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Emergent Structure in Magnetic Microrollers

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Microrollers are rotating colloidal particles that become active close to a wall due to an asymmetric flow of the fluid around the particles [1]. They can be experimentally realized by driving magnetic particles with a magnetic field rotating perpendicular to the wall [2]. The velocity of a microroller is much slower than the velocity of the fluid pumped around it. Therefore, a particle put in the flow field around a microroller will have a velocity much higher than the microroller itself. This leads to strong collective effects where the average velocity of a suspension of microrollers increases as a function of the density. These collective effects lead to a rich array of emergent structure, from shocks, to fingering patterns, to stable, hydrodynamically-bound clusters.

We study these collective effects using a variety of techniques, including fluorescent imaging and a custom, dual-view microscopy setup. This custom setup allows for viewing the fast-moving bound clusters both from below and the side, to allow us to obtain projected three-dimensional structure information. We are also developing techniques to study the detailed fluctuating structure of these suspensions in uniform flow. For example, at higher densities the particles form two layers: a slow one close to the wall and a much faster one above it. We study this layering structure in detail using a small fraction of tagged particles, and these results are complemented by high-resolution Brownian dynamics simulations [3].

Furthermore, we study the interaction of microrollers with obstacles in their path. In contrast to many other active matter systems [4], the propagation direction in this system is prescribed, resulting in different particle-obstacle interactions. As the fluid flow around the microrollers reaches multiple particle diameters from the wall, we study the effect of the height of obstacles, as well as their thickness. Finally, as we are using two-photon polymerization to obtain the obstacles, we can design gates with variable heights to see the effect of an overhang in the flow field around a microroller.

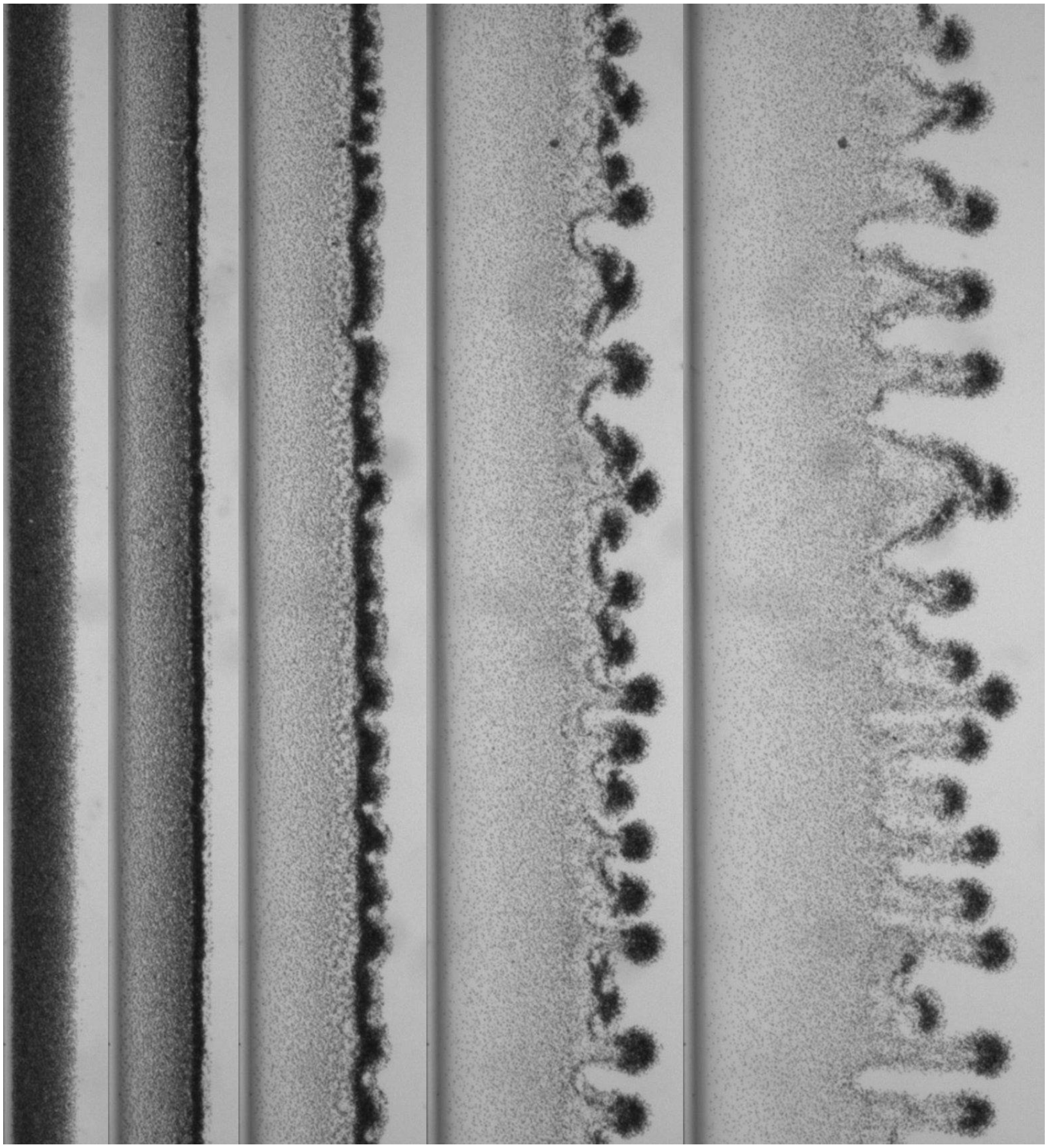

Figure 1. Fingering instability which occurs in the magnetic micro roller system.

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