Sedimenting flexible fibers against obstacles in a viscous fluid

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The motion of flexible fibers often happens in complex media that are structured by obstacles. Examples range from the transport of biofilm streamers through porous media to the design of sorting devices for DNA molecules. For large number of such problems, the fiber dynamics result from the complex interplay between internal elastic stresses, contact forces and hydrodynamic interactions with the walls and obstacles. By means of numerical simulations, experiments and analytical predictions, we investigate the dynamics of flexible fibers settling in a viscous fluid embedded with obstacles of arbitrary shapes [1]. We identify and characterize two types of events : gliding (Fig.1(a)) and trapping (Fig.1(b)), for which we detail the mechanisms at play. We observe nontrivial trapping conformations on sharp obstacles that result from a subtle balance between elasticity, gravity and friction (Fig.1($c-d$)). In the gliding case, a flexible fiber reorients and drifts sideways after sliding along the obstacle. The subsequent lateral displacement is large compared to the fiber length and strongly depends on its mechanical and geometrical properties. We show how these effects can be leveraged to propose a new strategy to sort particles based on their size and/or elasticity (Fig.1(e)). This approach has the major advantage of being simple to implement and fully passive, since no energy is needed.

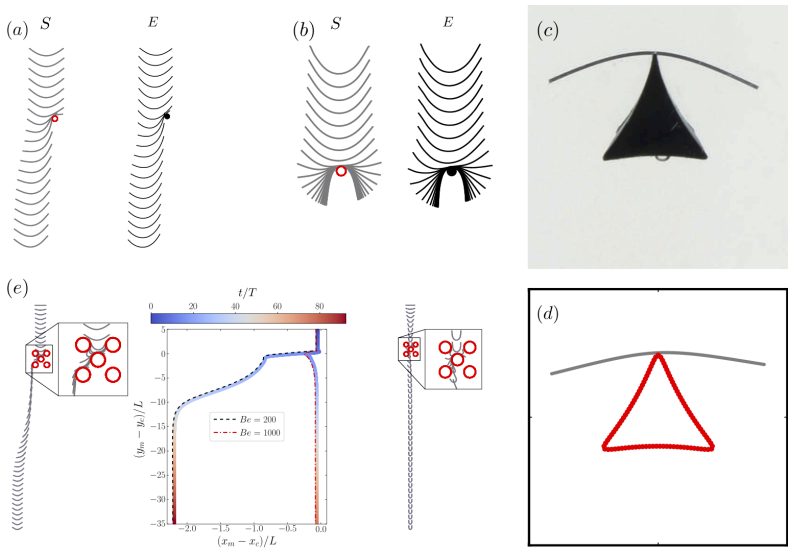

Figure 1. ($a-b$) Numerical (S) and experimental (E) chronophotographies of a flexible fiber settling against an obstacle in a viscous fluid. ($c-d$) Trapping events from experimental (c) and numerical (d) results. (e) The central panel shows the trajectories of the center of mass of two fibers with the same length and different flexibilities ($Be = 200$ and $Be = 1000$). The side to side panels show the corresponding chronophotographies of the fiber centerline settling through a unit cell.

Références

1. U. Makanga, M. Sepahi, C. Duprat & B. Delmotte, *arXiv preprint*, arXiv :2209.10692 (2022)