BOHDAN GLISEVIC

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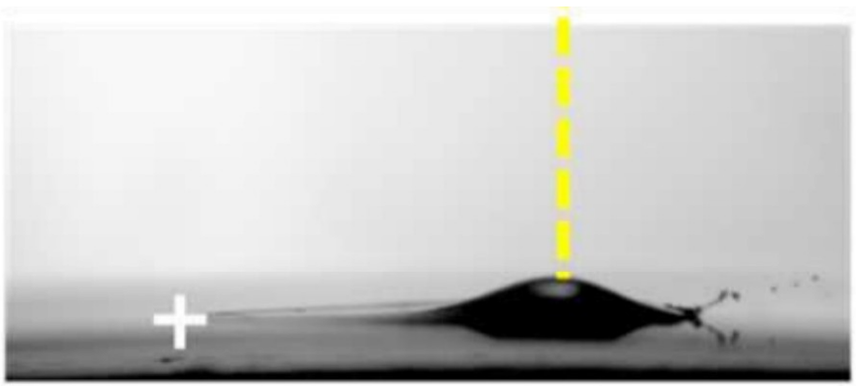
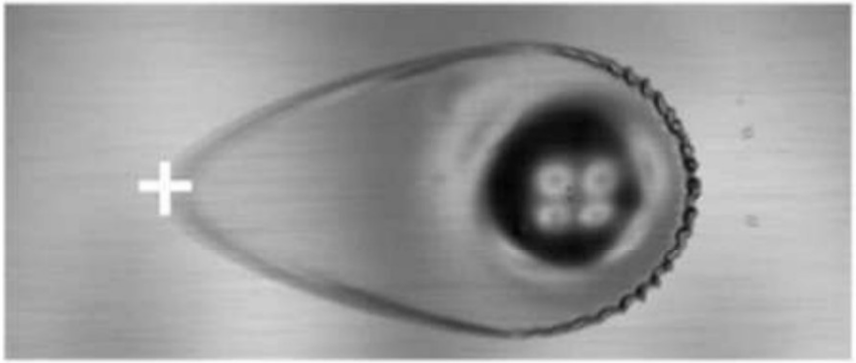
4

DYNAMIC HYDROPHOBICITY

When a drop of liquid impacts on a horizontally **moving surface**, the droplet **may be reflected or not**, depending on the **speed** of the surface. Investigate the interaction between a moving surface and a liquid drop.

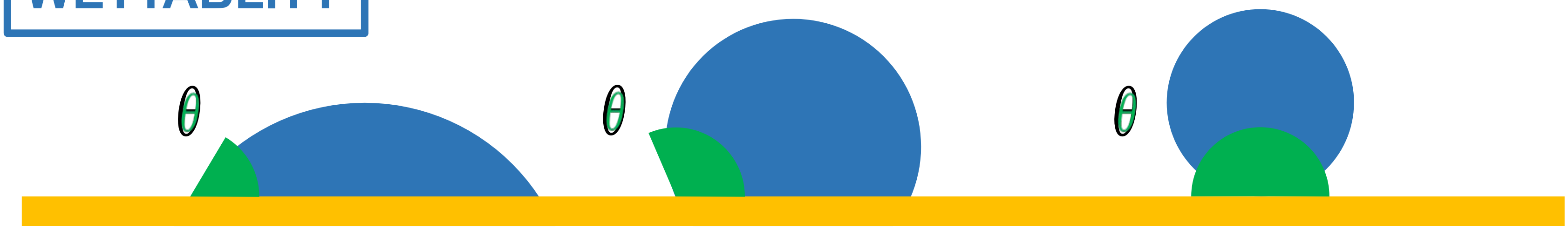




BASIC UNDERSTANDI NG

BASIC UNDERSTANDING

WETTABLITY



hydrophilic ***hydrophobic*** ***superhydrophobic***

Should we expect similar behaviour?

