Wetting of patterned elastic substrates

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1. Abstract

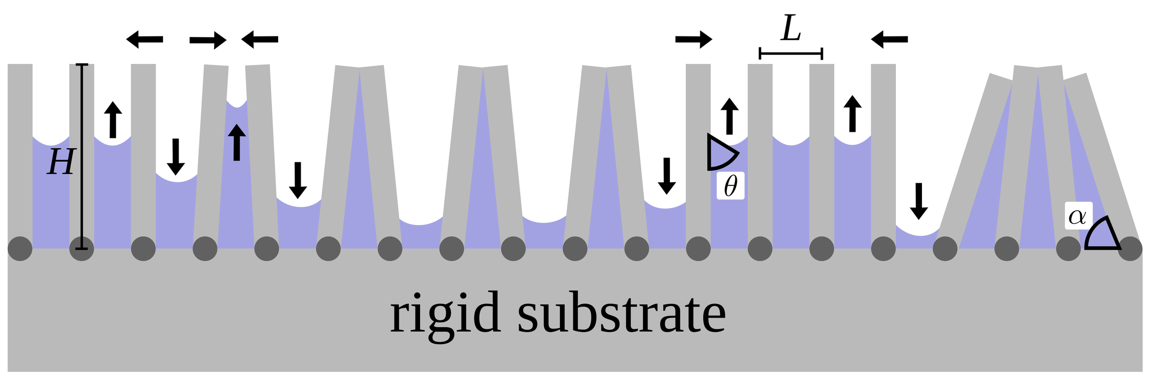
- We study the wetting properties of patterned elastic substrates.
- As liquid adsorbs on the substrate the substrate geometry changes due to surface tension and Laplace pressure.
- This change in geometry leads to a change in the wetting properties of the substrate and to sudden jumps in the adsorption of liquid.
- This wetting⇆geometry feedback leads to hierarchical self-assembly of the substrate patterns.

2. Introduction

- The control of surface wetting properties is important for technologies such as “lab-on-a-chip” and microfluidic devices.
- Geometrical patterning of a substrate has profound influences on the wetting properties, e.g. in superhydrophobic surfaces.
- The wetting properties of elastic substrates are not well studied, despite the potential importance of elasticity for wetting phenomena [1,2].

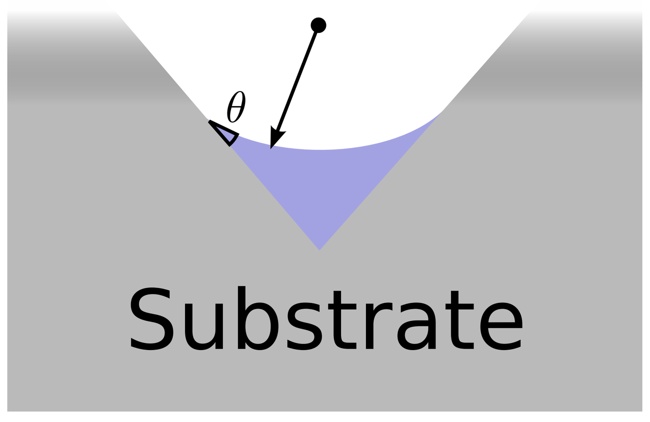
3. Model & Methods

- Idealized substrate of rigid plates that tilt elastically around baseline:



- The adsorption is calculated using a macroscopic model [3], where the radius of curvature of the interface is given by the Laplace equation:

