Research Networking Programmes

Short Visit Grant ☒ or Exchange Visit Grant ☐

(please tick the relevant box)

Scientific Report

Scientific report (one single document in WORD or PDF file) should be submitted online within one month of the event. It should not exceed eight A4 pages.

Proposal Title: Small Josephson junctions: Voltage-Voltage correlation function and power spectrum in the regime of Absolute Negative Mobility

Application Reference N°: 5820

1) Purpose of the visit

I visited the University of Katowice from September 22 to October 05 (as planned) in order to undertake the proposed research.

2) Description of the work carried out during the visit

The phenomenon of Absolute Negative Mobility (ANM), or absolute negative conductance, constitutes a counterintuitive phenomenon whereby the response near zero-bias occurs into the opposite direction of the applied force. This phenomenon is a manifest non-equilibrium result which cannot emerge near thermal equilibrium, due to the validity of the Le Chatelier-Braun principle there.

Such Absolute Negative Mobility for Brownian particles can occur in spatially symmetric potentials, when external driving acts. The forcing is setup by use of a zero-mean time-periodic force this part implies the nonequilibrium condition) and an additional constant bias force. This phenomenon has been theoretically predicted by us [1] and even also recently observed also experimentally in a single Josephson junction device [2].

During this first short visiting grant period we started to research the following points: We set up the theoretical description to detect absolute negative mobility in the power spectrum of the temporal voltage-voltage fluctuation-correlation-

function. This already was not simple because the power spectrum must be defined properly for the voltage fluctuations when external time-periodicforcing is at work. It in particulat requires the averaging over a time span of the periodic forcing so that the Wiener-Khinchine theorem can be invoked. It became clear to us that the simpler way is to substitute the ac-driving with a stochastic process of zero mean. In a first attempt we use a symmetric dichotomic noise source as the substitute of the ac-driving mechanism.

[1] L. Machura, J. Łuczka, M. Kostur, P. Talkner and P. Hänggi, Absolute negative mobility induced by thermal equilibrium fluctuations, Phys. Rev. Lett. 98 (2007) 040601; L. Machura, M. Kostur, P. Talkner, P. Hänggi and J. Łuczka, Anomalous transport in biased ac-driven Josephson junction: Negative conductances, Phys. Rev. B 77 (2008) 104509).
[2] J. Nagel, D. Speer, T. Gaber, A. Sterck, R. Eichhorn, P. Reimann, K. Ilin, M. Siegel, D. Koelle, and R. Kleiner, Observation of Negative Absolute Resistance in a Josephson Junction, Phys. Rev. Lett. 100 (2008) 217001.

3) Description of the main results obtained

We discussed the main quantifiers; namely the expression for the autocorrelation of the voltage-voltage fluctuations under ANM conditions. The theoretical expressions for both, (i) an explicit ac-driving and (ii) a stationary stochastic, unbiased driving, in presence of a static bias has been devised. We obtained the theoretical expressions and started to discuss its numerical implementaion with the help of a Ph.D canidate from the University of Katowice (J. Spiechowicz). Moreover, we identified that the spectral weights in presence and absence of ANM must change in a characteristic manner which we hope to corroborate with numerics.

4) Future collaboration with host institution (if applicable)

This work is presently in progress. The main next step is now to obtain the numerically evaluated power spectrum as a function of the parameters which rule ANM. The programme is presently set up at first tests will be done in the following 2 months. In addition, we plan that this work is continued with visitis from Professor Luczka to the University of Augsburg and, as well, a planned mutual exchange of students.

5) Projected publications / articles resulting or to result from the grant *(ESF must be acknowledged in publications resulting from the grantee's work in relation with the grant)*

We plan a regular publication in an archive journal such as Physical Review E or maybe also New Journal of Physics.

6) Other comments (if any)

none