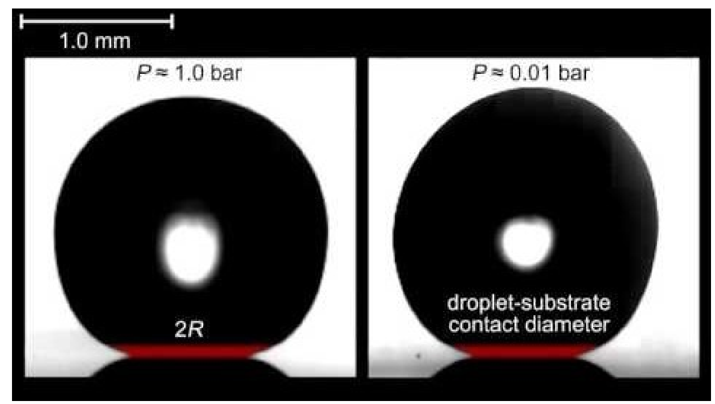
Maybe, but it will be rare…

Dependence on:

surface material

surface tension of the liquid

gas surrounding liquid and surface



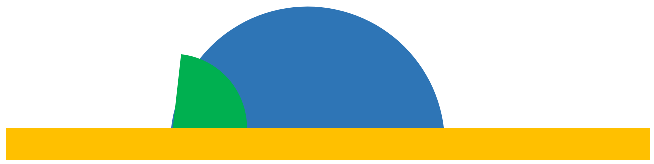
$\theta > 150°$

θ – *contact angle*

BASIC EXPLANATION

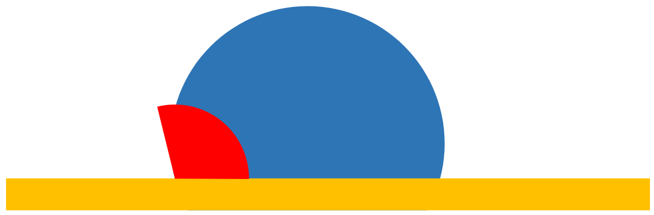
SPEED OF THE SURFACE

θ *is close to* $90°$



stationary surface

