Memory in a Contact Line

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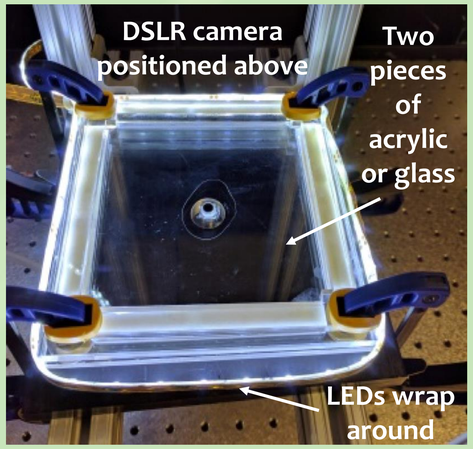
Experiment Overview

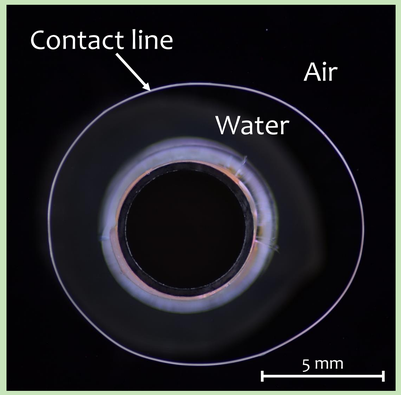
- Can the shape of a water drop hold memory?
- Syringe pump infuses and withdraws same volume of water repeatedly, changing contact line shape
- Pictures taken once per cycle and analyzed

Apparatus



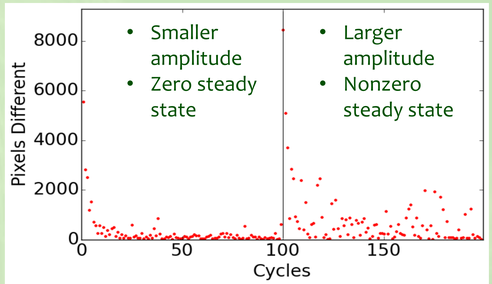
Contact Line

- Interface between water and air in the channel is the contact line.



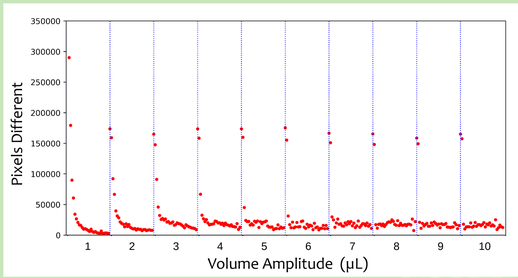
Steady State

- After many cycles, contact line reaches steady state where changes in shape are minimal.

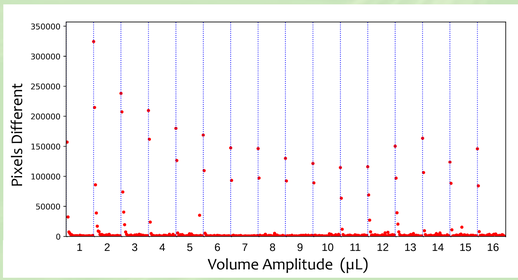


Results

- On **acrylic** channel, contact line reaches **nonzero** steady state at high volume cycles.

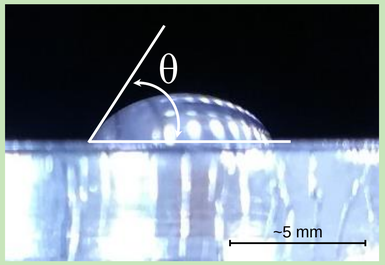


- On **glass** channel, contact line only reaches **zero** steady state, even at higher volumes. This surprise prompted the search for other behaviors exhibited by glass.

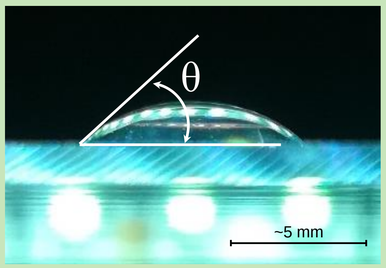


Hydrophobicity and Contact Angle

- Acrylic is relatively hydrophobic, while glass is hydrophilic.
- This difference is roughly measured by the contact angle θ and might explain the materials' different contact line dynamics.



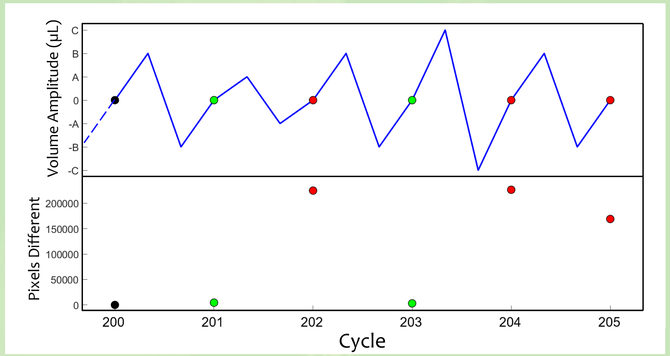
Acrylic
Hydrophobic
θ≈61°



Glass
Hydrophilic
θ≈51°

Diagnosing Return Point Memory

- Return Point Memory (RPM): Returning to a previous input restores the state of the system, unless a larger input is applied.[3]
- Testing on glass because contact line returns to same state



Pixel differences measured by comparing to trained steady state (black).
Green: Low difference from steady state
Red: High difference from steady state

1. "Train" contact line by repeating same volume amplitude for 200 cycles; system eventually reaches steady state
2. Introduce smaller amplitude
3. Repeat initial amplitude → expect steady state intact
4. Introduce larger amplitude
5. Repeat initial amplitude → expect steady state lost

Conclusions

- Behavior of contact line depends on channel material
- Contact line can store trained volume as info that can be retrieved later
- Contact line on glass may exhibit RPM, but need more rigorous tests

In the future:

- Test for RPM on variety of materials
- Test for memory of multiple volumes simultaneously

References:

1. Corté et al., *Random Organization in Periodically Driven Systems.* Natural Physics, 2008
2. Snoeijer, J. H., & Andreotti, B. (2013). Moving Contact Lines: Scales, Regimes, and Dynamical Transitions. Annual Review of Fluid Mechanics, 45, 269–292.
3. Keim, N. C., Paulsen, J. D., Zeravcic, Z., Sastry, S., & Nagel, S. R. (2019). Memory formation in matter. Rev. Mod. Phys., 91, 035002.

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