Colloquium

MAX PLANCK INSTITUTE
FOR DYNAMICS AND
SELF-ORGANIZATION

Morphological transitions of flexible filaments transported in viscous flows

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Here we present the individual dynamics of flexible and Brownian filaments under shear and compression. We use actin filaments as a model system and observe their dynamics in microfluidic flow geometries using fluorescent labeling techniques and microscopic tracking methods. The experimental results are completed with analytical and numerical modeling based on slender body theory.

Under shear we characterize successive transitions from tumbling to buckling and finally snake turns as a function of an elasto-viscous number, comparing viscous to elastic forces. Under compression we reveal the formation of three dimensional helicoidal structures and explain their formation from linear and weakly nonlinear stability analysis. In more complex, time dependent or mixed flows, as oscillatory shear flows or transport in porous media, filament morphology is modified and buckling instabilities can be suppressed under certain conditions. Pillar arrays can be used to obtain filament separation according to length and flexibility.

Finally, we attempt at linking the microscopic observations to the macroscopic suspension properties with preliminary measurements of the shear viscosity of dilute suspensions of actin filaments in microfluidic rheometers and numerical simulations.

Wednesday, Jan. 11th, 2023 at 2:15 pm

MPI-DS, Prandtl Lecture Hall
Am Fassberg 11, Göttingen, and
Zoom Meeting ID: 959 2774 3389
Passcode: 651129, direct link

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