

Active Particles Crossing Sharp Viscosity Gradients

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ABSTRACT

Swimming microorganisms and other active particles often navigate through complex and inhomogeneous environments by exhibiting taxis, where they reorient themselves to move up or down gradients in chemical or material properties of their surroundings. Recent experiments conducted on the alga *Chlamydomonas reinhardtii* have revealed complex refraction and scattering behavior when encountering sharp viscosity gradients. Inspired by these findings, we developed a simple hydrodynamic model of active particles swimming near and across similar sharp changes in the viscosity of the suspending fluid. The algae are modelled as spherical squirmers and we have found the reorientation process of pushers, pullers and neutral swimmers is qualitatively similar. Our theory is consistent with the experimental observations as the scattering phenomenon occurs only when the initial orientation of the particle relative to the interface normal is large and it is crossing from low to high viscosity. Otherwise, the particle crosses the interface by undergoing some reorientation. The law we derived governing the reorientation of neutral swimmers is analogous to Snell's law of ray optics as previously shown for gliders on a frictional substrate.