Droplet durotaxis on very soft substrates

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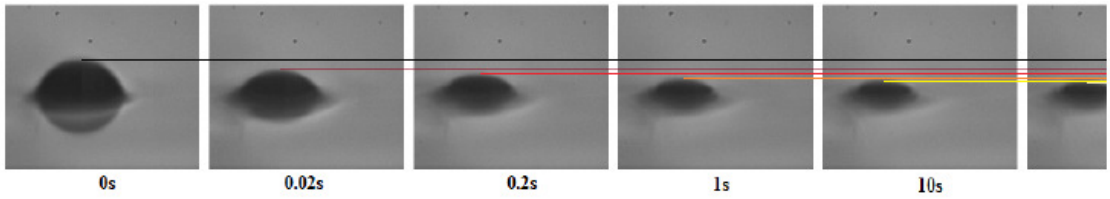
The spreading of liquid droplets on stiff, flat surfaces is governed by the contact angle. In equilibrium, a small droplet takes the shape of a spherical cap with uniform contact angle θ determined by Young's law:
$\gamma_{LV} \cos\theta = \gamma_{SV} - \gamma_{SL}$, where the indices L, S, and V for the interfacial energies γ, refer to liquid, solid, and vapor, respectively. Recent experiments have shown that on soft substrates, the apparent contact angle varies with droplet size and substrate stiffness. This is because a partially-wetting liquid can deform the underlying elastic substrate upon which it rests. Hence, modulations in the substrate stiffness can lead to spontaneous droplet motion – a simple mechanical analogue of durotaxis by which numerous types of cells show a remarkable ability to detect and move along gradients in stiffness of an underlying substrate [1].



Time-sequence (in side-view) of droplets sinking while moving towards the softer part of the substrate from recent experiments performed in Manchester.

Recent experiments in Manchester have shown that droplets can sink while displacing towards the softer parts of the substrate if the substrate is sufficiently soft. This sinking motion enhances the sideways displacement. The aim of this project is to characterise and interpret physically the motion of droplets along gradients of substrate stiffness by correlating the rheology of the substrate with the dynamics of the droplets. Soft substrates will be fabricated and characterised with confocal microscopy. Controlled experiments of droplet motion will be correlated to rheological measurements of the substrate elasticity and yield stress in order to gain insight into the mechanics of the system. In this project, the student will gain experience of several modern measurement techniques used in soft matter physics, and develop physical insight into viscoelastic materials that can behave like both solids and liquids.

[1] Style et al. Patterning droplets with durotaxis PNAS 110 (31), 12543 (2013)