Dynamic elastocapillary coalescence of slender structures

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Some small animals, such as bees, bats or passerine birds, are nectarivores. They feed by dipping periodically their hairy tongue - resembling a brush - in the nectar. As a first step to understand this intricate fluid capture mechanism, we consider a minimal tongue consisting of two hairs. I will first present the results in the quasi-static regime: when partially immersed, they interact with each other through the capillary force induced by their menisci. As they are removed from the bath, their dry length increases, and they become easier to bend until the capillary force is strong enough to trigger contact. Surprisingly, the structures snap to contact from a finite distance at a critical dry length. The transition to coalescence is thus subcritical and exhibits a large hysteresis loop between two stable states. An analytical coalescence criterion is derived and agrees well with experimental data.

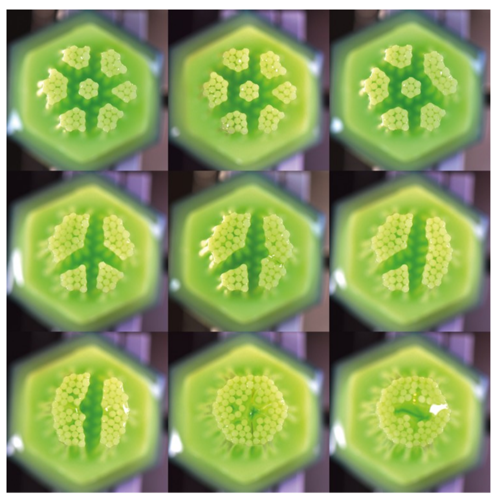

Figure 1. Aggregation of fibers in a brush with an increasing withdrawal speed (from top-left to right-bottom).

I will then consider the role of the withdrawing speed. We show that the capillary "Cheerios" force strongly increases with the retraction speed by up to a factor ten compared to the static case. This remarkable increase stems from the shape of the dynamical meniscus between the two fibers. We first study the dynamical meniscus around one fiber and obtain experimental and numerical scaling of its size increase with the capillary number, which is not captured by the classical Landau-Levich-Derjaguin theory. We then show that the shape of the deformed air-liquid interface around two fibers can be inferred from the linear superposition of the interface around a single fiber. These results yield an analytical expression for the attraction which compares well with the experimental data.

I will finally present preliminary results on the withdrawal of brushes containing many rigid and flexible fibers.