Motions, patterns and collective oscillation in complex biological fluids out of equilibrium

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In this talk I will show two experimental studies for complex fluid systems out of equilibrium. The first part is about the motion of biological polymers driven by temperature and solute gradients. Atoms and molecules move along a gradient of temperature, which is called thermophoresis or the Soret effect. Thermophoresis depletes a polymer such as polyethylene glycol (PEG) from the hot region and builds a concentration gradient [1]. In such a solution, solutes of small concentration experience thermophoresis and the restoring force dependent on PEG gradient of large concentration [2]. Under focused laser heating, DNA and RNA as solutes localize as a ring-like structure which diameter monotonically decreases with their size following a behavior analogous to gel electrophoresis [3]. Moreover, I show that the motion of small RNA depends on its stem-loop structure [4]. Thus trapping and selection of molecules could be physically feasible in a simple way relying on temperature gradient. Thermophoresis of RNA enzyme might be relevant to primitive life: Separation of RNA from the large library of RNA world might occur at the thermal vent of the deep ocean where large temperature gradient is present.

In the latter half, I will present the collective motion of microscopic objects in a confined space. The array of water-in-oil droplet that moves with long-range hydrodynamic interaction is observed in a thin microfluidic channel. Above the critical velocity of oil flow, sustained oscillatory motion of droplets emerges and synchronization also occurs. The vortices formation is investigated and the mechanism of instability will be discussed.

[1] Braun & Libchaber (2002) PRL 89: 188103. [2] Jiang, et al. PRL (2009) 102: 208301. [3] Maeda, et al. (2011) PRL 107: 138301. [4] Maeda, et al. PNAS (2012) 109: 17374.