Dynamics of fibers in a wide microchannel

Agnieszka M. Słowicka, Maria L. Ekiel-Jeżewska, Krzysztof Sadlej, and Eligiusz Wajnryb
Institute of Fundamental Technological Research,
Polish Academy of Sciences,
Pawińskiego 5B, 02-106, Warsaw, Poland

In this work, we consider a single non-Brownian mobile and flexible fiber immersed in Poiseuille flow in a channel consisting of two parallel infinite walls. We investigate migration of the fiber toward the central plane of the channel. We study how the migration rate depends on the aspect ratio of the fiber, its stiffness and position across the channel.

We assume that a characteristic length scale of the system is close to micrometers and velocity of the flow is very small, counted in micrometers per second. In this case the resulting flow is characterized by a very small Reynolds number $\mathrm{Re} \ll 1$ and the fluid inertia effects are negligible. We assume that the Peclet number is large, $\mathrm{Pe} \gg 1$, and Brownian motions are irrelevant. For the system specified above, the fluid velocity $\mathbf{v}$ and pressure p satisfy the stationary Stokes equations with the stick boundary conditions at the walls [1, 2]. The external fluid flow inside the channel of width H is the Poiseuille flow. To determine the fiber motion, the bead model is used [3]. The relative motion of the beads is discretized by elastic and bending forces, which are constructed as described in [4]. In the calculations we use the HYDROMULTIPOLE numerical code [5], which implements the theoretical multipole method [6, 7] of calculating hydrodynamic interactions between bodies in Stokes flows. We evaluate hydrodynamic interactions between parts of the fiber and take into account the influence of the walls on the behavior of a single flexible fiber.

The main conclusion of this work is the following. Investigating fibers which migrate toward the central plane of the channel we found out that longer and more flexible fibers migrate faster toward the middle plane of the channel and move slower along the flow [8].

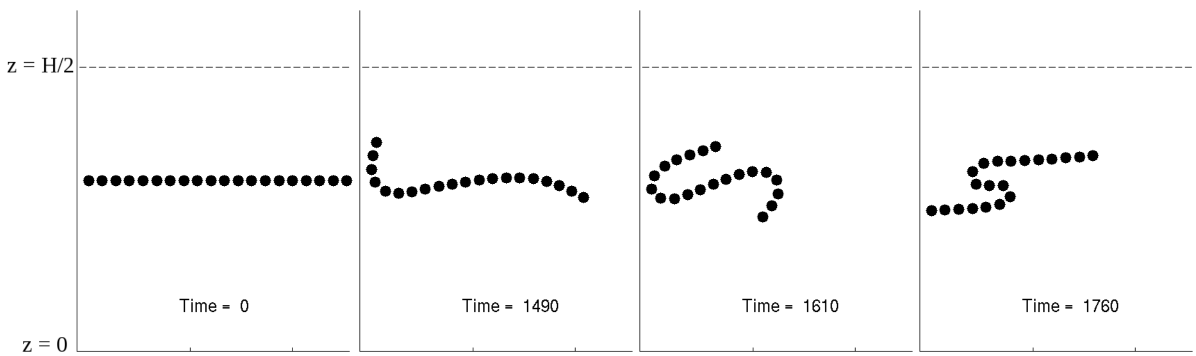

FIG. 1: Tumbling motion of a single fiber in Poiseuille flow. A typical example of the shape deformation (HYDROMULTIPOLE numerical simulations). Channel walls are at z = 0 and z = H. The time unit is the ratio of the bead diameter to the maximal velocity of the Poiseuille flow.

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