$$R = \frac{\sigma}{\Delta\rho\Delta\mu}$$

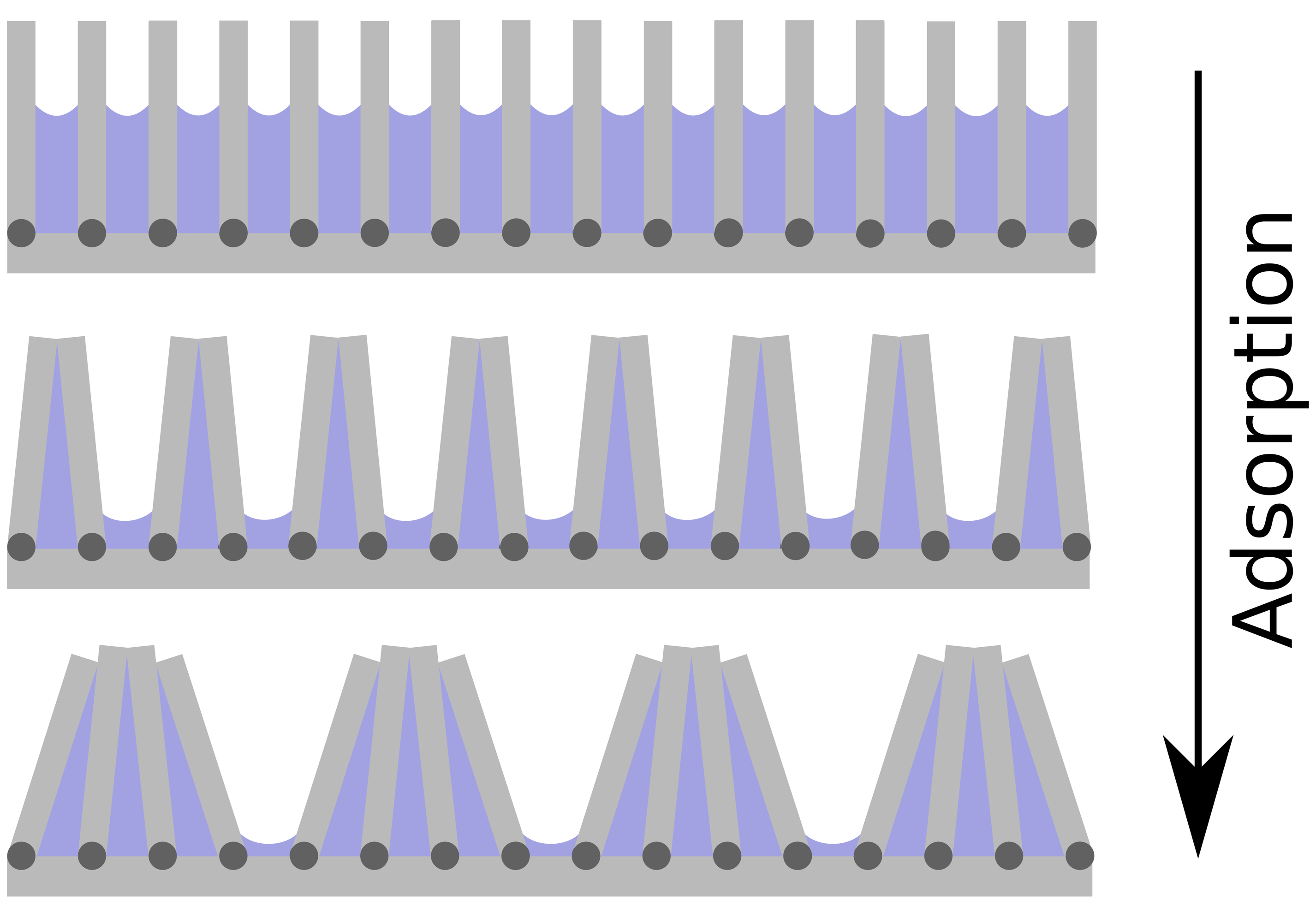


Here σ is the surface tension of the liquid-gas interface, $\Delta\rho$ is the difference in number density between liquid and gas, $\Delta\mu$ is the deviation of the chemical potential from co-existence and θ is the contact angle.

- The change in geometry is calculated by analysing the linear stability of the geometrical configurations.