θ *exceeds* $90°$



moving surface

Change of the contact angle will be velocity dependent

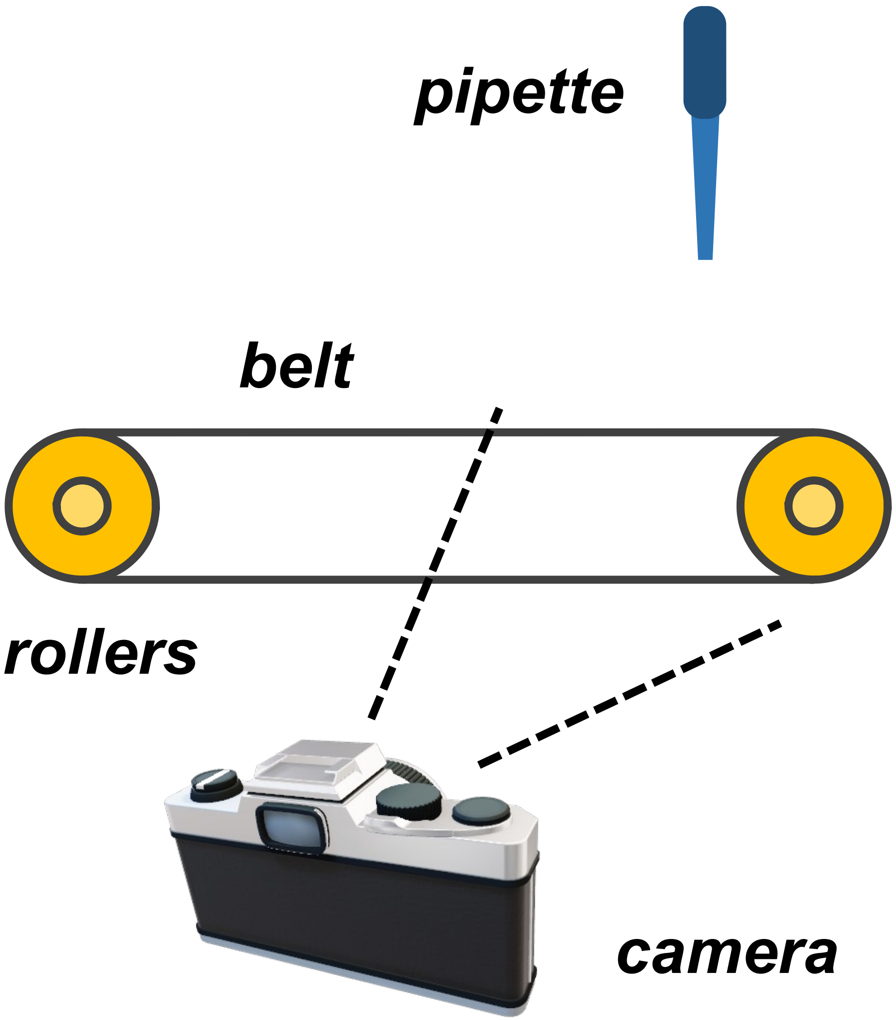
Might be reflected or splashed

APPARATUS

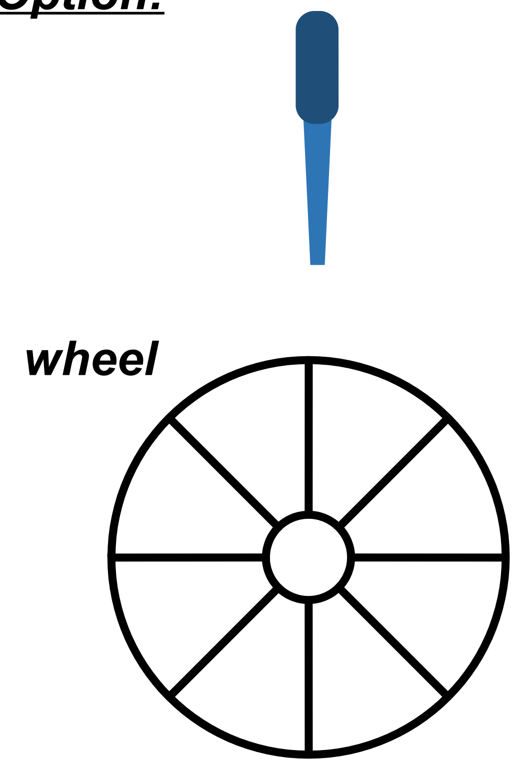
APPARATUS

Suggestion

You can reuse the old setup from Problem No.13 of IYPT 2020 (Friction Oscillator)



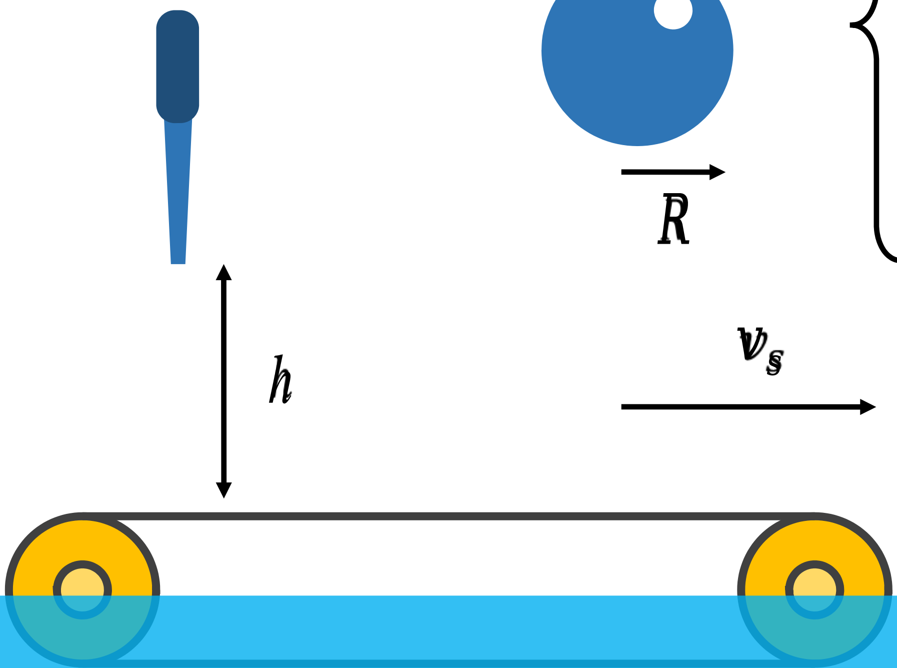
Second Option:



