Dynamics and fragmentation of small flexible fibers in turbulence

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The dynamics of small flexible, inextensible fibers in a turbulent flow is found to follow most of the time that of a stiff rod. Then, they are aligned with the solution to Jeffery's equation [3]. Still, this simple dynamics becomes unstable when the fiber is strongly compressed by the flow [2]. As shown in [1], such events are very rare and intermittent because of the long-term Lagrangian correlations of turbulent velocity gradients. We investigate the consequence of such a dynamics on fiber fragmentation. Two mechanisms are considered : tensile failure, when the fiber breaks because of a too strong local tension and flexural failure, when the fiber breaks because of a too strong curvature. By characterizing the statistics of the extrema of tension and of curvature, we provide estimates for the fragmentation rate. One expects large values of the tension to be attained when the fiber is in a fully straight configuration and experiences a strong stretching from the flow. The simplest fragmentation process is then due to tensile failure, because only depend on the fluctuation of the turbulent flow. Conversely, flexural failure can only occur when the fiber buckles. Fragmentation processes are hence determined by the most excited buckling mode and thus have an intricate dependence on the fiber flexibility.

Références

1. S. Allende, C. Henry, and J. Bec., Stretching and buckling of small elastic fibers in turbulence, *Phys. Rev. Lett.*, **121**, 154501 (2018).
2. L. Becker and M. Shelley., Instability of elastic filaments in shear flow yields first-normal-stress differences, *Phys. Rev. Lett.*, **87**, 198301 (2001).
3. A. Tornberg and M. Shelley, Simulating the dynamics and interactions of flexible fibers in Stokes flows, *J. Comput. Phys.*, **196**, 8–4 (2004).