Scientific report on the short visit grant 4067

about the short visit of Prof. Dr. Lutz Schimansky-Geier from the Institute of Physics, Humboldt-University at Berlin, Newtonstr. 15 12489 Berlin (FR Germany), in Hasselt (Belgium) to visit Prof. Dr. Christian van den Broeck from the Universiteit Hasselt, Gebouw D, Agoralaan, 3590 Diepenbeek, Limburg (Belgium).

Topic:

Rectifying Brownian fluctuations in a magnetic field.

Technical outlines:

The visit took place in March/April 2011. Schimansky-Geier visited Hasselt from March 29th till April 2nd, 2011.

At March 30th and at April 1st Prof.. Schimansky-Geier and Prof. C. Van den Broeck met at University of Hasselt and discussed the various aspect of the scientific topic of the grant.

During the visit at March 31st Prof. Schimansky-Geier gave a seminar at the Service de Physique Non-Linaire and Mecanique Statistique at the Universite Libre in Bruxelles about â€žFluctuations in Models of Self-Propelled Particles€œ. During the visit Prof. Schimansky-Geier had extensive scientific discussions with Prof. G. Nicolis about stochastics of nucleation-processes, with Prof. Gaspard and with Dr. M Esposito about fluctuation theorems and with Prof. D. Kosov about transport in quantum systems and about non-Hermitian operators in quantum theories.

Scientific results of the visit of Schimansky-Geier:

During the visit we had interesting discussion of Brownian motion in external magnetic fields and how work can be extracted from the heat in such systems.
Prof. Schimansky-Geier reported about the performed extended simulations of charged Brownian particles in magnetic fields. Due to their permanent molecular agitation and the action of the magnetic field the Brownian particles in the magnetic field move along curved trajectories (Larmor cycles). The particles are reflected on a concave surface. Due to the thermally agitated Larmor-motion their exist an optimal temperature where more particles are reflected in one direction than on the other one. Therefore, a directed particle current maximizes for a given temperature. This particle current can be further optimized if colored noise is applied to the Brownian particle (nonequilibrium noise or/and euqilbrium noise connected with dissipative forces by

a fluctuation dissipation relation).

Prof. van den Broeck proposed to extend the physical investigations also to the inclusion of a cold heat bath which generates the magnetic field which creates the Larmor-cycles. The interaction of the two bath systems via the magnetic field might be a possible origin of a thermalization of both heat bathes and the magnetic field transports heat from one bath to the other. Such a interpretation that the considered situation include in fact two heat bathes would not be stand in contrast to the second law of thermodynamics, The created work in the outgoing model would be the result of two heat bathes with different temperatures which is a common situation in thermodynamics. Such investigations require inclusion of relativistic theory into the model which needs at the moment further clarification.

In addition to a consideration of the thermodynamic embedding of the problem we also discussed other important problems as boundary conditions and a possible reduction of the problem to a one-dimensional periodic flux of particles. Also the inclusion of asymmetric obstacles which are driven by the circulating Brownian particles might be another possible realization of the rectifier. The important aspect of a possible cooling of the heat bath by extracting work was another interesting point of the discussion. But investigations in this direction would require the performance of molecular dynamics of Brownian motion in the considered situation.

Future work and cooperation:

The visit in Hasselt was full scientific success from the view point that the different physical aspects of the interesting situation have been discussed. The discussion will be continued during the following visit of Prof. Van den Broeck in Berlin in October 2011. A possible documented result in form of a submitted or printed manuscript is at the present stage of the investigations not seen and will require a longer period of scientific exchange. Presently the complex problem still need the physical foundation but some cornerstones of a possible explanation have been formulated during the visit.