THEORY

THEORETICAL MODEL

Parameters



η = dynamic viscosity

γ = surface tension

ρ = density

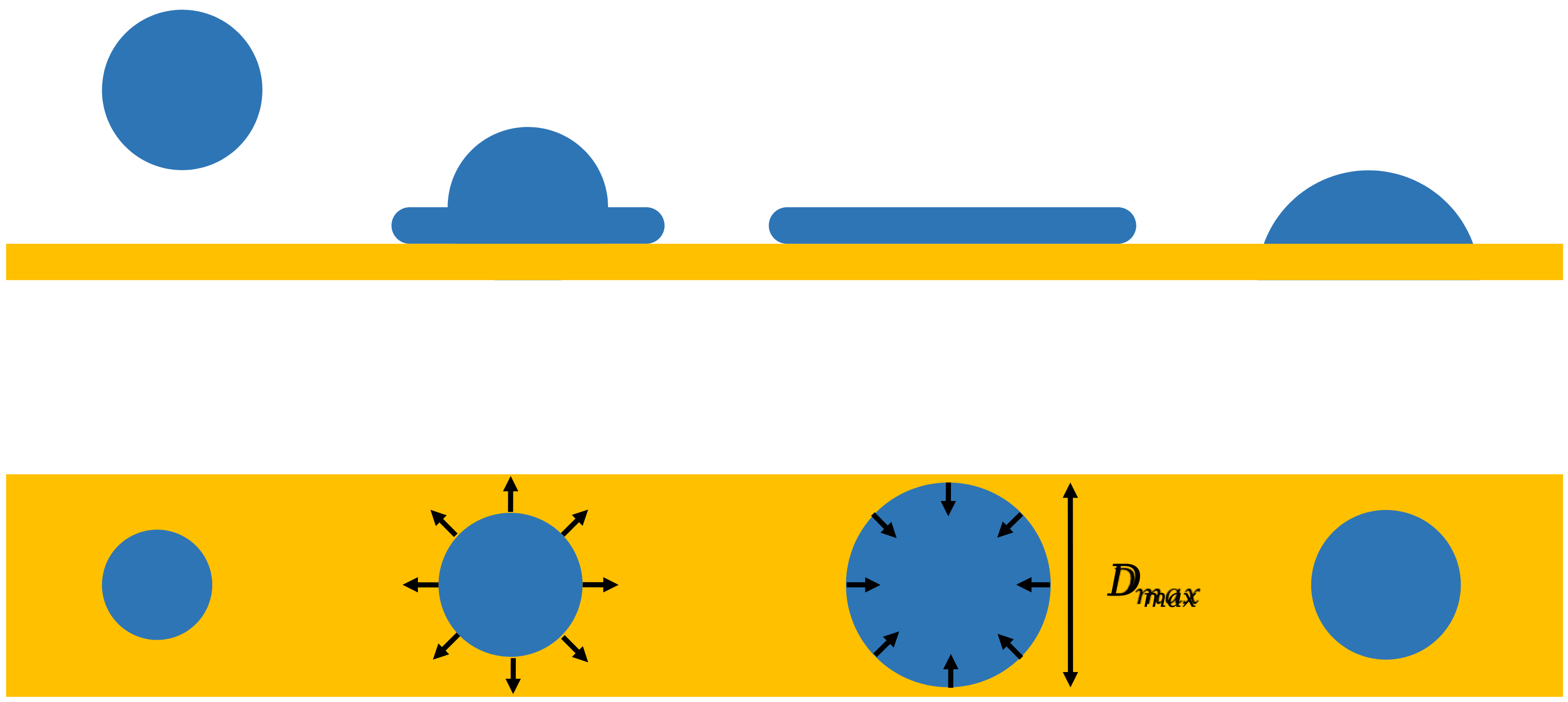
λ = shape factor

liquid nonsense

Let us make some key assumptions!

