Wetting on Patterned Liquid Surfaces

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Recent years have seen intense interest in exploiting chemical and topographical patterning of solid surfaces to control the shape and motion of liquid droplets. Such strategies, however, often suffer from contact-line pinning and solid-liquid friction hindering the liquid mobility, which pose serious limitations to key applications, such as in microfabrication, printing, and heat transfer. **But what if we could exploit wettability patterns not on a solid, but on a liquid surface?** For example, we can create a conformal liquid layer that follows the shape of a solid microstructure topography (Fig. 1a) [1] or make the liquid layer to be formed by separate domains of immiscible liquids (Fig. 1b) [2]. Fundamentally, a liquid surface is smooth down to the atomic length scale, and thus can give rise to a very different droplet-on-liquid wettability. Our overarching aim is to research the concept

Fig. 1: Patterned liquid surfaces.

of Patterned Liquid Surfaces (PaLS) as a new type of pinning-free and ultra-low friction surface thereby transforming the concept of solid surface wettability into liquid surface wettability.
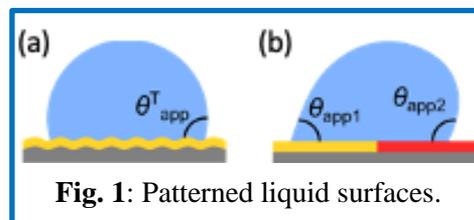
To date very little is known of the fluid mechanics of droplets on these new surfaces, so there is an opportunity for research that unveils exciting science and also advances in technological applications. We will draw important concepts of classical wetting and identify, study and exploit their counterparts in a droplet-on-liquid system. Key concepts to address include:

- What is the equivalent of the Young's contact angle?
- What determines contact angle hysteresis and lateral adhesion?
- What is the effective droplet-substrate boundary condition, including at the contact line?
- On a patterned solid surface, droplet motion is affected by pinning/de-pinning of the contact line from surface features. How will an underlying patterned liquid surface affect droplet dynamics?
- Can we generate droplet self-propulsion by tuning the liquid wettability contrast?

The PhD student will harness a lattice Boltzmann simulation method, where recent advances from our groups put us in a unique position to carry out the project [3,4]. Moreover, the PhD student will benefit from close interactions with our experimental partners at the University of Edinburgh (Prof Glen McHale and Dr Gary Wells). The student will also have opportunities to contribute to an open source lattice Boltzmann software, as part of a collaboration with Dr Jianping Meng at STFC Daresbury Laboratory.

References:
[1] G. Launay et al., Sci. Rep. 10, 14987 (2020)
[2] D. Paulssen et al., ACS AMI 11, 16130 (2019)
[3] M. Wöhrwag et al., PRL 120, 234501 (2018)
[4] E. Ruiz-Gutiérrez & R. Ledesma-Aguilar, JPCM 32, 214007 (2020).