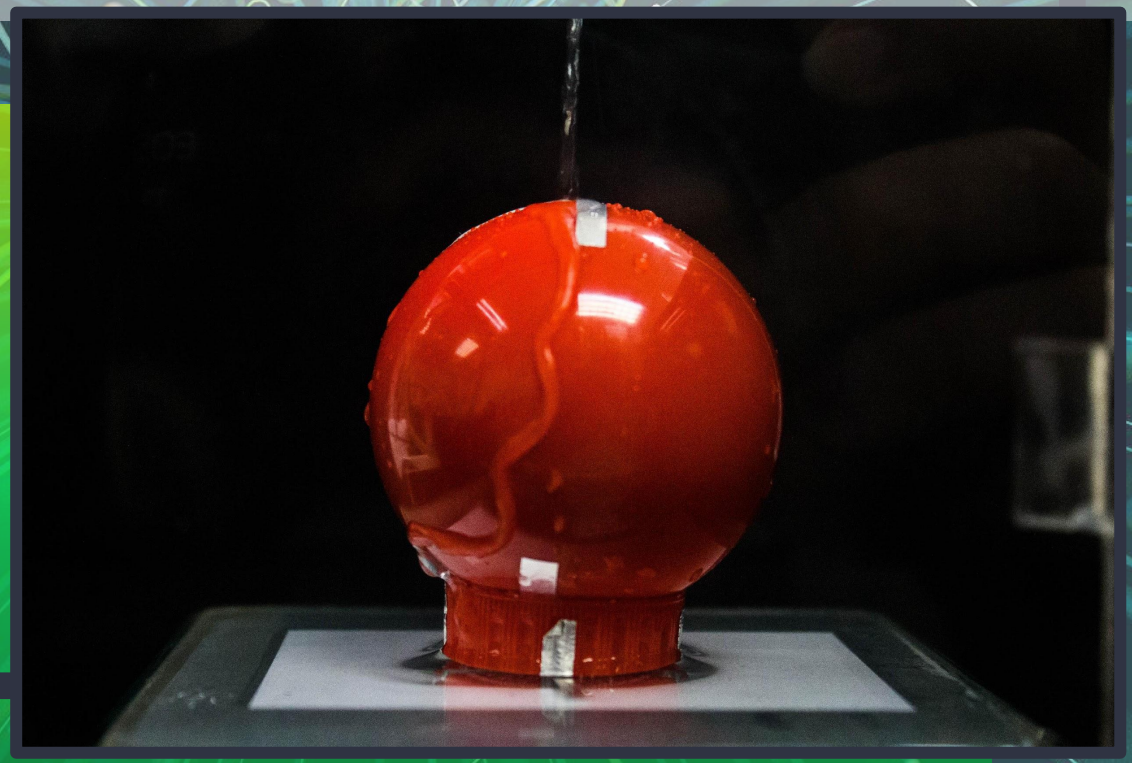
IFUSP
Instituto de Física da USP

PROBLEM 8 – RIPPLED WATER COLUMNS



Reporter: Mariana Mercucci, Vitória Dias

IFUSP
Instituto de Física da USP

RIPPLED WATER COLUMNS

When a vertical water jet hits a surface, ripples may appear. If certain conditions are met, the **ripple structure** is pronounced, steady and very reproducible. **Describe** the phenomenon. What **properties** of the **fluid** and the **flow** can be deduced from the observations?

Gustavo Pimentel, Juliana Fernandes, Lauro Barreto, Mariana Mercucci, Samir Salmen, Vitória Dias