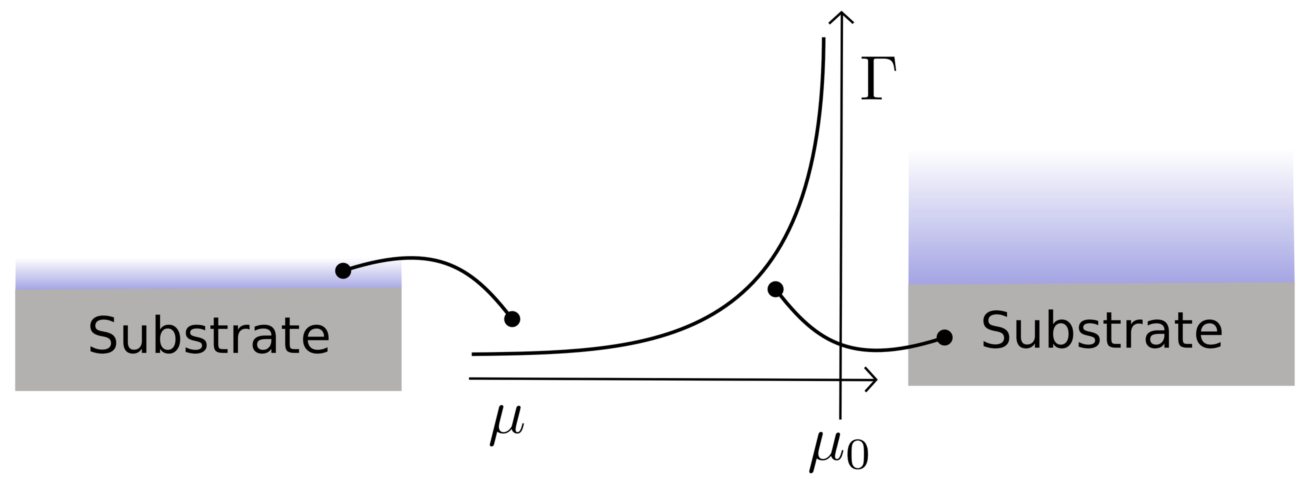
4. Self-Assembly

- The collapse of the substrate under the surface tension and Laplace pressure leads to hierarchical self-assembly of the substrate:

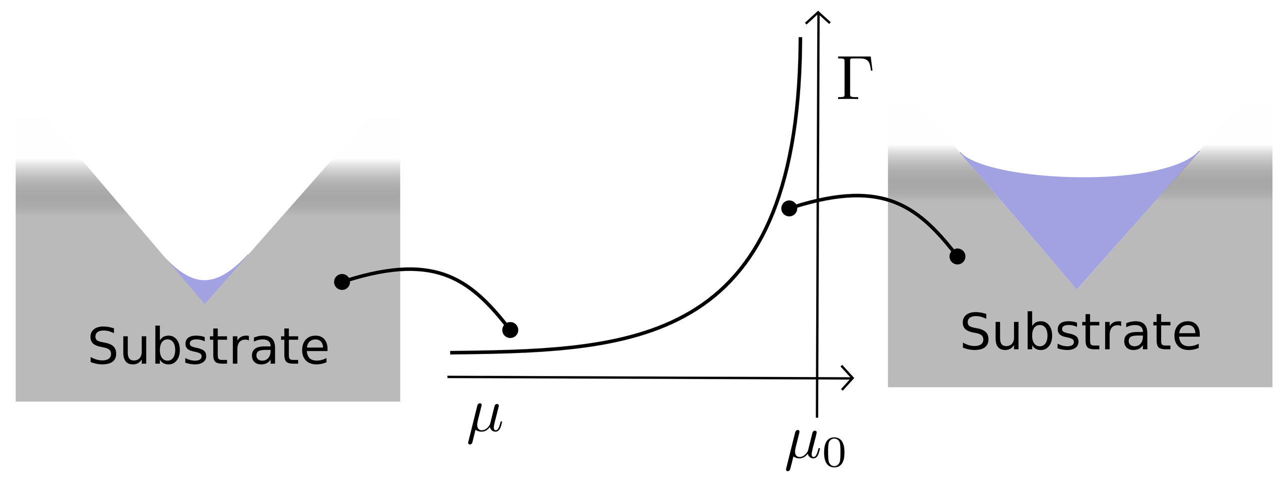


5. Results

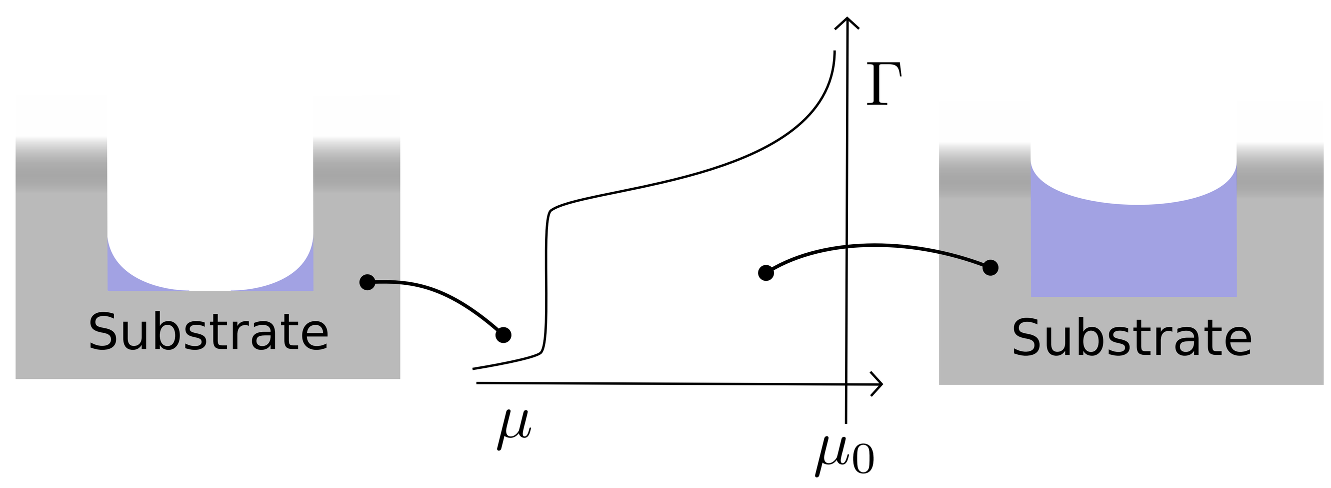
- Adsorption on a planar substrate:



