Active nematic pumps

Ignasi Velez-Ceron[1,2], Rodrigo C. V. Coelho[3,4], Pau Guillamat[5], Margarida Telo da Gama[3,4], Francesc Sagues[1,2] and Jordi Ignes-Mullol[1,2]

[1] Department of Materials Science and Physical Chemistry, Universitat de Barcelona, 08028 Barcelona, Spain.
[2] Institute of Nanoscience and Nanotechnology, IN2UB, Universitat de Barcelona, 08028 Barcelona, Spain.
[3] Centro de Física Teórica e Computacional, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal.
[4] Departamento de Física, Faculdade de Ciencias, Universidade de Lisboa, P-1749-016 Lisboa, Portugal.
[5] IBEC, 08028 Barcelona, Spain.

Harnessing flows originating in active fluids, normally chaotic, is a paradigm for the successful development of bioinspired micro-machines. We present results from experiments and numerical simulations to demonstrate that the addition of inclusions with specific asymmetric geometries into an extensile active nematic gel stabilizes vortical fields generating self-pumping flows. These structures, based on lattices of triangular obstacles, locally break the fore-aft symmetry of the isotropic active turbulent flows. We describe as well an scenario of colloidal cargo transport along virtual, wall-free channels. Permeable boundaries also enable effective mixing of solutes, along with the downstream flow. We analyze the performance of these active pumps, both isolated and within cooperative ensembles in terms of their output velocity and hydrostatic pressure buildup. Finally, we demonstrate strategies to incorporate them into specifically designed microfluidic platforms to advantageously tailor the geometry of active flows. Our results reveal new possibilities for leveraging the self-organized mechanodynamics of active fluids.

Type

ORAL