Forces on capillary floaters

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A body can be supported at the water-air interface by virtue of the equilibrium among its weight, surface tension and hydrostatic forces. Quantifying the forces these bodies experience is of critical importance for understanding the motion of living organisms at the water-air interface [1] and can inform the design of aerial-aquatic microrobots for environmental exploration and monitoring [2]. Here we measure and rationalize two forces experienced by *centimetric bodies* at the water-air interface : capillary attraction force and sliding friction.

It is well known that two particles trapped at a fluid interface may interact due to the deformation they induce on the free surface [3]. This capillary force has been previously measured for bodies at the sub-millimetric scale [4]. We present direct measurements of the force between centimetric disks resting at air-water interface. Using a novel experimental setup, we characterize how the attraction force depends on the disk mass, diameter, and relative spacing, and compare our measurements with theoretical predictions.

Second, we experimentally show that the motion of centimetric 'sliders' is dominated by skin friction due to the boundary layer that forms in the fluid beneath the body, which results in a friction force $F_D \propto v^{3/2}$ [5]. We develop a simple model that considers the boundary layer as quasi-steady, and is able to capture the experimental behaviour for a range of body sizes, masses, shapes and fluid viscosities. We define a dimensionless *sliding number* as the ratio between the fluid inertia and the body inertia, which allows us to assess the regime of validity of our model. Furthermore, we demonstrate that friction can be reduced by modification of the body's shape or bottom topography.

Références

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