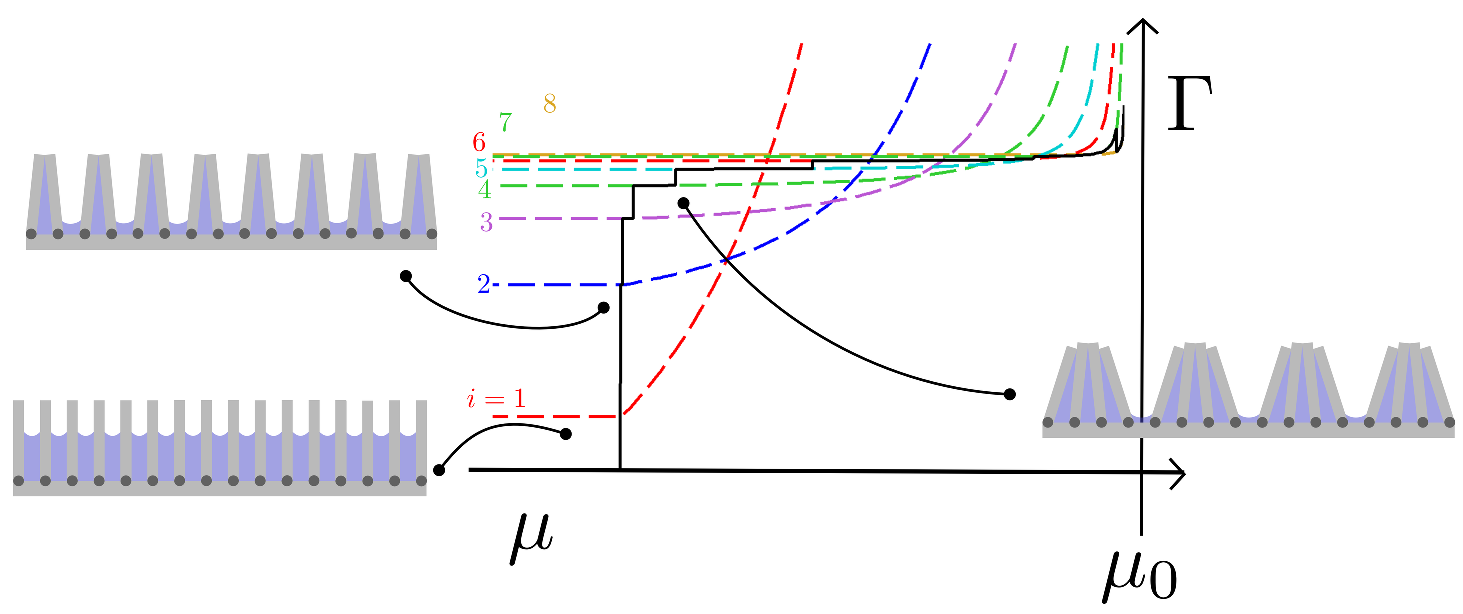
- Adsorption on a wedge:



- Adsorption on a capillary:



- Adsorption on an elastic substrate:



- Adsorption isotherm consists of a series of sudden jumps, when the structures cluster.
- Adsorption isotherm even shows a “desorption” jump, however the model might not be reliable at this point and this might be an artefact.

6. Conclusions

- Substrate elasticity has a profound effect on wetting properties.
- Adsorption isotherm reflect the self-assembly of elastic structures in a series of sudden adsorption jumps.
- Electric fields can be used to control wetting properties “on-the-fly”.

7. References & Acknowledgements

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