Experimental and theoretical multiple-scale investigation of droplet migration on a textured surface

S. V. Jalikop[a], B. Scheichl[a,b]

The spreading of a droplet over an engineered surface has recently gained much attention, both experimentally and theoretically[1]. This can be attributed to a multitude of phenomena, still debated intensively, where the dynamics of the wetting line probably represents the most prominent one. Interest is also raised by the thriving importance of textured surfaces specifically designed to serve as a `storage' or `guidance' for lubricants in tribological applications, to minimise consumption and avoid starved lubrication[2]. Motivated by this idea, we consider the Stokes flow of a droplet on an unidirectionally grooved, nominally planar, rigid substrate. Body forces act vertically onto this (gravity) and possibly also horizontally (centrifugal force). We present the results of an ongoing study that aims at a thorough understanding of the separation of scales involved. This sets the basis for a rigorous description of the flow, initiated by the release of a droplet and terminated either by its steady state or, at the other extreme, its disintegration into a network of channel flows through the surface grooves. Novel experimental techniques are tied in with dimensional and asymptotic analysis, accounting for the individual flow regions at play. We focus on the crucial regime where the droplet already forms a slender but still fully wetting, developed layer characterised by suitably defined capillary and Bond numbers, the apparent contact angle α and (at least) two microscopic aspect ratios λ_1, λ_2 describing the groove geometry (Fig. 1). The texturing essentially breaks the initial axial symmetry of the droplet and provokes its directional (desired). The match of first experimental and theoretical results is promising.

---

[a] Simulations & Modelling Pool, AC2T research GmbH, 2700 Wiener Neustadt, Austria

[b] Institute of Fluid Mechanics and Heat Transfer, TU Wien, 1060 Vienna, Austria

[1] Kant, Hazel, Dowling, Thompson and Juel, *Soft Matter,* **14**, 44, 2018.

[2] Grützmacher, Jalikop, Gachot and Rosenkranz, *Surf. Topogr.: Metrol. Prop.* **9** (2021) 013001

[3] Batchelor, Fluid Dynamics, Cambridge (1967).

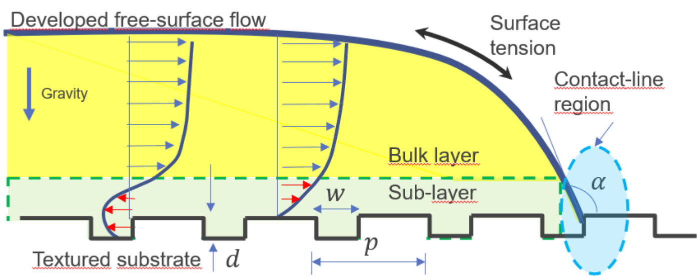

Figure 1: Surface grooves (depth d, width w, period p defining $\lambda_1=d/p$, $\lambda_2=w/p$) govern the microscopic flow in a sublayer; its displacement controls the macroscopic developed bulk flow and the propagation of the contact line dictated by the temporal evolution of the flow in a wedge region (α) encompassing the contact line and preceding the sublayer.