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Elasticity and capillarity: wet hairs and origami

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Capillary forces are responsible for a large range of everyday observations : the shape of rain droplets, the imbibition of a sponge, the clumping of wet hair into bundles. Although they are often negligible on macroscopic structures, surface capillary forces may overcome volume forces at small scales and deform compliant micro-structures. Capillary-induced sticking can indeed prevent the actuation of mobile elements in micro-electro-mechanical systems (MEMS), or even cause their collapse. Capillary forces also have important consequences in biology such as the buckling of the airway lumen induced by surface tension, which can eventually cause the lethal closure of lung airways (known as neonatal respiratory distress syndrome). We will review a few experimental situations where capillary forces are able to deform two types of objects: rods, and thin sheets. For instance, the nanotubes of a "carbon nanotube carpet" self-assemble into conical "teepee" structures after the evaporation of a solvent and can produce intriguing cellular patterns. Similarly, macroscopic wet hairs tend to assemble into bundles through a cascade of successive pairings. Comparing attracting capillary forces to bending elasticity, leads to a characteristic "elasto-capillary" length. The case of thin sheets is challenging because of geometrical constrains, which generally leads to singularities. Can a thin sheet spontaneously wrap around droplet? We will describe in detail this "capillary origami" experiment.

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