall effect (FQHE).

Recently, it was understood both theoretically and experimentally that studying electronic charge transport when a temperature bias is applied gives original informations on the system, which completes those obtained when a voltage bias is applied. The current noise in the presence of a temperature bias has been called “delta-T noise”. The nanophysics team has made several important contributions to the study of the delta-T noise, in particular for the edge states of the FQHE.

The goal of this M2 internship will be to compute delta-T noise in an electronic Fabry-Perot interferometer. Interferometers, whose principle is borrowed from optics, are setups where transport can occur through two controllable paths, allowing to observe interferences between these two paths. The study will consider how the temperature bias can impact the interferences, and how the combination of the two allow to obtain new informations on the system.

A first part of the internship will be devoted to the calculation for a non-interacting system, which can be realized using edge states of the integer quantum Hall effect. For this case, exact non-perturbative calculations can be performed using the Landauer scattering formalism. Understanding the impact of the temperature bias in this non-interacting case will serve as a basis for the calculation for the interacting system, which can be realized using edge states of the FQHE. There, perturbative calculations within the Luttinger liquid formalism, using Keldysh Green functions techniques, should allow to obtain valuable results for the delta-T noise.

This internship involves analytical calculations and some numerical calculations to illustrate the results.

Prerequisites: priority is given to to M2 students who have followed the 6 credit course “Advanced Quantum Statistical Physics” and the 4 credit course “Out of Equilibrium Quantum Statistical Physics”.

Warning: the candidate for this internship will have to submit his/her L3 and M1 grades, a letter of recommendation from the M1 director or the M1 internship tutor, a short CV and a short letter of motivation.

Duration: the normal duration of a Aix Marseille Université M2 internship (March-June 2023), or longer if the student has his/her own funding from his/her institution (such as Ecole Normale Supérieure).

References:

- O. Lumbroso, L. Simine, A. Nitzan, D. Segal, and O. Tal, *Electronic noise due to temperature differences in atomicscale junction*, Nature (London) **562**, 240 (2018).

- J. Rech, T. Jonckheere, B. Grémaud, and T. Martin, *Negative Delta-T Noise in the Fractional Quantum Hall Effect*, Phys. Rev. Lett. **125**, 086801 (2020).

- A. Popoff, J. Rech, T. Jonckheere, L. Raymond, B. Grémaud, S. Malherbe and T. Martin, *Scattering theory of non-equilibrium noise and delta T current fluctuations through a quantum dot*, J. Phys.: Condens. Matter **34**, 185301 (2022).

- G. Rebora, J. Rech, D. Ferraro, T. Jonckheere, T. Martin, and M. Sassetti, *Delta-T noise for fractional quantum Hall states at different filling*, Phys. Rev. Research **4**, 043191 (2022).

- G. Zhang, I. V. Gornyi, and C. Spånslätt, *Delta-T noise for weak tunneling in one-dimensional systems: Interactions versus quantum statistics*, Phys. Rev. B **105,** 195423 (2022).