PROBLEM 8 – RIPPLED WATER COLUMNS

Theoretical introduction

- Describing the phenomenon
- References - Starting points

Experimental analyses

- Phenomenon observation
- Prediction of relevant parameters

Experimental procedure

- Methods and materials
- Proceedings
- Microscope Analyses

- Wetted trail
- Water with detergent

Conclusion

- Relevant parameters
- Closure

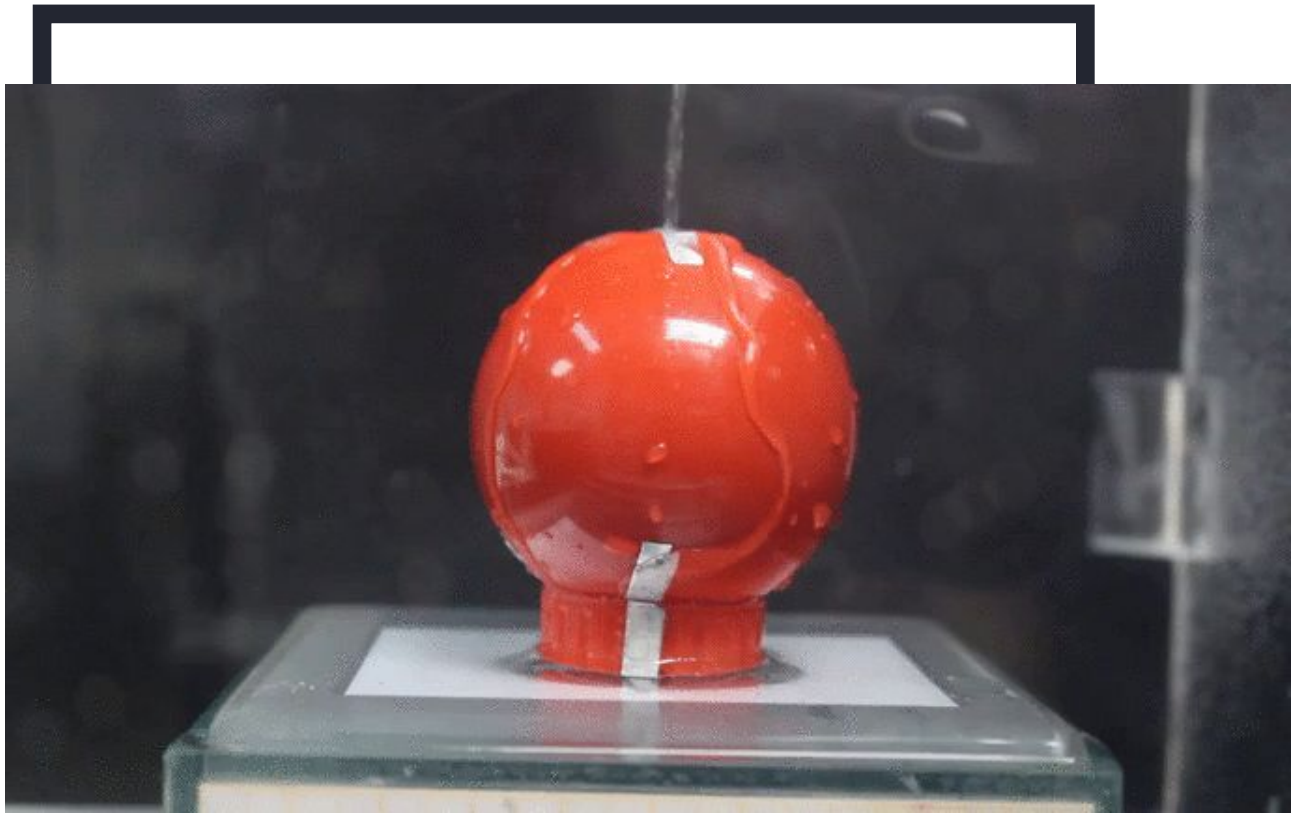
Theoretical introduction

Describing the phenomenon

- The ripples apparently are not stable;
- They seem to follow different patterns in different experimental achievements;

So the **main** question is:

Under certain **conditions** is this ripple **stable** and follow the **same pattern** in different achievements?

