

## ABSTRACT

The study of confined diffusion of molecules or small particles is crucial due to its prominent role in many processes such as catalysis, osmosis, particles selectivity, particles separation, controlled drug release, etc. The geometrical confinement controls the volume of the phase space accessible to the particles, due to which the entropic barriers arise and influence the diffusive behavior of these particles. In particular, the entropic effects are ubiquitous in systems such as biological cells, ion channels, nanoporous materials, zeolites, microfluidic devices, ratchets, and artificial channels. Knowingly, the FJ approach provides a powerful tool to capture many important properties of the confined diffusion. In order to extend our understanding of the confined diffusion, we study the diffusion of Brownian particles in confined geometries under various conditions.

In this context, first, we study the diffusive transport of biased interacting Brownian particles in a 2D symmetric channel considering both the no-flow and the reflecting boundary conditions at the channel walls. Quite often, particles encounter a crowded environment while passing through the confined structures. Thus, we extend our work to the diffusive behavior of biased Brownian particles in a 2D symmetric channel filled with the freezing obstacles. We also study the rectification of interacting Brownian particles in a 2D asymmetric channel in the presence of an external periodic driving force. In addition, we reveal a mass-based separation mechanism to sort out particles of various masses by passing them through a 2D narrow asymmetric channel. Finally, we extend our study to the diffusive transport of both nonchiral and chiral active Brownian particles in a 2D microchannel with a Poiseuille flow.

**Keywords:** Confined diffusion, Entropic effects, FJ approach, Freezing obstacles, Rectification, Mass-based separation