Navigation of Diffusiophoretically Self Propelled Colloid along the Boundaries

Self-propelled, chemically-powered colloidal locomotors are engines which convert fuel from the environment into mechanical propulsion. They are designed to transverse small scale landscapes in a range of applications involving micropumping, sensing and cargo transport. Precise navigation across prescribed pathways is usually required, and for this purpose onboard steering mechanisms can be incorporated. Here we demonstrate, through numerical simulation, how boundaries can simply and passively guide locomotors to move along desired pathways.

As a model system we choose an engine design in which a spherical Janus colloid coated with a symmetrical catalyst cap converts fuel into a product solute on one side of the colloid. The solute is repelled from the colloid through a short range interaction in a thin layer around the particle which creates a slip velocity that propels the swimmer in the direction opposite to the cap (self-diffusiophoresis).

As a first example of boundary guidance, we have previously shown that diffusiophoretically-driven Janus colloid locomotors reaching a planar wall can, for a range of active catalyst areas, rotate to a configuration in which the active side is partially inclined from the wall and the locomotor skims at a constant separation distance. Here we demonstrate more advanced and intricate examples of boundary guidance: We examine the motion of a spherical Janus locomotor in a two dimensional channel, and the trajectory of spheroidal locomotors around a spherical obstacle. Locomotors with small catalyst areas in a channel repeatedly reflect off of the channel wall until they become rotated to a symmetrical cap orientation, which focuses them to move at the channel centerline. For larger coverages, the swimmers approach one wall of the channel and skim directly without reflection. For ellipsoidal and spherical locomotors approaching a spherical obstacle, locomotors becomes locked in an orbit around the obstacle for large obstacles, but, for smaller obstacles, only partly navigate around the obstacle before leaving the orbit and moving away from the obstacle.