SHORT-TIME DYNAMICS OF ELASTIC FILAMENTS IN A SHEAR FLOW

Agnieszka M. Slowicka[1], Nan Xue[2], Paweł Sznajder[1], Janine K. Nunes[2], Howard A. Stone[2], Maria L Ekiel-Jezewska[1]
[1]*Institute of Fundamental Technological Research, Polish Academy of Sciences, Pawinskiego 5b, 02-106 Warsaw, Poland*
[2]*Department of Mechanical and Aerospace Engineering, Princeton University, Princeton, NJ 08540, USA*

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Abstract:
Short-time dynamics of a relatively short and moderately elastic filament in a simple shear flow are studied experimentally and numerically [1]. The Reynolds number is much smaller than unity. In the elastic equilibrium, the filaments are straight. Initially, they are straight and at different 3D orientations with respect to the flow. Later, they rotate along effective Jeffrey orbits. We focus on time scales of the order of a few Jeffery periods, and analyze dependence of the dynamics on the ratio A of bending to shear forces. In the experiments, we observe fibers in the flow-vorticity plane, using a setup which gives insight into the motion out of the shear plane [2]. In the simulations, we use th bead model and determine the 3D dynamics, performing the multipole expansion corrected for lubrication and implemented in the precise Hydromultipole numerical codes [3].

We observe that for a very limited range of initial orientations from the compressional region of the shear flow, excluding those very close to or at the flow-vorticity plane, fibers undergo a compressional buckling [4], with a pronounced but very short deformation of shape along their whole length, which is in contrast to the typical local bending that originates over a long time from the fiber ends [5]. Since relatively short and moderately elastic filaments straighten out in the flow-vorticity plane while tumbling, the compressional buckling is transient – it does not appear for times longer than 1/4 of the Jeffery period. For larger times, bending of fibers is always driven by their ends.

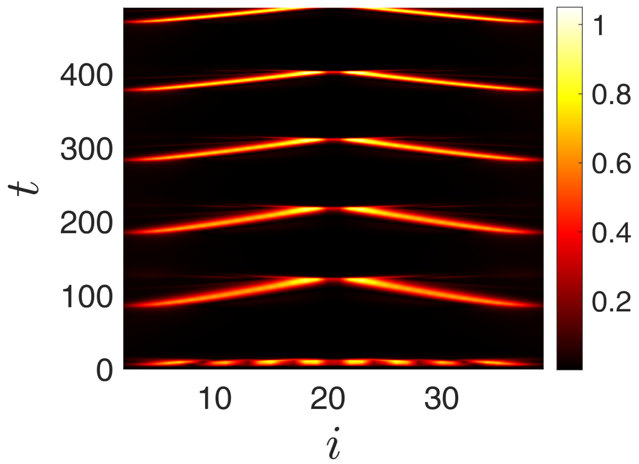

Figure 1. Local curvature (colorbar) at the segment i of the filament made of 40 beads versus time t. At each time t, the local curvature is normalized by its maximum value with respect to all the beads. Buckling, with many local maxima, is visible at the bottom, for short times only. Later, the filament bends starting from both filament ends, with only two local maxima at a given time t.

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