Anomalous mobility of Brownian particles in a tilted symmetric sawtooth potential

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We consider one-dimensional overdamped dynamical systems, where Brownian particles move in a spatially periodic piecewise linear symmetric potential V, which has one minimum per period. The applied force consists of an additive static force F and a noise term composed of thermal noise ξ and a colored three-level Markovian noise. The system is described by the stochastic differential equation

$$\kappa \frac{dX}{dt} = -\frac{dV(X)}{dX} + F + \xi(t) + fZ(X,t),$$

where κ is the friction coefficient, f is a constant force, and $Z(X,t)$ represents spatially non-homogeneous fluctuations assumed to be a Markovian stochastic process taking the values $z_n \in \{-1, 0, 1\}$.

On the basis of an exact expression for the current we have found a number of cooperation effects: (i) a resonant-like behavior of absolute negative mobility (ANM) at intermediate values of the switching rate; the presence and intensity of ANM can be controlled by the switching rate and by temperature, (ii) existence of a negative differential resistance, (iii) for large values of the switching rate and a low temperature the current is, at some values of the tilting force F, very sensitive to a small variation of F — a phenomenon called hypersensitive differential response (HDR), and in the region of HDR the value of differential mobility can be controlled by means of thermal noise; (iv) for certain system parameters, there is a finite interval of the tilting force where the current is very small as compared to that in the surroundings (the effect of "disjunct windows"). It seems that the behavior mentioned last is a new anomalous transport phenomenon for Brownian particles.

The phenomenon of ANM in systems similar to ours have been studied in [1]. However, in contrast to ours, in those models the authors choose a symmetric potential $V(x)$ with two minima per period. Perhaps the most fundamental difference is that in the models of [1] unbiased transitions can take place between the discrete states only at the minima of potentials. As a consequence the dependence of the current on the switching rate disappears.

We emphasize that to our knowledge such a rich variety of anomalous transport effects have never been reported before for an overdamped Brownian particle in a 1D periodic structure with a simple symmetric potential (with one minimum per period).

1. Cleuren, B. and Van den Broeck, C. (2003). Brownian motion with absolute negative mobility. *Phys. Rev. E* **67**, 055101(R).