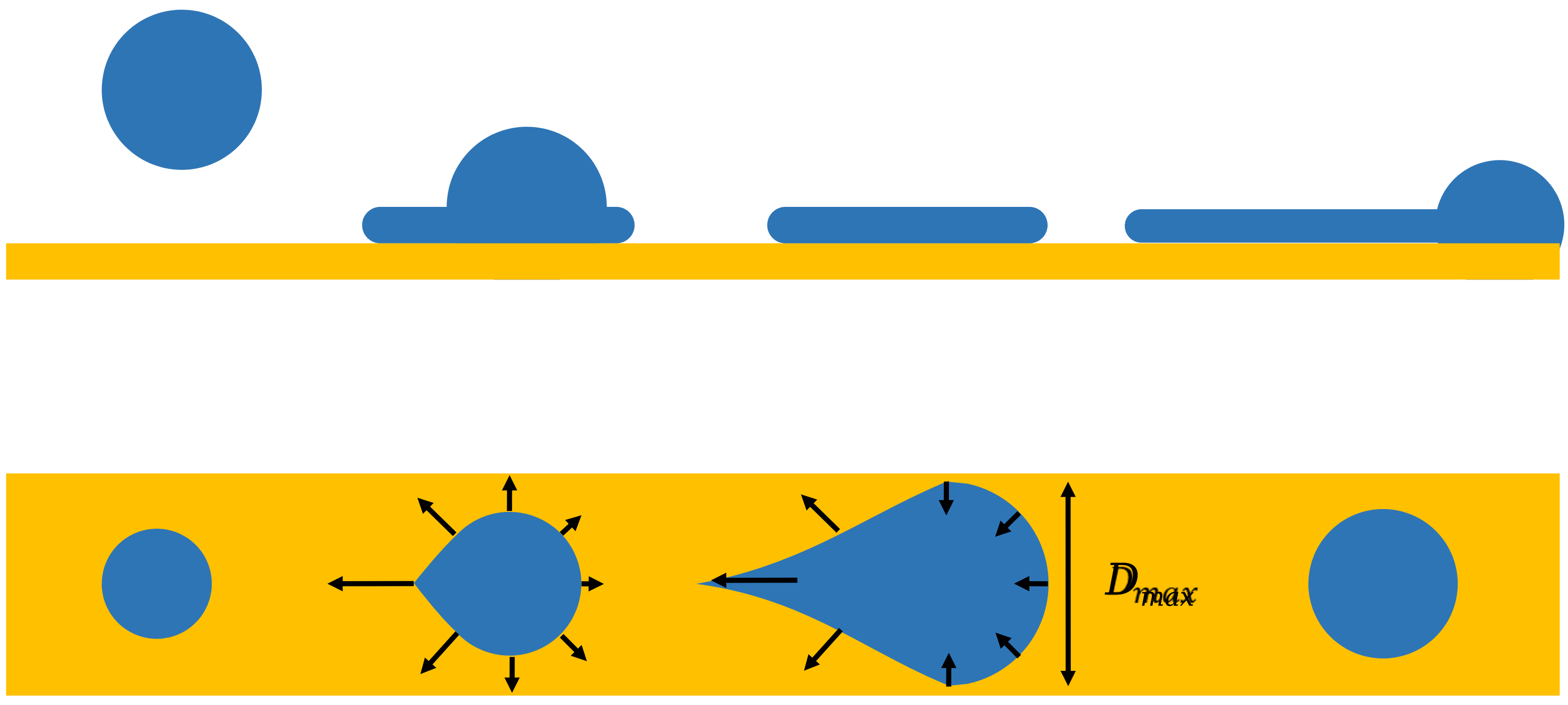
THEORETICAL MODEL

Stationary Surface



THEORETICAL MODEL

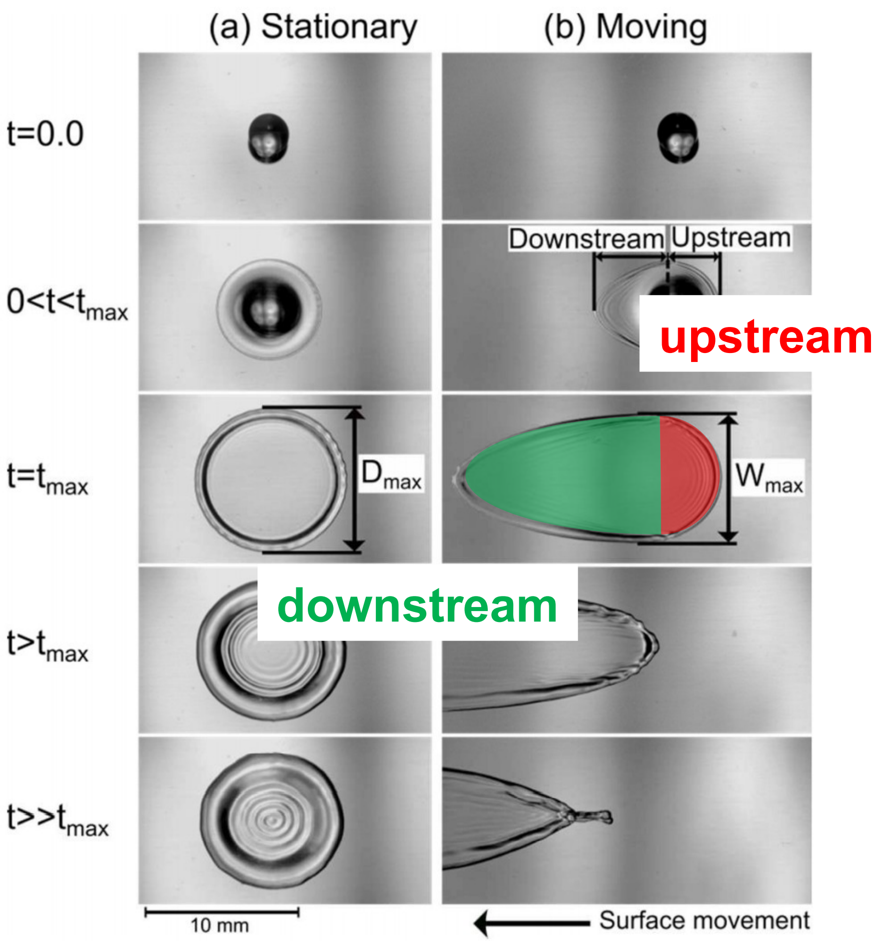
Moving Surface



THEORETICAL MODEL

Radius

$$r(t) = R\left[1-\exp\left(-\left(\frac{2\gamma_{LG}}{R^{12}}+\frac{\rho g}{9R^{10}}\right)\frac{24\lambda V^{4} t}{\pi^{2}\eta}\right)\right]^{\frac{1}{6}}$$



EXPERIMEN
TS

EXPERIMENTS

[1] H.Almohammadi, A.Amirifazli, 'Understanign the drop impact onto a moving hzdrophilic and hydrophobic surfaces', Department of Mechanical Engineering, York University, Toronto

Velocity of the Surface - v_S

$0\,m/s < v_S < 17\,m/s$ **in paper [1]**

try to focus on the boundary velocities when creating phase diagrams

Velocity of the Drop - v_N

Change initial height of the drop (pipette) – free fall

$$v_N = \sqrt{2gh}$$

Wettability of the Surface

Use variety of different surfaces and determine wettability by measing contact angle for stationary surface for particular liquid

