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MIGRATION OF MICROFIBERS ENTRAINED BY POISEUILLE FLOW IN A MICROCHANNEL

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Key words: microfibers, microchannels, Stokesian dynamics, multipole expansion

Abstract– Migration of microfibers in Poiseuille flow [1-4] is the fundamental problem of modern lab-on-chip hydrodynamics, important in various biological, medical and industrial contexts. Dynamics of flexible microfibers in simple shear and Poiseuille flows has been analyzed theoretically, numerically and experimentally in numerous publications [5-12]. In this work, we study motion and shape deformation of a single non-Brownian flexible microfiber in Poiseuille flow. The fluid is bounded by two planar solid walls with the stick boundary conditions. The fluid sticks also the microfiber boundary. We assume that the fluid inertia effects are negligible. To characterize a single microfiber the bead model is used [13]. A microfiber strand is constructed out of N solid spherical particles of diameter d which can move with respect to each other. The relative motion of the beads results from elastic and bending forces. The dynamics of the microfiber is calculated by the multipole method of solving the Stokes equations [14], implemented in the numerical code HYDROMULTIPOLE [15]. As we have shown in [16], the migration of microfibers is characterized by a critical distance z_c from the wall where microfibers tend to accumulate. In this paper we describe in details how the accumulation planes z_c depend on stiffness and aspect ratio of microfibers.

We investigated microfibers with N = 5, 10 and 20 beads in the channel width h = 50d for many values of the stiffness parameter A. The parameter A describes ratio of bending to viscous forces acting of the microfiber. We have found out that for a large stiffness (e.g. A=1), microfibers accumulate at a critical position $z_c/d<N$ i.e. smaller than the microfiber length (Fig. 1 a). However, for more flexible microfibers (e.g. A = 0.05), z_c/d becomes much larger, as illustrated in Fig. 1 b. This tendency is observed for microfibers with N = 5, 10 and 20. It seems that accumulation of stiff microfibers is caused by

the wall, which prevents them from escaping. Flexible microfibers accumulate independlly of the wall owing to their shape deformation and the flow curvature.

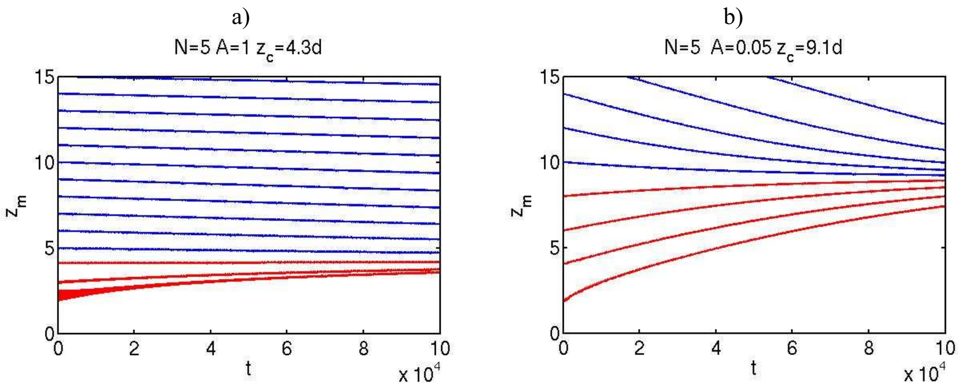

Fig. 1. Evolution of a microfiber center-of-mass z_m, starting from different distances from the wall, for different values of stiffness parameter A (the blue lines -trajectories which move away from the central plane of the channel at z = 25, the blue lines – trajectories which move away from the wall at z = 0).

We found out that microfibers of a different length and stiffness accumulate at different positions across the channel. Differences between the critical position for different microfibers can be used in the process of microfibers separation by the flow.

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