INTRODUCTION

- In confined foams there exist wall Plateau borders (PBs), or menisci, where the films meet the confining substrates.
- What is the shape of a PB of a given size on a surface of a given wettability (i.e., contact angle $\theta_o$)? Can that surface support a foam?
- This is important for firefighting foams, containers for foamy foodstuffs, etc.
- We solve the Young-Laplace equation with gravity for a planar film spanning a gap between two horizontal, flat substrates, to predict the shape of the PBs.
- Validate results by comparing with Surface Evolver and experimental data.

THEORY

- Young-Laplace equation for PBs where flat film meets planar substrate:
  $$\left[1 + \left(\frac{d\theta}{dz}\right)^2\right]^{3/2} \frac{dz}{d\theta} = -\frac{\Delta p}{\gamma}$$
  where $\Delta p$ is the pressure difference across the surface and $\gamma$ is the surface tension.
- Rewrite equation in terms of film inclination $\theta(z)$: boundary conditions are $\theta(0) = \theta_c$, $\theta(h) = \pi/2$.
- Assume hydrostatic PBs, normalise lengths by $h$ and introduce Bond number $Bo = \rho gh^2/\gamma$.
- Analytically exact solutions for bottom (+) and top (−) PBs:
  $$x'(z') = \int z' \left(1 - z'' \cos \theta_c \pm \frac{Bo}{4} z''^2 \right) dz''$$
- In zero gravity ($Bo = 0$, top=bottom):
  $$x'(z') = \frac{1}{\cos \theta_c} \left\{1 - \left[1 - (1 - z')^2 \cos^2 \theta_c \right]^{1/2}\right\}$$

EXPERIMENT

- Contact angle meter (GBX Scientific Instruments, France).
- Commercially available soap solution (Pustefix, Germany), surface tension $\gamma = 28.2 \pm 0.3$ mJ m$^{-2}$.
- Five different solid surfaces:
<table>
<thead>
<tr>
<th>Material</th>
<th>$\theta_c (^\circ)$</th>
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<tbody>
<tr>
<td>SiO$_2$</td>
<td>18.2 ± 2.8</td>
</tr>
<tr>
<td>Teflonised polished Si</td>
<td>51.7 ± 0.3</td>
</tr>
<tr>
<td>PDMS elastomer</td>
<td>61.0 ± 2.1</td>
</tr>
<tr>
<td>Teflonised rough Si</td>
<td>64.0 ± 0.4</td>
</tr>
<tr>
<td>Teflonised black Si</td>
<td>109.3 ± 0.3</td>
</tr>
</tbody>
</table>
- In-house microfluidic tool consisting of (i) microfluidic reservoir with a number of capillary slots, made of ABS plastic; (ii) thin, flexible, hydrophilic loop which supports liquid film, made of polymide-coated capillary tubing (Molex, USA). Gives bottom PB shape only, not top.

RESULTS

- Analytically-calculated PBs at the bottom substrate for various combinations of $Bo$ and $\theta_c$.
- Comparison of bottom PB shapes from analytical theory (solid line) and Surface Evolver (dotted line).
- Regions of allowed (white, below dashed line only in right panel) and forbidden (elsewhere) PBs in ($\theta_c$, $Bo$) space, at the bottom (left) and top (right) substrates. The curves are lines of constant $x'(z' = 0)$.
- PBs at four of the five surfaces used in the experiments.
- Scaled PB half-width $x(z = 0)/h$ vs Bond number, from theory (curves) and experiment (symbols).

CONCLUSIONS

The combination of a particular surface ($\theta_c$) in contact with a particular foam ($\rho$ and $\gamma$) leads to allowed and forbidden wall PBs. Therefore both surface and liquid (foam) properties need to be taken into account in applications where wetting of surfaces by foams is important.