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Sheets shaping liquids and liquids shaping sheets

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An ultrathin elastic sheet floating on a liquid surface sits between two extremes: surface tension can easily bend the film, but cannot cause macroscopic in-plane stretching. We demonstrate several striking consequences of this separation of energy scales in two settings. First, we study the wrapping of a water droplet by a polystyrene film that is $\sim$100 nm thick and 3 mm in diameter. The sheet becomes patterned with small-scale wrinkles, crumples, and folds, and the resulting three-dimensional shape is highly non-axisymmetric. Remarkably, we can understand this overall shape with a simple geometric principle: a thin sheet spontaneously maximizes the volume of the enclosed liquid, given a fixed area of the initially flat sheet. Thus, in the limit of zero bending resistance, a sheet can still sculpt the shape of a liquid droplet. Second, we show how the same geometric principle leads to a thickness-independent folding transition for an annular sheet on a flat bath. In both settings, we uncover an asymptotic regime of ultrathin films, where the gross effects are independent of the thickness, modulus, or even the wettability of the film. Such films provide a robust platform for adding further functionality.