Thin sheets achieve optimal wrapping of liquids

JOSEPH PAULSEN, VINCENT DÉMERY, BENNY DAVIDOVITCH, CHRISTIAN SANTANGELO, THOMAS RUSSELL, NARAYANAN MENON, Univ of Mass - Amherst — A liquid drop can wrap itself in a sheet using capillary forces [Py et al., PRL 98, 2007]. However, the efficiency of “capillary origami” at covering the surface of a drop is hampered by the mechanical cost of bending the sheet. Thinner sheets deform more readily by forming small-scale wrinkles and stress-focussing patterns, but it is unclear how coverage efficiency competes with mechanical cost as thickness is decreased, and what wrapping shapes will emerge. We place a thin (~100 nm) polymer film on a drop whose volume is gradually decreased so that the sheet covers an increasing fraction of its surface. The sheet exhibits a complex sequence of axisymmetric and polygonal partially- and fully- wrapped shapes. Remarkably, the progression appears independent of mechanical properties. The gross shape, which neglects small-scale features, is correctly predicted by a simple geometric approach wherein the exposed area is minimized. Thus, simply using a thin enough sheet results in maximal coverage.

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