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Indenting a Thin Floating Film: Force and First-fold Formation[1]

MONICA RIPP, JOSEPH PAULSEN, Syracuse Univ — When a thin elastic sheet is gently pushed into a liquid bath, a pattern of radial wrinkles is generated where the film is locally compressed. Despite the simplicity of this setting, basic questions remain about the mechanics and morphology of indented thin films. Recent work shows that traditional post-buckling analysis must be supplanted with an analysis where wrinkles completely relax compressive stresses. Support for this far-from-threshold theory has been built on measurements of wrinkle extent and wavelength, but direct force measurements have been absent. Here we measure the force response of floating ultrathin (∼100 nm) polystyrene films in indentation experiments. Our measurements are in good agreement with recent predictions for two regimes of poking: Early on force depends on film properties (thickness and Young‘s modulus) and later is independent of film properties, simply transferring forces from the substrate (gravity and surface tension) to the poker [1]. At larger indentations compression localizes into a single fold [2]. We present scaling arguments and experiments that show the existing model of this transition must be modified. [1] Vella et al., Phys. Rev. Lett. 114, 014301 (2015). [2] Holmes and Crosby, Phys. Rev. Lett. 105, 038303 (2010).

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