LadHyX Seminar – July 27, 10:45

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Measuring condensate rheology with micropipette aspiration and fluid-structure interactions at low Reynolds number

In this presentation, I will discuss the two main themes of my PhD research: fluid-structure interactions and the development of rheological techniques for intracellular use.

At low Reynolds numbers, axisymmetric ellipsoids undergo periodic tumbling motions known as Jeffery orbits. However, in nature, most particles are neither axisymmetric nor rigid, leading to the breakdown of these conditions, resulting in chaotic orbitals and net particle drift across fluid streamlines. In our study, we derive a novel mechanism for particle drift in simple shear when the particle becomes highly asymmetric. In this mode, the particle ceases all rotation and drifts perpendicular to both the flow and vorticity directions, potentially enhancing Taylor dispersion. Furthermore, we investigate the impact of shape perturbations on the channel walls rather than on the particle itself, providing a correction to the classical theory of Taylor to account for surface roughness.

In the second part of the talk, I will focus on methodologies for measuring common rheological properties of biological condensates. These condensates are becoming increasingly important in understanding cellular processes and intracellular regulation. However, due to limited sample availability, traditional rheological methods for determining viscosity or surface tension are often challenging to use. To address this, we have developed a theoretical model for experimentally measuring condensate viscosity and surface tension using micropipette aspiration. This innovative technique allows us to extract both parameters from a single experiment, which can be performed in vivo.

We believe that micropipette aspiration is a powerful tool for quantifying material properties of these biological fluids, particularly because it enables the measurement of two properties through a relatively simple experiment. Additionally, its potential extension to measure viscoelastic properties and its direct application to cells make it even more promising for future research in this field.