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PREFACE

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Preface

Special issue on complex fluids at structured surfaces

Guest Editors

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Advances in controlling and exploiting the wetting and adsorption properties of complex fluids, such as liquid crystals, ionic liquids, colloids and active matter, have been fostered by impressive technical achievements allowing the fabrication of tailored surfaces with a well-controlled distribution of micro- or nano-scale features. Such patterned substrates may be used to control the properties of adsorbed fluids in ways relevant to applications including microfluidic devices, surfaces with switchable wettability, new generation liquid crystal displays, or supercapacitors for efficient energy storage. In this special issue we collect together experimental, theoretical and computational papers that showcase recent contributions to understanding complex fluids at structured surfaces. These underline the diversity of phenomena encountered when complex fluids interact with complex surfaces.

Hydrophobic surfaces patterned with posts are superhydrophobic. They have high contact angles and low contact angle hysteresis which leads to fast run-off. For applications, such as self-cleaning and drag reduction, the challenge is to stabilise the Cassie or suspended state, in which the liquid lies on top of the posts, with an air gap beneath. This is particularly demanding if superoleophobic substrates are needed, because of the low surface tension of most oils. Panter and Kusumaatmaja use a diffuse interface model, best suited to model surfaces with micron-scale features, to discuss how post shape affects the stability of the Cassie state. They argue that condensation and cavitation are important effects that contribute to how and when collapse will occur.

Amabili *et al* examine similar questions from a more microscopic perspective, using rare event simulations to study the collapse transition of a suspended liquid on a nanostructured surface as the pressure is increased. They find that the liquid can be extruded from the surface by applying negative pressures, and that the intrusion and extrusion curves form a hysteresis cycle because of the large free energy barriers between suspended and wet states. Their simulation results also stress the importance of substrate geometry in determining the pressures needed to drive surface transitions and help to elucidate cavitation in the Wenzel state.

Classical density functional theory, a venerable approach in this area, continues to provide insights. Yatsyshin *et al* identify new surface transitions driven by a stripe of lower contact angle than the surrounding substrate. Haghmoradi *et al* generalise Wertheim's thermodynamic perturbation theory of association to predict surface coverage when wall association sites can bond with two particles, as a function of wall site density and temperature. This calculation is relevant to how molecular fluids bond with surfaces with functional divalent groups or how patchy colloids behave at surfaces with large attractive patches.

Several papers in the special issue consider how liquid crystalline fluids interact with surfaces. Liquid crystals introduce anisotropy, and the possibility of diverse surface topologies and anchoring leads to competition that can result in the stabilization of topological defects (Rojas-Gomez *et al*). This is illustrated by Silvestre *et al*, who show that a disclination line in a nematic film in a sinusoidal channel breaks into a zig-zag pattern as the twist elastic energy is reduced.

Peng *et al* construct a periodic splay-bend director pattern by photopatterning a surface with regions of alternate homeotropic and planar alignment. Colloids shaped like boomerangs migrate towards regions of maximum bend; by contrast spherical particles move towards regions of maximum splay, giving the possibility of particle sorting.

Colloidal silica rods act as micron-sized liquid crystal 'molecules' that can be imaged directly using scanning-confocal microscopy. Cortes *et al* report experiments showing that

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the rods form isotropic, nematic and smectic phases as a function of height in a cuboid confining chamber, because of their density mismatch with the surrounding solvent. See, in particular, figure 4 of their paper which is a beautiful illustration of how a smectic phase behaves in confinement.

This special issue contains diverse contributions addressing the dynamics of fluids near surfaces, from papers considering active colloids moving at walls with surface-chemistry gradients (Popescu *et al*) to the possibility of a discontinuous and possibly hysteretic friction curve for a shear thinning fluid (Warren). Wilcek *et al* use thin film modelling and simulations to study dip coating on a substrate with patterns of different wettabilities and orientations, relating their results to Langmuir–Blodgett experiments.

Recent studies have demonstrated that macrotextures on a superhydrophobic surface can reduce contact times by breaking up an impacting drop. Patterson *et al* show that a similar behaviour is seen for a Leidenfrost droplet at a macrotextured (spoked) wettable surface, and investigate the relationship between contact time and surface geometry.

Many of the papers in this special issue rely on state-of-the-art micro- and nano-fabrication techniques which allow detailed surface design, and on improved imaging in both space and time. These have driven the resurgence of this classical field of fluid-surface interactions and led to surprises in physical phenomena that appeared well characterised many years ago. The challenge is now to create surfaces that are robust, reproducible and cheap enough for wide application to drag reduction, water harvesting or repellency, de-icing and novel sensors and displays.

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