Hydrodynamics and rheology of fluctuating, semiflexible, inextensible, and slender filaments in Stokes flow

Aleksandar Donev[1], Ondrej Maxian[1], Brennan Sprinkle[2,1]
[1]*Courant Institute, New York University, New York, United States,* [2]*Department of Mathematics and Statisics, Colorado School of Mines, Golden, United States*

Every animal cell is filled with a cytoskeleton, a dynamic gel made of inextensible filaments / bio-polymers, such as microtubules, actin filaments, and intermediate filaments, all suspended in a viscous fluid. Similar suspensions of elastic filaments or polymers are widely used in materials processing. Numerical simulation of such gels is challenging because the filament aspect ratios are very large.

We have recently developed new methods for rapidly computing the dynamics of non-Brownian and Brownian inextensible slender filaments in periodically-sheared Stokes flow [1-3] . We apply our formulation to a permanently1 and dynamically cross-linked actin mesh3 in a background oscillatory shear flow. We find that nonlocal hydrodynamics can change the visco-elastic moduli by as much as 40% at certain frequencies, especially in partially bundled networks [3,4].

I will focus on accounting for bending thermal fluctuations of the filaments by first establishing a mathematical formulation and numerical methods for simulating the dynamics of stiff but not rigid Brownian fibers in Stokes flow.4 I will emphasize open questions for the community such as whether there is a continuum limit of the Brownian contribution to the stress tensor from the filaments.

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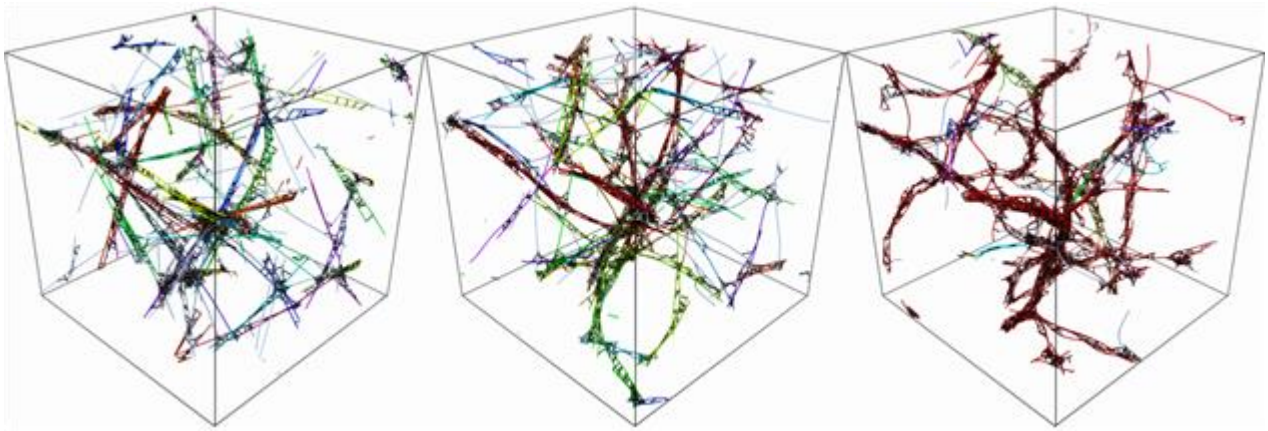

References

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