Dynamics of fibers transported in confined viscous flow

J. Cappello[a], C. Duprat[b], O. du Roure [a], A. Lindner[a]
[a]*Physique et Mécanique des Milieux Hétérogènes, CNRS UMR 7636, ESPCI Paris, Université Paris Diderot, Paris, France*
[b]*LadHyX, CNRS UMR 7646, Ecole Polytechnique, Université Paris-Saclay, Palaiseau, France*

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The transport and dynamics of elongated objects has been extensively studied in unbounded media such as the situation of sedimenting fibers in Stokes flow. Here we focus our study on the dynamics of fibers transported in pressure-driven flows in confined geometries. We show that the confinement tunes the friction forces on the fiber and as a consequence the velocity of the object becomes anisotropic for high confinement [1]. These passive hydrodynamic effects lead for example to a lateral drift of simple straight fibers transported in confined channels. Elastic fibers on the other hand can be deformed while transported. Fibers perpendicular to the flow will bend while parallel fiber can show a buckling instability.

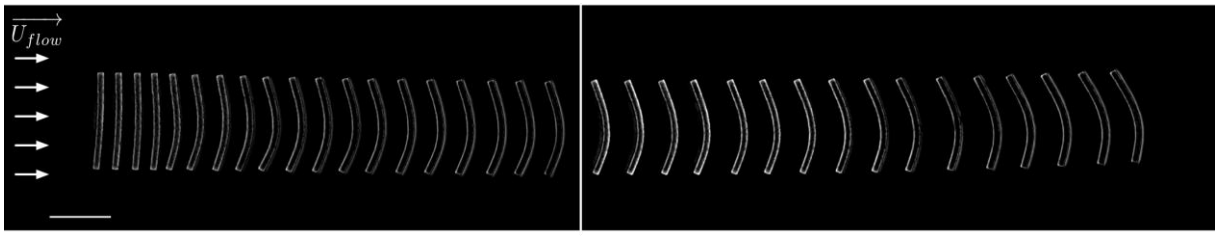

Figure 1: Bending of a confined flexible fiber transported in a confined viscous external flow.

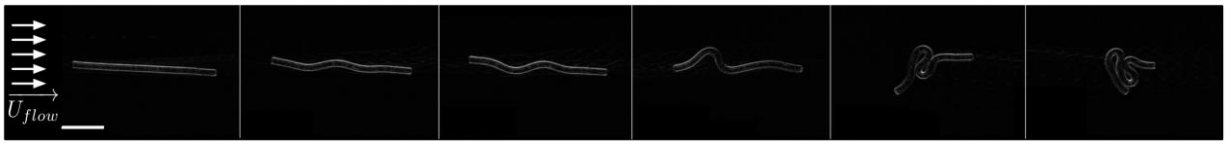

Figure 2: Buckling of confined flexible fibers transported in a confined viscous flow.

We chose to investigate these effects with a combination of well-controlled microfluidics experiments and simulations using modified Brinkmann equations [2]. We control shape, orientation, and mechanical properties of our particles using micro-fabrication techniques [3] and in-situ characterization methods [4].

We show that the bending of the perpendicular fiber is proportional to an elasto-viscous number and we fully characterize the influence of the confinement on the deformation of the fiber. Experiments on parallel flexible fibers reveal the existence of a buckling threshold.

References

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