Hydrophilic – Stainless Steel $\theta \approx 40°$

Use impregnation spray

Hydrophobic – Teflon $\theta \approx 110°$

EXPERIMENTS

Surface Tension - γ

Use detergent to change surface tension of the water

dynamic viscosity and density should not be affected significantly

Dynamic Viscosity - η

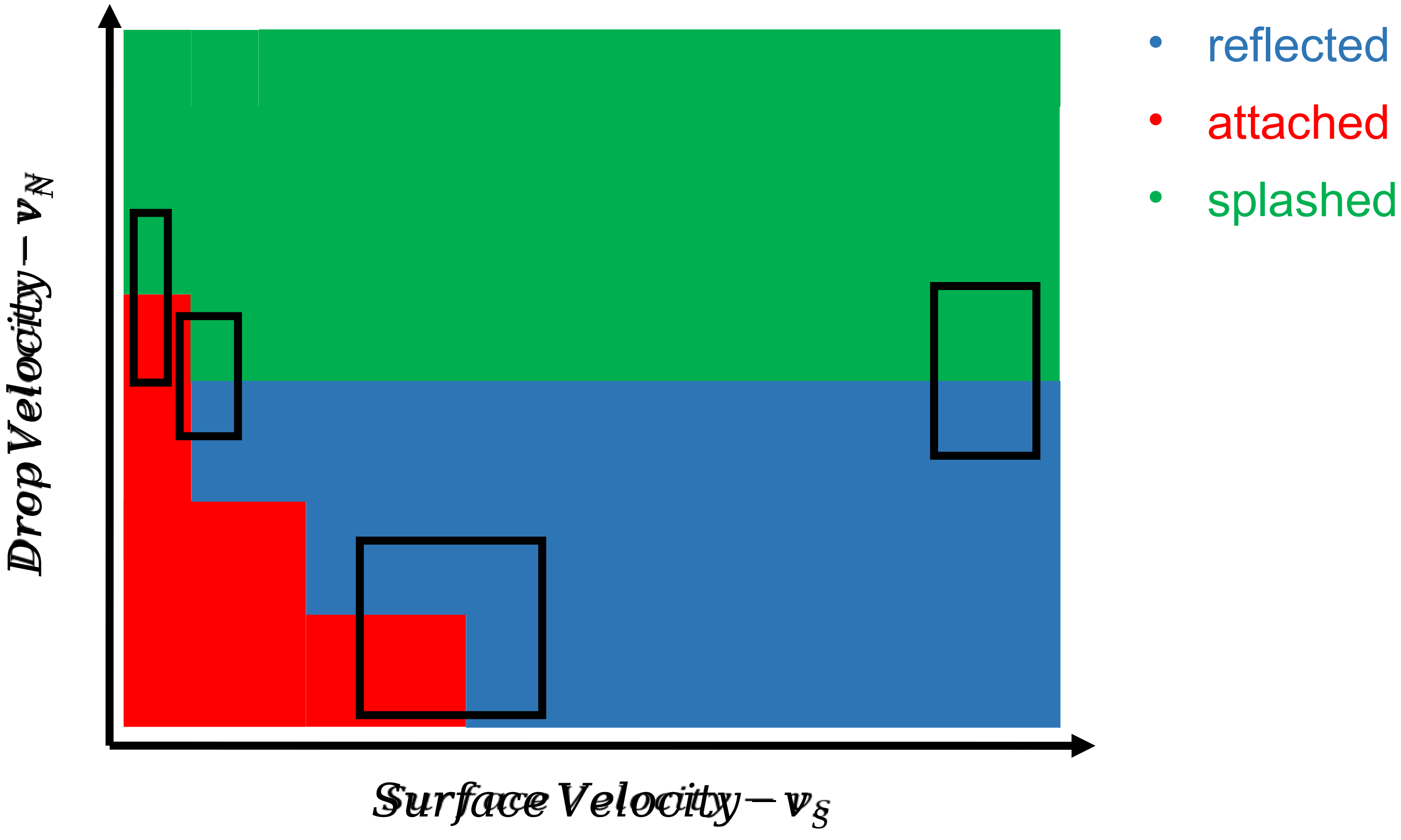
Use glycerol to effectively change dynamic viscosity of the water **in paper [1]**

Table 1. Physical properties of the working fluids

Liquid name	Percentage of glycerol (wt %)	Density ρ (kg/m^3)[25]	Surface tension σ (mN/m)[25]	Dynamic viscosity μ (mPa.s)[26]
Water	0	998.2	71.7	1.005
Mixture 1	24	1057.2	70.6	2.025
Mixture 2	42	1104.7	69.2	4.106

EXPERIMENTS

Statistical Phase Diagrams



always provide analysis of the statistical phase diagram

EXPECTATIO NS

EXPECTATIONS

1 BEGINNERS

- Change all parameters in the section EXPERIMENTS systematically
  - Velocity of the surface
  - Velocity of the droplet (height of the pipette)
  - Surface tension
  - Dynamic viscosity
  - Material of the surface (wettability)
  - Size of the droplet
- Quantify wettability (by measing contact angle θ)
- Create statistical phase diagrams
- Provide qualitative explanation behind behaviour of the droplet (Why?)
- Ability to control size of the droplets (good pipette)
- Uncertainties in the measurement (essential for this problem)
  - one experiment is certainly not sufficient for overall understanding
- Always provide proofs of your ideas of explanation (HFR video)

EXPECTATIONS

2 ADVANCED

- Provide quantitative analysis of the experiment
  - Look at the behaviour of the droplets – change of lamella shape
  - Length of the upstream and downstream of the droplet for various velocities
- Quantitative model describing change of contact angle
- Phase diagrams with change of the droplets maximum diameter D_{max} and analysis of critical diameter
- Try to combine parameters of the liquid into one crucial parameter (try dimensionless numbers in hydro physics – Weber's Number, Bond Number, Reynolds number, but justify their applicability
- Provide quantitative theory and give predictions based on initial parameters

THANK YOU