Directed transport in equilibrium and modified Boltzmann distribution

A. Bhattacharyay

Indian Institute of Science Education and Research, Pune, India

It is generally believed that to get directed transport of a mesoscopic object in contact with a heat bath one has to drive the system out of equilibrium. With the help of a model of a symmetry broken dimer I will show that directed transport can be achieved in equilibrium. Obviously one cannot extract energy from such a system, but, this is a dissipation less transport through a heat bath. I will show a generalization of the model taking into account coordinate dependent damping and will propose an alternative equilibrium distribution for such generalized systems involving coordinate dependent damping. In a conventional theory for such stochastic systems with coordinate dependent damping (multiplicative noise) I will show that one goes by the conflicting demand of a Boltzmann distribution in equilibrium and existence of no current. The procedure of handling multiplicative noise is convention dependent and also requires an ad hoc cancellation of the so called spurious current present in equilibrium. Moreover, in the presence of a coordinate dependent damping, the damping term itself breaks the homogeneity of space apart from the interactions. In such a situation the Boltzmann distribution only takes into account a part of the spatial homogeneity breaking cause and does not involve the other one i.e. damping. Simple understanding indicates that the damping being a homogeneity breaking cause of space must also reflect on the equilibrium distribution because it can make two different points over space inequivalent. I will show that, considering the over-damped dynamics, instead of starting from conflicting postulates, if one takes the sufficient condition that in equilibrium there is no average current in the system one can map the dynamics of such a system on the standard Langevin dynamics of a Brownian particle with coordinate independent damping. Thus, the particle would equilibrate at a minimum of a relevant potential giving rise to a modified Boltzmann distribution in equilibrium. This distribution obviously involves damping and since the solution comes through a mapping to constant damping model it becomes an additive noise problem and no convention and associated conflicts of conventions is required to solve the stochastic problem. I will generalize these results of the Langevin dynamics to the situation where the inertial term is present and a velocity distribution appears.

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