Institute for Research in Fundamental Sciences

Title:

Micro/Nanoswimmers in Heterogeneous Media

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Abstract:

Micro/nanoswimmers form a broad class of active particles that possess internal mechanisms, enabling them to swim in fluid media at low Reynolds numbers. A commonly used model to describe such systems is that of active Brownian particles (ABPs) that are modeled as particles self-propelling at constant speed subject to translational and rotational Brownian noises. In bounded media, these particles can produce nonequilibrium stationary states with peculiar patterns of spatial distribution, specifically of enhanced particle accumulation at system boundaries, which is primarily caused by the persistent motion of active particles. While most studies have focused on ABPs in homogeneous media, and possibly bounded by hard confining walls, in this thesis we aim at investigating essential properties of ABPs in heterogeneous media, typically designed by placing permeable boundaries between distinct fluid media, in which ABPs can experience different motility strengths (self-propulsion speeds). We first consider the case of ABPs confined within a permeable enclosure or between two permeable flat membranes and calculate the active pressure exerted by ABPs on these permeable boundaries through Brownian Dynamics simulations. We thus map out a detailed phase diagram, identifying regions of the parameter space, where the said pressure can be negative (inward pointing) or positive (outward pointing). We then investigate effective interactions engendered between two permeable (hollow) disks in a bath of ABPs. We show that the ABPs can exhibit complex patterns of spatial distribution inside and outside the disks, hence, producing a complex range of attractive and repulsive interactions between the disks, especially when the interior and exterior regions are assigned mismatching ABP motility strengths. We extend such analyses to the case of rodlike swimmers and explore various aspects of the problem, including the non-central nature of the effective interactions emerging between hard disks immersed in the active bath.

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