♪ My drop will (not) go on ♫

Trapping in electrically tunable potential wells

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PCF PHYSICS OF COMPLEX FLUIDS

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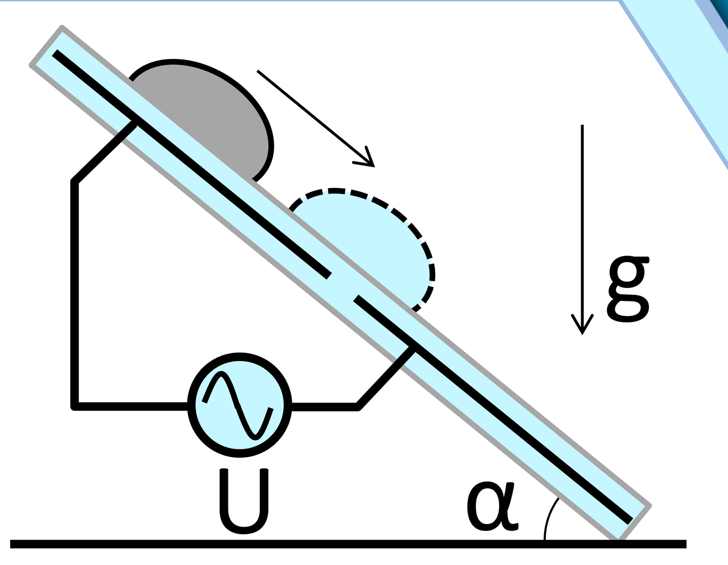
Introduction

Two electrodes separated by a small gap a provide an electrically tunable pinning center for droplets of diameter l moving over a surface. ▶

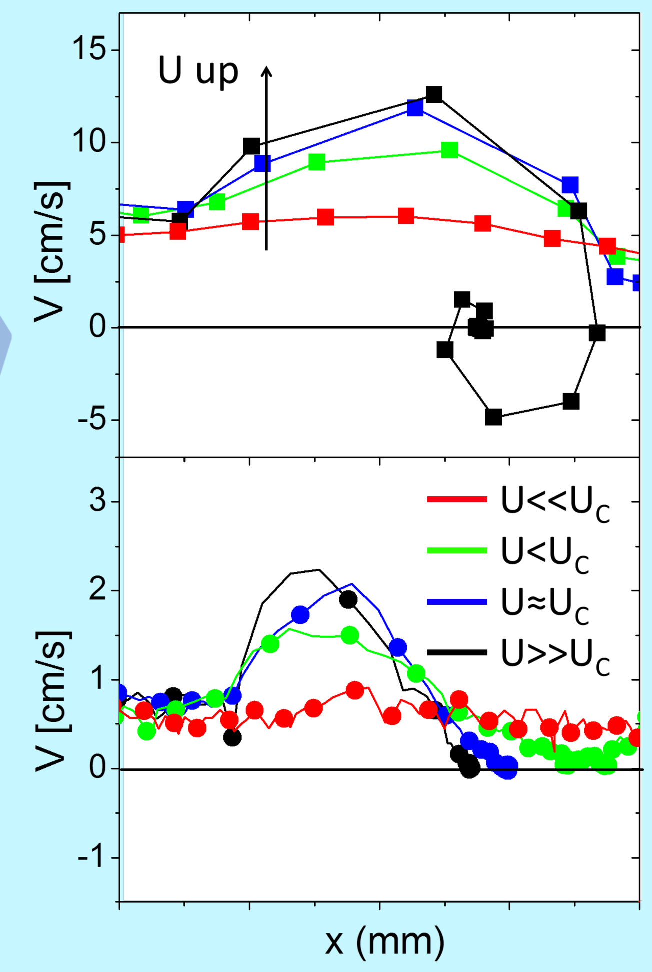


Inclined plane sideview
Surface: tape+silicone oil
$\theta_a=95^\circ$, $\theta_r=92^\circ$
$\alpha=3\text{-}15^\circ$

At low voltages the droplets can pass the trap. Above a certain critical voltage U_C the droplets get trapped. In this work, we investigate the critical conditions for trapping and release of sliding drops on inclined planes. We also show trapping and release in microchannels.

