Stochastic Resonance and Brownian Machinery: New Results – New Applications – New Goals

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Abstract. Is it possible to extract energy from random fluctuations and put it to beneficial use? This challenging question has provoked discussions ever since the early days of Brownian motion studies. Generally, noise in dynamical systems is considered a nuisance. But in certain nonlinear systems the presence of noise can in fact enhance the detection of weak signals. This phenomenon, called *Stochastic Resonance* (*SR*) does find useful applications in physical, technological and biomedical contexts [1]. In a second class of systems that are periodic – but which lack reflection symmetry – directed, noise induced transport can take place. The directed motion of particles in periodic potentials requires at least one source of non-equilibrium which must inherit an explicit or inherent statistical asymmetry. Such non-equilibrium systems have become known in the literature under the label of "ratchets" [2]. In both situations the importance of fluctuations is elevated to a level where noise must be viewed as source of order and complexity in its own right.

With this talk I present the basic principles that under-pin the exciting phenomenon of *SR*, and report on a series of novel applications such as its control in terms of harmonic mixing forces [3].

Turning to Brownian machinery we investigate whether microscopic fluctuations – such as Brownian motion – or even the haphazard motion of quantum particles, can cause particles to flow in one direction only. In recent years, this field has been the scene of remarkable activity, fueled mostly by the prospect of potentially high-profile technological and biological (molecular motors) applications. Only recently, though, this concept has been taken from the world of classical thermal Brownian motion to the quantum world [4], where the phenomenon of quantum tunneling presents a new challenge for the characterization of directed motion of electrons and alike. Prominent work of classical and quantum ratchet driven transport is reviewed. The focus will be mainly on *Quantum Brownian Rectifiers* [5], being driven by non-thermal perturbations that are unbiased on average.

Likewise, the rectification of quantum noise also impacts quantum diffusion, which can either be selectively enhanced or suppressed. The discussion of these theoretical results is supplemented by most recent experimental results of rectified electron motion taking place in triangular shaped quantum dot heterostructures, and in a periodic quantum ratchet device composed of asymmetric antidots [6–8]. As a result this new quantum concept can be used to the effect of constructing *shuttles* for electrons that operate on the nanometer scale.

References

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