Controlling Entropy-Driven Diffusion in Confined Systems

David Reguera [C, S] and Antoni Luque
Universitat de Barcelona, Departament de Física Fonamental, Barcelona, Spain
dreguera@ub.edu

P. Sekhar Burada
Max-Planck Institut für Physik komplexer Systeme, Dresden, Germany

Gerhard Schmid
Universität Augsburg, Institut für Physik, Augsburg, Germany

J. Miguel Rubi
Universitat de Barcelona, Departament de Física Fonamental, Barcelona, Spain

Peter Hänggi
Universität Augsburg, Institut für Physik, Augsburg, Germany

Confinement plays a very important role in many physical and biological systems. The diffusion of particles in zeolites and in microfluidic devices, the motion of biomolecules in the interior of a living cell or through ion channels, or the translocation of viral DNA into a cell, are examples where the evolution of the system is influenced by the tortuosity of a bounded region. In this contribution, we will discuss how these systems can be nicely described by using the concept of an entropic potential in the framework of mesoscopic non-equilibrium thermodynamics. We will see how the peculiar nature of the entropic barriers has important and counterintuitive consequences in the diffusion in these media. In particular, phenomena such as entropic stochastic resonance, diffusion enhancement and rectification take place in these systems and can be controlled by a smart application of external forces. These mechanisms can be used to optimize transport in confined media and for the manipulation and control of single molecules. Specifically, we will present a novel particle separation mechanism which induces motion of particles of different sizes in opposite directions. The mechanism is based on the combined action of a driving force and an entropic rectification of the Brownian fluctuations caused by the asymmetric form of the channel along which particles proceed. The entropic splitting effect could be controlled upon variation of the geometrical parameters of the channel and could be implemented in narrow channels and microfluidic devices.