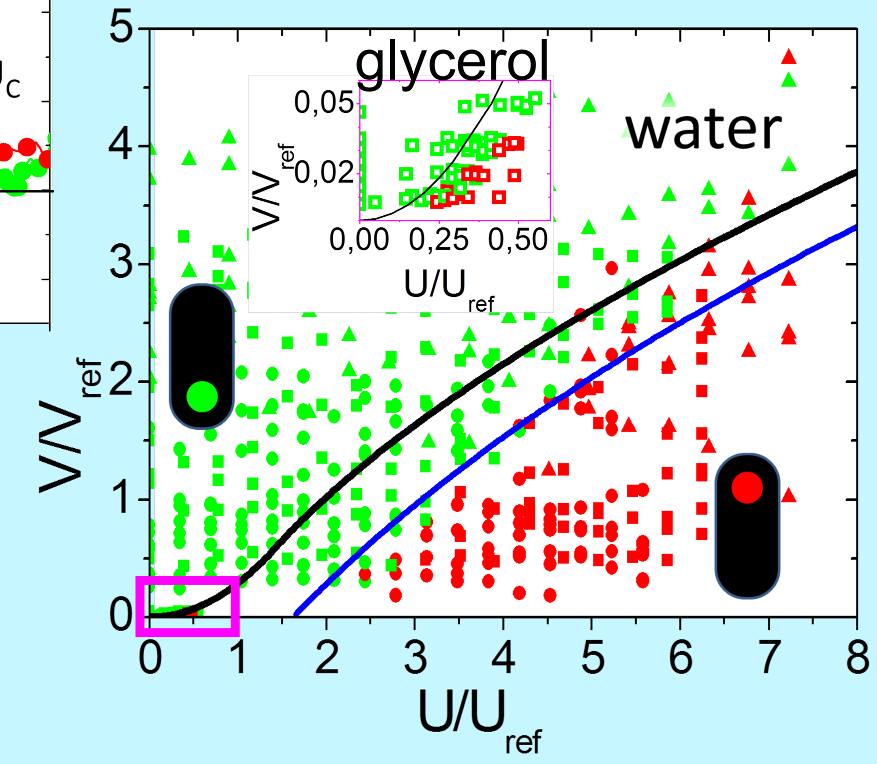
- Drop control for lab-on-chip
  Low power, High flexibility
- Model system for wetting

Results

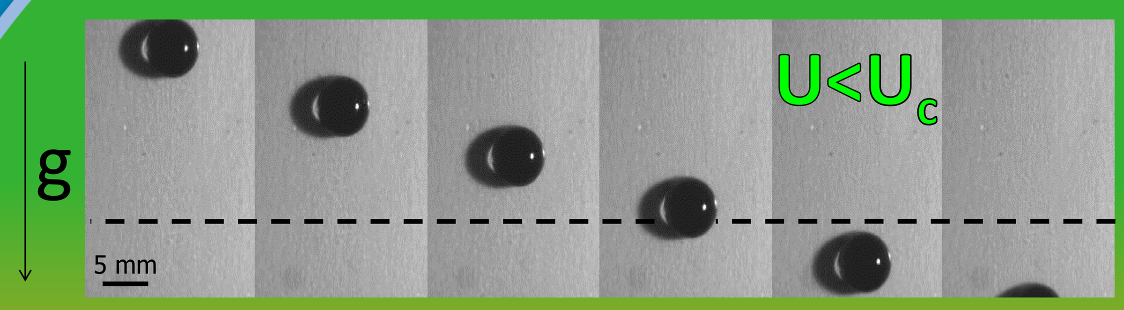


◀ Droplets of water (top) and glycerol (bottom) moving over the trap

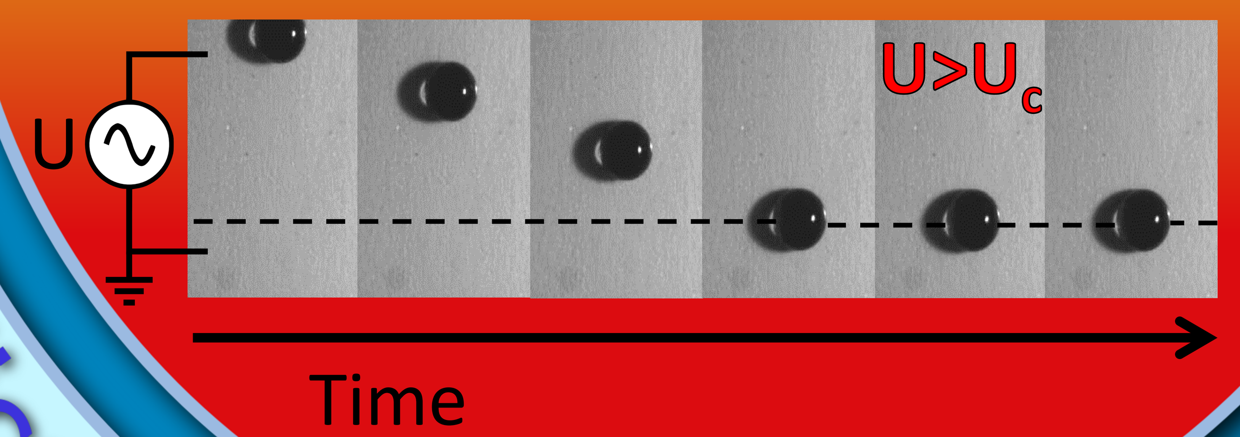
⟶ Overshoot means inertia is important for water but not for glycerol



▲ Rescaled trapping diagram. The lines give the predicted transition depending on how the pinning is reduced by electrowetting. Inset: zoom on glycerol:water droplets

