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Exploring the Physics of Small Devices (EPSD) visit: Universidad Complutense de Madrid
(scientific report)

This visit was planned to initiate and strengthen cooperation between workgroups at the Jagellonian University in Krakow and the one of Prof. Juan M. R. Parrondo at the Universidad Complutense de Madrid, Spain.

The performed visit was intended to discuss the problem of “Levy ratchet: current suppression and reversion by rocking”. The main idea of the project relied on the fact that in the thermal ratchet, the directed transport is induced into the direction of the steeper potential slope while in the rocking ratchet into the direction of the flat potential slope. Levy ratchet itself acts as a thermal ratchet, i.e. for a static potential with broken spatial symmetry presence of the symmetric Levy noise induces current into the direction of the steeper potential slope. The presence of an external periodic perturbation (“rocking addition”) is able to suppress or to reverse the current induced in the static Levy ratchet. The ideas underlying the proposed project turned out not only to be straightforward but in the meantime some of the ideas from the initial project were verified by others group. Therefore, after a discussion we decided to focus on other topic which we found more interesting and promising. Afterwards, during the days of my visit we not only extensively discussed the problem of joint interest but also we managed to perform preliminary analytical calculations. Both groups are interested in the problem of the fluctuation-dissipation relations. Finally, after the discussion we decided to work on the topic that we feel is most promising to be tackled within a joint collaboration. The proposed problem still involves the physics of Levy noise, i.e. non-Gaussian, but stable white noise, possessing independent increments with jump sizes that are distributed according to a Levy stable distribution in connection to the fundamental principles like fluctuation-dissipation relations.

New project of the joint interest:

The fluctuation-dissipation relations and linear response theory allow one to use equilibrium properties of a system in order to calculate the response of a system to an external (weak) perturbation. The paradigm of fluctuation-dissipation theorems turned out to be very interesting to both groups. Therefore, we decided to extend studies of the model inspected in J. Prost, J.-F. Joanny and J.M.R, Parrondo, Phys. Rev. Lett. 103. 090601 (2009) to non-equilibrium regime using the framework of fluctuation-dissipation relations. More precisely, we focused on studies of a response of the linear Langevin equation driven by Levy noises to external perturbations, i.e. we inspected a motion of a Levy-Brownian particle in the harmonic potential subject to the additional weak deterministic perturbation. Preliminary calculations, which were performed during my visit to Madrid, revealed that despite the fact that Levy noises are not of the equilibrium type it is still possible to calculate the susceptibility and the response of a system. For weak perturbations, the response of the system calculated both as the ensemble average and by use of the susceptibility perfectly agree. Successful application of the framework traditionally used to describe systems close to equilibrium to the system which is far from the equilibrium indicates that non-equilibrium

systems deserves further studies especially in the context of fluctuation-dissipation relations. So far we managed to perform preliminary calculations for linear systems only. However, our intention is to extend investigations to nonlinear or multidimensional system driven by Levy noises.

Additionally, during my stay in Madrid I presented results of my former studies of ratchet systems driven by alpha-stable Levy type noises during the group meeting which took place on 6th of May. Finally, beside fruitful discussions with prof. Juan M. R. Parrondo, I had the possibility to interact with other members of the Madrid group.

The performed visit and interactions with scientist from Madrid allowed us to focus our attention on some open issues regarding fluctuation-dissipation relation in systems driven by Levy type stable noises, which are of the non-equilibrium type. We believe that the project that we focused on is interesting and promising.

Yours sincerely,

Bartłomiej Dybiec