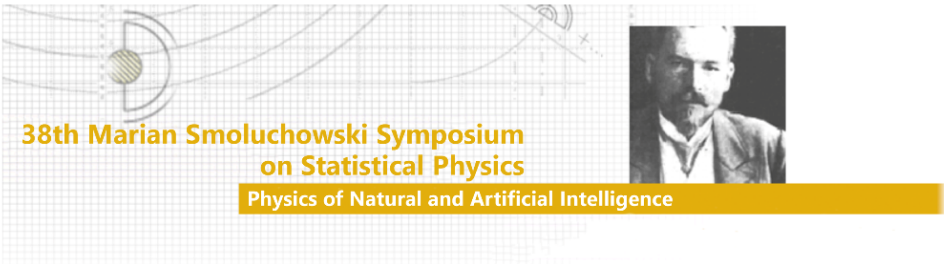

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Study of Particle Dynamics in a Conically Widening Channel

Tuesday, 16 September 2025 16:11 (1 minute)

Assessing the diffusion characteristics of tracer particles in complex environments, including soft matter and biological matter, yields valuable insights into material properties and biological processes. This is particularly evident in the transport of single molecules, viruses, and particles passing through natural and synthetic pores, which exhibit peculiar features that are the subject of intense theoretical and experimental research. Single nanopores are attracting increasing attention due to their potential use in nanofluidics, sensor technology, and information processing. In such systems, the observed diffusion is often anomalous and is characterized by non-linear growth of the mean squared displacement (MSD). A linear dependence of MSD on time is observed in the case of normal diffusion.
In this work, we show that variations in the geometry of the medium allow us to assess the effect of the structure of the medium on the transport of matter through it. We investigate the kinetics of spherical particles passing through a conical pore restricted by absorbing and reflecting boundaries from a wider to a narrower end and vice versa. We study the properties of diffusion as a function of particle size concerning pore width. Particles of different diameters are subjected to a random force. In addition to the mean squared displacement, we measure the mean and median of the first passage times. We show that the specific interplay of entropic forces and boundary conditions used to ensure the passage of events can explain the observation of effective subdiffusion in the tapered channel and effective superdiffusion in the widening channel. Furthermore, we study the diffusion of spherical particles in a conical widening channel (from a reflecting boundary to an absorbing one), focusing on the effects of deterministic drift and entropic forces.
The results show that the diffusion type depends on the drift strength. Without the drift, entropic forces induce superdiffusion; however, increasing drift strength shifts the system to standard diffusion and then subdiffusion.

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