Scientific Report for Short Visit Grant 5119
PESC: Exploring the physics of Small Devices (EPSD)

Title of Project: Transport in asymmetric SQUID devices driven by nonthermal Fluctuations

Dates of Visit (PI Peter Hänggi) at the Universoity of Silesia, Katowice

Arrival: afternoon of Thursday 29/08/2012 (one day earlier as planned originally, used for travel to Katowice)
Departure: Saturday 08/09/2012 =10 + 1 day (travel) = 11 days

Description of work carried out:
With this visit the PI and the host (Professor J. Luczka and one of his Ph.D student) undertook a study of transport in an asymmetric SQUID device as depicted below with the schematic sketch in a). The device consists of 3 Josephson junctions which are threaded by an external flux. An equivalent circuit diagram is depicted with part b). The device is further fed with both, an oscillating input current of strength I_1 and a varying static bias of strength I_0.

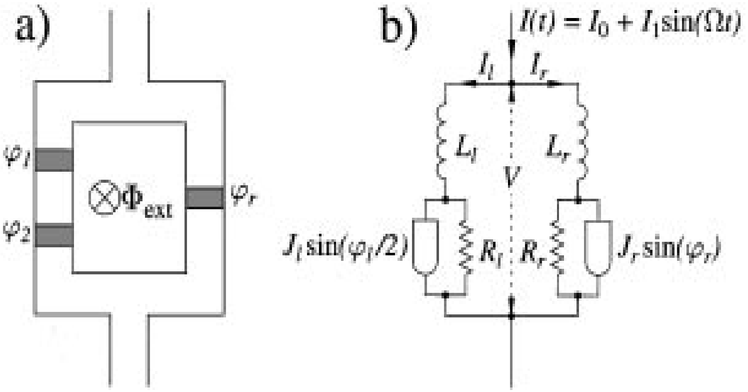

Figure 1: a) Schematic set up of an asymmetric SQUID with three Josephson junctions. The two junctions on the left are identical. b) An equivalent circuit diagram.

As detailed with prior work [I. Zapata et al., *Voltage rectification in a Squid ratchet*, Phys. Rev. Lett. **77**: 2292-2295 (1996)], the total Josephson phase for this system is ruled by an asymmetric ratchet dynamics with an effective potential of ratchet type, as indicated by the solid line in Fig. 2. In contrast to that previous work we study here the role of *inertial effect*s, being induced by finite capacitances for the three junctions. In the previous work the dynamics was strictly limited to the extreme overdamped limit which suppresses all effects of chaos dynamics; experimentally, however, inertial effects cannot be completely neglected. Moreover, for moderate-to-weak damping we expect a whole wealth of intriguing novel non-equilibrium phenomena.

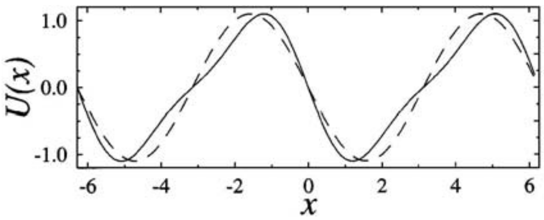

Figure 2: Asymmetric ratchet potential for the total Josephson phase for the small device depicted with Figure 1 a). The dashed line depicts the symmetric potential with a single sine-function.

Open problems:
Already the deterministic dynamics is rather complex for this set-up. We started to do extensive numerical calculations in extended parameter regimes showing complex current features. Using our commonly established, very effective numerical tool [by use of graphic processing units (GPU] for Langevin dynamics in higher dimensional state spaces we, together with students at the Silesian University, also started to study the role of thermal noise in biased situations. The two senior collaborators Hanggi and Luczka set up the theory for the thermal noise-driven set up and also generalized the scheme when the dirving current is not strictly deterministic but as well contains a *non-thermal* stochastic component, namely Poissonian shot noise and two-state noise.

Main results (as of now):
1. During this first visit the starting equations have been set up and the numerical simulations in the deterministic case are undertaken with first promising results. In parallel the higher-dimensional inertial, and ac-driven Focker-Planck dynamics has been implemented. 2. The two PI’s also formulated the modifications when the ambient noise is composed of common thermal Nyquist noise and uncorrelated, nonthermal current noise for the input current I(t) in Fig. 1 b).

Projected publication(s):
The PI’s Hänggi and Luczka plan to validate the theoretical considerations with extensive numerical simulations. In doing so we scan large parameter regimes in order to detect unusual transport features that are generic for ac-driven *inertial stochastic dynamics*. The project will still consume considerable time (including possible a second visit in 2013 by this PI (Hänggi).
Our finalized manuscript is planned to be submitted for publication to either Phys. Rev. E or also Eur. Phys. J. B.

Katowice, Sept. 07, 2012