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Elasto-capillary adhesion: How does deformation affect adhesion strength and detachment?

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A wetting droplet confined between two solids exerts a force that pulls the two solids together by the action of surface tension. If one or both solids can deform elastically, a positive feedback between surface tension and deformation has the potential to enhance the adhesion significantly. We explore the effect of deformation on capillary adhesion using a combination of theory and experiment; we consider a model system consisting of a clamped, tense membrane adhered to a rigid substrate by the surface tension of a liquid droplet. By understanding its equilibrium states, we find significant enhancement in the adhesive force compared to an equivalent capillary adhesion between rigid plates. The choice of membrane tension, which sets the level of membrane deformability, gives additional control over the system and allows for new adhesion and detachment strategies to be explored. Experiments, however, suggest that strong adhesion may not always be achieved; we investigate the role of dynamic effects in controlling the adhesion achieved and discuss the dynamics of detachment.

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