The Physics of Soft and Biological Matter

Capillary force on a micrometric sphere trapped at a fluid interface exhibiting arbitrary curvature gradients

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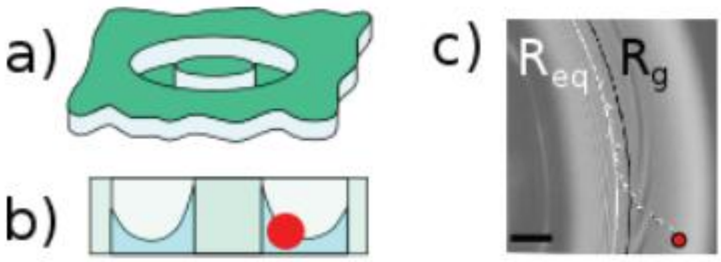
Strong normal restoring forces due to the surface tension are sufficient to confine solid objects at fluid interfaces. In many studies, the interface is planar and spatially uniform, merely providing a 2D confinement on particles. When curved, interfaces might play a more active role, imposing a lateral force on the particles. A spectacular demonstration of this force is the meniscus-climbing technique of the beetle larva [1]. In the presence of a curved interface, the mechanical equilibrium conditions at the triple line larva/water/air impose an extra surface deflection and thus a lateral force on the larva. This force is also sufficient to drive micron-long cylinders self-assembly on a water/air curved interface [2]. Despite these interesting studies a full comparison between experiment and theory is still lacking.

In this Letter [3], we combine theory and experiment to address the capillary force acting on a spherical colloid placed on a curved fluid interface. We develop a new theoretical model able to predict this force in the general case of interfaces with arbitrary curvature. Using a built-in interferometric method coupled with particle tracking, we measured the femto-Newton forces which control the equilibrium position of microspheres. We found a good agreement with our theoretical predictions. Our findings open the way to the control of the force and the assembly of micrometric size particles by the design of the interface morphology.



a) top view and b) side view of the experimental cuvette. Also drawn in b) the designed mineral oil/air interface having a gradient of gaussian curvature with a trapped bead (in red). c) Superposed images of bead trajectory in bright field and of interface morphology by Mirau interferometry. A bead partially embedded in oil overpasses its gravity potential minimum R_g (black arc), climbs the slope and finally reaches an equilibrium radius R_{eq} (white arc) with $R_{eq} < R_g$. Bar indicate 5 μm.

[1] D. L. Hu and J. W. M. Bush, *Nature* (London) 437, 733 (2005)

[2] M. Cavallaro, L. Botto, E. P. Lewandowski, M. Wang, and K. J. Stebe, *Proc. Natl. Acad. Sci.* U.S.A. 108,20 923, (2011)

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