Surface wrinkling of a thin liquid-infused membrane

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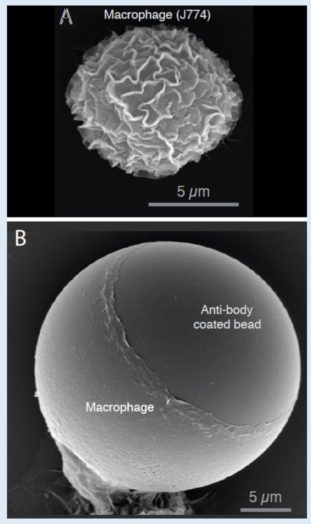
Context

- Deformation of a synthetic membrane under elastocapillarity
- Analogy : deformation of biological tissues
- Applications : stretchable electronics, smart textiles, soft biomedical devices, etc.

Key words

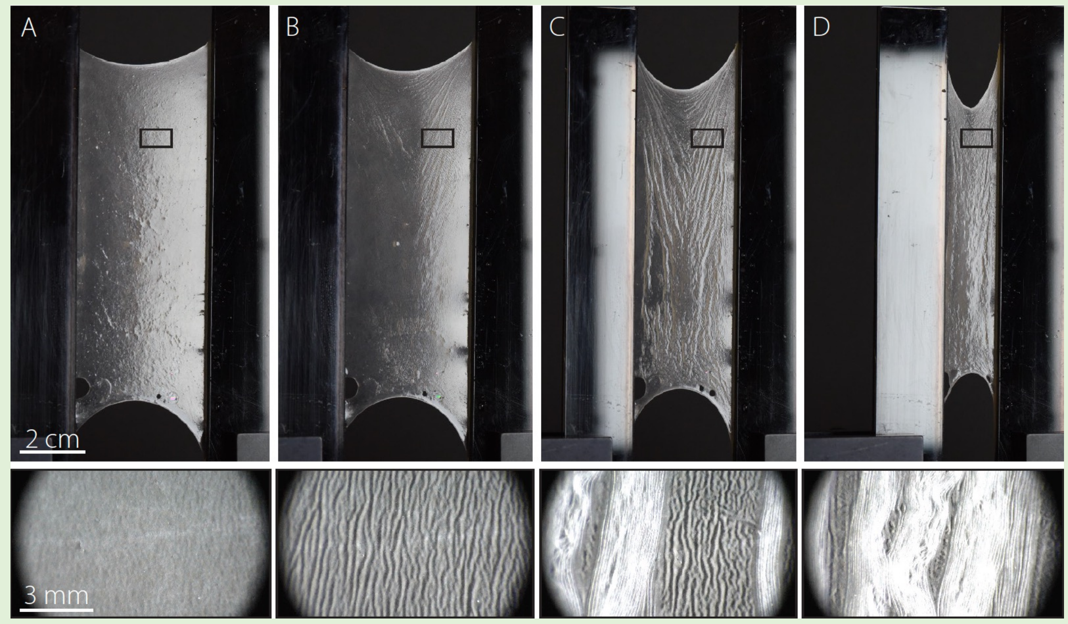
- Elastocapillarity
- Thin structures
- Wrinkling
- Surface reservoir
- Phase transformation



Lam et al. Biophys. J (2009)

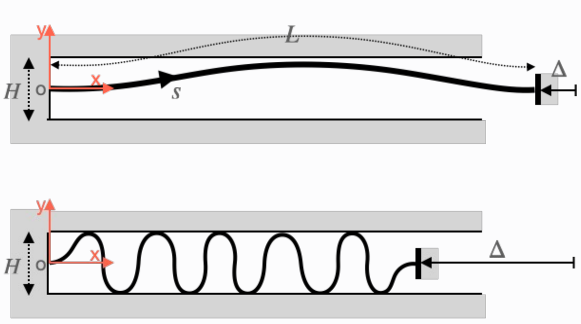
Deformation of a macrophage

Experiment Pictures

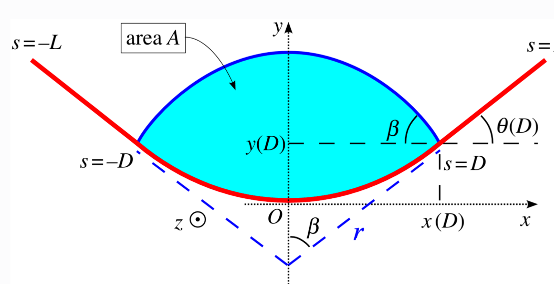


P.Grandgeorge, PhD thesis, (2018)

