Swimming dynamics and efficiency in chain diatom colonies

Julien Le Dreff[1], Blaise Delmotte[1]

LadHyX, CNRS, Ecole Polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France
julien.le-dreff@polytechnique.edu

Diatom chains are cohesive assemblies of unicellular microorganisms typically found in still and fresh water [1]. While some species are passively transported by ambient currents and settle due to the weight of their dense silica shells, others use various strategies to move or self-propel [2]. One species in particular, called *Bacillaria paxillifer*, forms colonies of stacked rectangular cells that slide along each other while remaining parallel (cf. Fig. 1 a). This unique collective motion leads to beautiful and nontrivial trajectories at the colony scale (cf. Fig. 1 b-c). Using a numerical method developed to simulate rigid bodies with kinematic constraints and hydrodynamic interactions in Stokes flows [3], we show that the swimming speed of such chains changes non-monotonically with the sliding delay between adjacent cells. The swimming efficiency, as a function of sliding delay between cells, shows multiple local maxima, which contrasts with the behavior typically observed in flagellate microorganisms [4]. In addition, the optimal cell aspect ratio for swimming found with our simulation matches those observed in real diatoms.

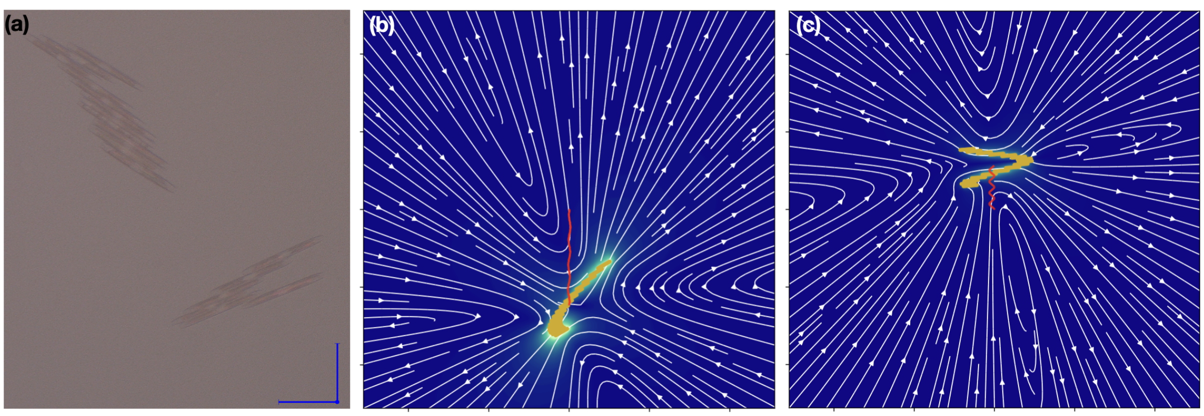

Figure 1. a) Microscope view of two *Bacillaria paxillifer* colonies. The scale bar is 50 μm. b-c) Simulated flow fields around two colonies with different conformations. The red line represents the trajectory of the center of mass of the colony.

Références

1. E. Virginia Armbrust, The life of diatoms in the world's oceans, *Nature*, **459**, (2009).
2. J. Arrieta, R. Jeanneret, P. Roig & I. Tuval, On the fate of sinking diatoms : the transport of active buoyancy-regulating cells in the ocean, *Phil. Trans. R. Soc. A*, **378**, (2020).
3. J. J. L. Higdon, A hydrodynamic analysis of flagellar propulsion, *J. Fluid Mech.*, **90**, (1979).
4. F. B. Usabiaga and B. Delmotte, A numerical method for suspensions of articulated bodies in viscous flows, *J. Comput. Phys.*, **464**, (2022).