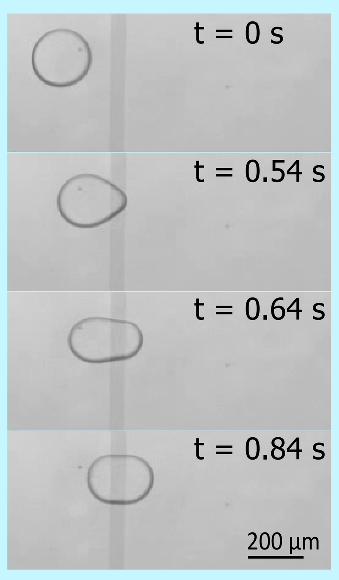


You shall not pass



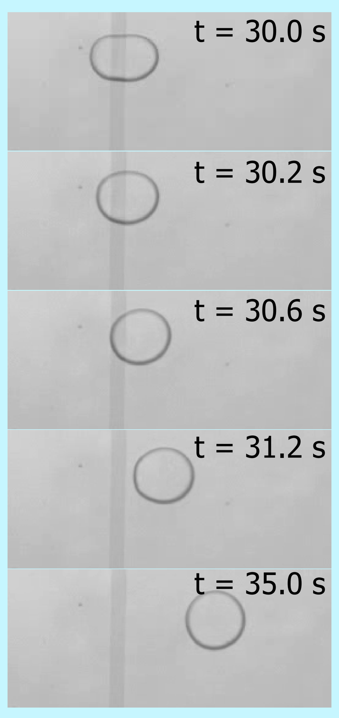
Microfluidics

Trap

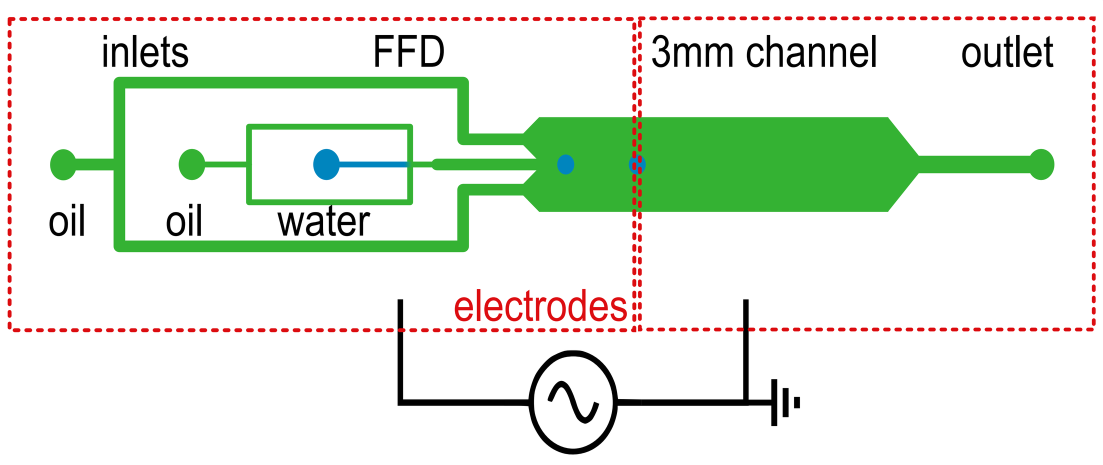


◀ Shows a water drop in oil flow. The pinning force exceeds the viscous drag.

Release



Schematic view of the PDMS microchannel. The substrate consists of Teflon coated ITO electrodes ▼



◀ The drop can be held in the trap for analysis, and released to go to the next position. Different electrode configurations can be used to guide the drop as well.

Modelling

Droplet trapping can be modelled as a damped harmonic oscillator

$$\overbrace{m\ddot{x}}^{\text{acceleration}}+\underbrace{\lambda\dot{x}}_{\text{damping}}+\underbrace{k(U)x}_{\text{trapping force}}=\overbrace{mg\sin(\alpha)}^{\text{gravity}}-\overbrace{F_p(U)}^{\text{pinning force}}$$

Solving gives two rescaling factors:

V_{ref} = velocity so τ_{relax} is $\frac{l}{V_{ref}} = \frac{\lambda(l-a)}{4m}$

U_{ref} = Voltage so $lk\,(F_{trap})$ is $\lambda V_{ref} = \frac{\lambda}{2}\sqrt{\frac{d(l-a)}{\varepsilon\varepsilon_r ml}}$

Conclusion

- Drop trapping can be achieved and is reproducible as function of viscosity and size. This offers a novel method to sort drops.
- Trapping is modelled to predict the trapping threshold.
- Trapping and release is possible on both inclined planes and in microchannels

Outlook

- Droplets can also be steered by a different trap geometry, which could lead to an electric drop sorter.
- Airjets are used to push droplets over traps in immersion lithography. This behaviour can be studied using these traps.