Graduate Student Research Seminar

Fall 2022

APS DFD Conference Presentations

Monday, November 14th

3:00 pm (EST) – 132 Fluor Daniel Building

Thin film flow between fibers: inertial sheets and liquid bridge patterns

Chase Gabbard (PhD student)

Advisor: Dr. Joshua Bostwick

Thin film flows down fibers have been widely studied due to their complex behavior and practical applications. In contrast, flow between fibers has received less attention despite its relevance to closely packed fiber arrays where narrow inter-fiber spacings are optimal for mass transfer processes. Here, we perform experiments on liquid flow between fibers for a range of liquid properties, fiber diameters D_f, flow rates Q, and inter-fiber spacings w. We observe two possible behaviors: 1) periodic liquid bridges and 2) a uniform column (or sheet). Liquid bridge patterns appear for low flow rates Q, large D_f, and large w and result in a series of isolated bridges with equal speed and separation length, forming a unique "liquid ladder" pattern. Alternatively, for flows with higher Q, smaller D_f, and smaller w, a thin liquid column can form that spans the length of the fibers. Liquid columns can span significant widths ($w > 2.5l_c$) for flow rates common in typical bead-on-fiber applications—a result of the flow replenishing the thin column. Furthermore, we show how liquid properties and fiber diameter D_f can be optimized to sustain a liquid column at minimal flow rate Q. We conclude by illustrating the unique patterns and shapes these flows form with curved fibers.

Control strategies for magnetically driven artificial microswimmers

Jake Buzhardt (PhD student)

Advisor: Dr. Phanindra Tallapragada

Artificial microswimmers have received significant experimental and theoretical research attention due to their promising potential biomedical applications, such as targeted drug delivery, minimally invasive surgery, and micro-particle manipulation. While various means of propulsion have been considered, swimming bodies driven by externally applied magnetic fields seem particularly promising, as they present the capability of controlling the swimmers remotely. While previous works have controlled such microswimmers using simplified models for control or by aligning the rotation direction of the magnetic field with the desired steering direction, for complex swimming tasks, more advanced control strategies are needed. Here, we consider a micro-robot composed of three rigidly connected spheres, driven by a torque induced through an externally applied magnetic field. Through Stokesian dynamics simulations, we examine model-based and data-driven control strategies for various swimming scenarios, such as path tracking for a single swimmer, manipulation of a passive particle, and control of multiple swimmers using a single, global magnetic field.

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An Experimental Study on the Co-flow of Newtonian and non-Newtonian Fluids in a T-shaped Microchannel

Nayoung Kim (BS student)
Advisor: Dr. Xiangchun Xuan

Abstract

Microfluidic mixers and separators often concern flow of non-Newtonian fluids through a T-junction. The flow dynamics at the junction plays an important role on the performance of such devices. Some previous studies have focused on the topic with same fluids flowing through the T-junction in an opposing configuration. But many of the real applications use dissimilar fluids having different rheologies together. Thus, a fluid rheology-based understanding on the flow dynamics for combinations of Newtonian and viscoelastic fluids will be beneficial. Hence, we investigate different polymer solutions with diverse shear-thinning and elastic properties in conjunction with a Newtonian water flow through a planar T-microchannel experimentally. Preliminary results indicate development of different vortical/nonvortical and unstable flow regimes based on the fluid rheology.

Stagnation flow of polymer solutions in a T-shaped Microchannel

Savannah Till (BS student)
Advisor: Dr. Xiangchun Xuan

Abstract

Viscoelastic flow of polymer solutions opposingly flowing through a T-junction have been a subject of interest for particle manipulation and droplet-based microfluidics lately. Some studies have been conducted on the non-Newtonian fluid dynamics near the stagnation point at the junction, which eventually can dictate the efficacy of those microfluidic operations. But a systematic understanding of the fluid rheological responses, namely different combinations of shear-thinning and elasticity, is still lacking in such channels. In this study, we experimentally investigate the responses of these different rheological properties of the polymer solutions symmetrically and opposingly flowing through a planar T-junction microchannel. The flow visualization results indicate that the flow regimes can be expected to be either vortex dominated or having unstable streamlines, depending on the strength of elasticity and shear-thinning of the fluid under such flow conditions.

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