Directed autonomous motion of active Janus particles induced by wall–particle alignment interactions

Poulami Bag[1]
[1]Presidency University, Kolkata, Kolkata, India

We propose a highly efficient mechanism to rectify the motion of active particles by exploiting particle–wall alignment interactions. Through numerical simulations of active particles' dynamics in a narrow channel, we demonstrate that a slight difference in alignment strength between the top and bottom walls or a small gravitational drag suffices to break upside-down symmetry, leading to rectifying the motion of chiral active particles with over 60% efficiency. In contrast, for achiral swimmers to achieve rectified motion using this protocol, an unbiased fluid flow is necessary that can induce orbiting motion in the particle's dynamics. Thus, an achiral particle subject to Couette flow exhibits spontaneous directed motion due to an upside-down asymmetry in particle–wall alignment interaction. We consider the particle–wall interaction to depend on the self-propulsion velocity direction whereby some specific particle's alignments with respect to the boundary walls are stabilized more. The rectification effects caused by the alignment we report are robust against variations in self-propulsion properties, particle's chirality, and the most stable orientation of self-propulsion velocities relative to the walls. Our findings provide key insights into the controlled transport of active matter and demonstrate a novel strategy for sorting both artificial micro swimmers (e.g. Janus particles) and natural biological species (such as, bacteria and sperm cells) based on their intrinsic chirality and self-propulsion velocities.