
Evaluating the efficacy of using drop-film interaction to estimate the film's tension and surface energy.

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Abstract

We investigate the equilibrium solutions of axisymmetric systems consisting of sessile drops on free-standing, pre-stretched, elastic membranes. The capillary forces acting on the membrane deform it appreciably, and so we incorporate both geometric and material nonlinearities in the model. The surface energies at the membrane-liquid and membrane-air interfaces are not assumed to be constants, and they vary with stretches within the membrane. We minimize the free energy of the system to obtain the governing equations. Assuming that the surface energies are strain-independent, we solve these coupled nonlinear equations and obtain the global equilibria of the drop-membrane system. We then study the effects of drop's volume and membrane's pre-tension on the system's geometry and tension/stretch distribution in the membrane, thereby providing an insight into the role of geometric and material nonlinearities of the membrane. For a given liquid drop, its volume, and membrane's solid material, we calculate the pre-tension and surface energies of the membrane and compare our results with experiments. This allows us to compare and contrast our more exact model with that of Davidovitch and Vella (1). They found that the drop considerably alters the stress state within the sheet, and thus, the current state of stress cannot be employed to measure the pre-tension within the sheet prior to wetting, disputing the understanding obtained from previous experiments (2,3). However, the analysis of (1) made several approximations, and we revisit this issue utilising our more exact description. (1) Davidovitch, B., & Vella, D. (2018). Partial wetting of thin solid sheets under tension. *Soft Matter*, 14(24), 4913-4934.

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