Modelling inspiration



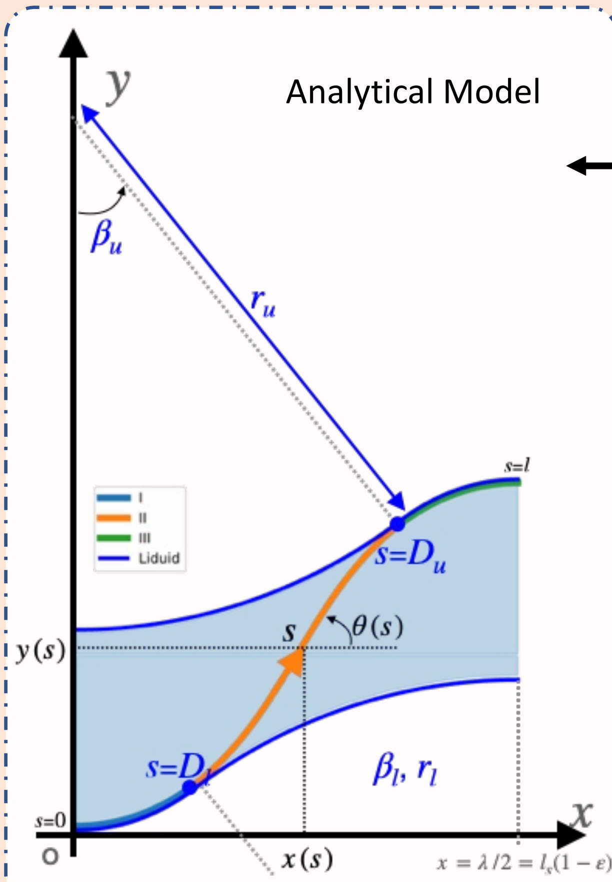
Buckling of an elastic beam between rigid walls



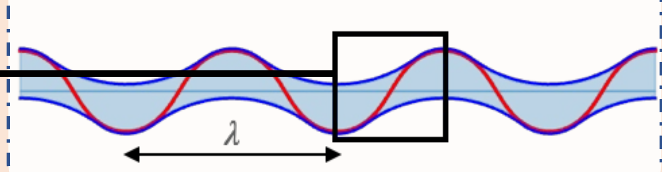
S.Neukirch et al., Proceedings of the Royal Society A, (2013)

Bending of an elastic beam by a liquid drop

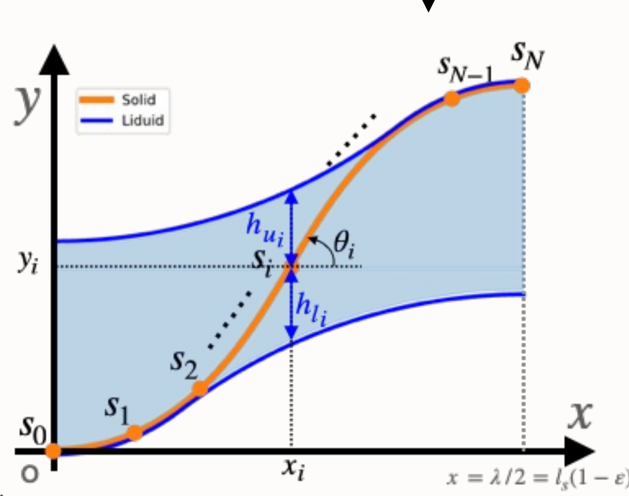
Analytical Model



For establish the model, we suppose the section view looks like:



Numerical discretization



Geometry :

$$\theta'(s) = \kappa(s)$$
$$x'(s) = \cos\theta(s)$$
$$y'(s) = \sin\theta(s)$$

Boundary conditions :

$$\theta(0) = \theta(l) = 0$$
$$x(0) = y(0) = 0$$
$$x(l) = l(1-\varepsilon) = \lambda/2$$

Volume conservation :

$$\mathcal{V}_{liquid} = 2\,lH_i$$

(H_i : initial liquid thickness at one sides)

Energy :

$$\mathcal{E}_\gamma = \gamma\,\ell_{lv}$$
$$\mathcal{E}_{elas} = \int_{s=0}^{l} \frac{B}{2}\kappa^2(s)\,ds$$
$$\mathcal{E}_{elem} = \mathcal{E}_{elas} + \mathcal{E}_\gamma$$

Objective :

$$\min\ \mathcal{E}_{tot} = \frac{L_{tot}}{l}\mathcal{E}_{elem}$$

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