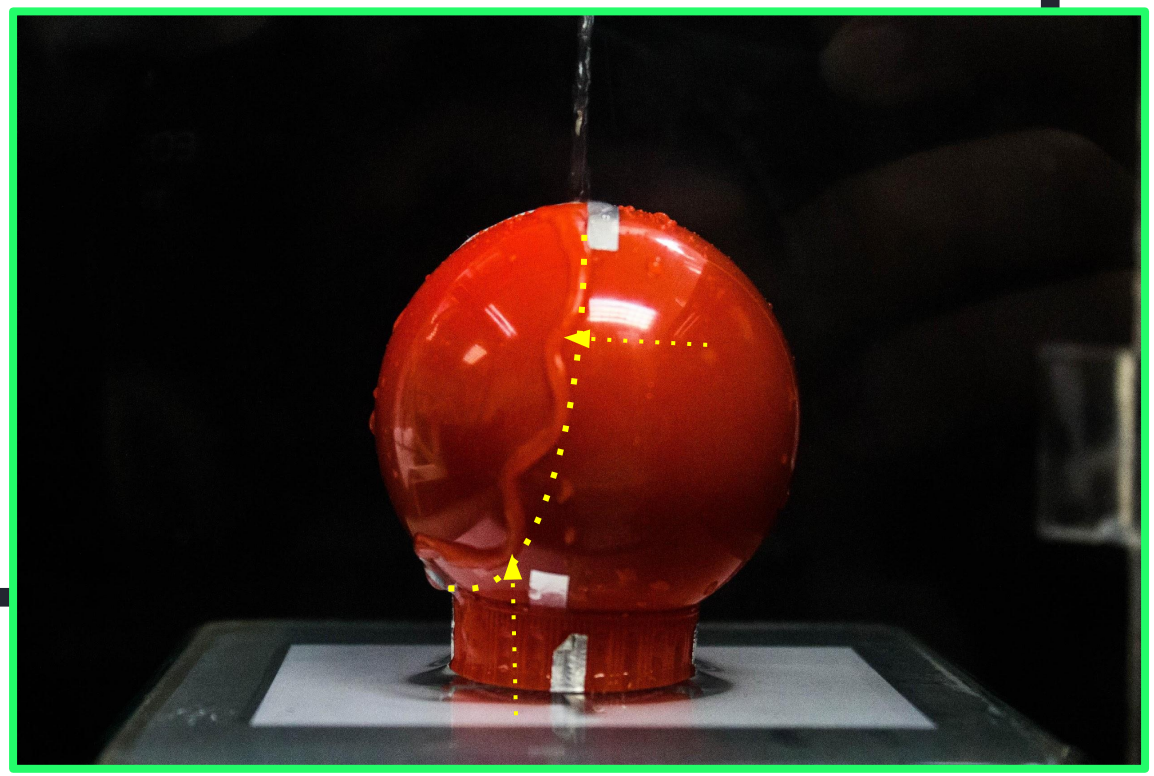


Theoretical introduction

Describing the phenomenon

RIPPLE! (definition)

The **well twisted defined** path formed by the water jet when it hits a surface



Theoretical introduction

References - Starting points

Static situation: [1]

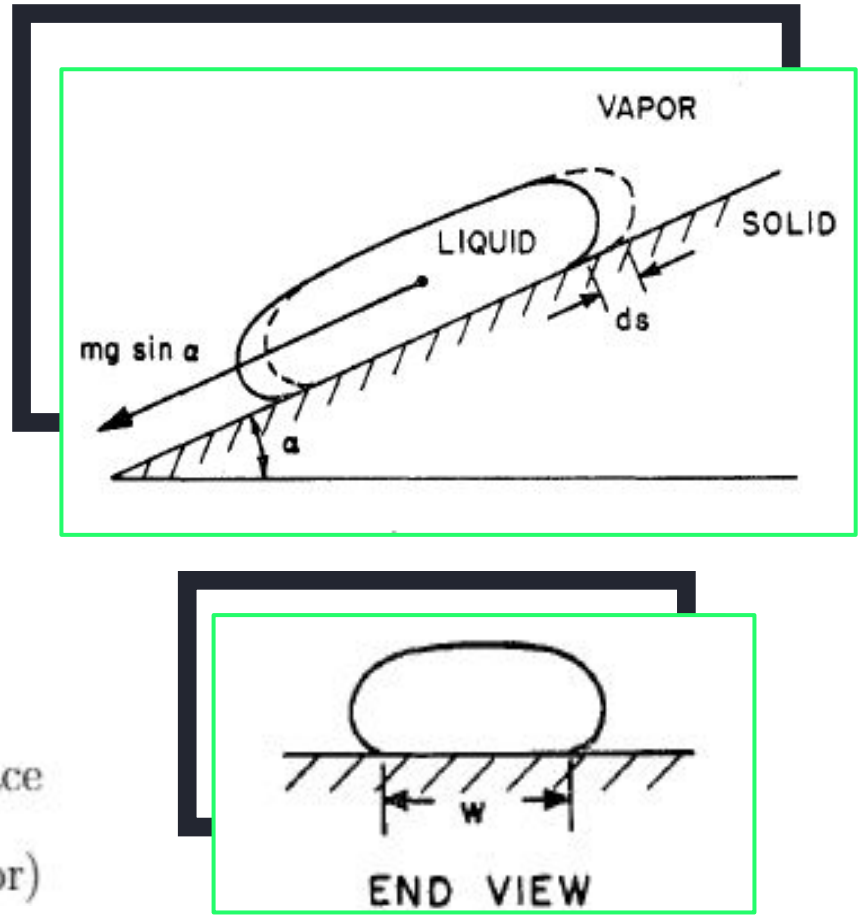
Contribute to the movement

Hinder the movement

$$\mu g \sin \alpha_c = w(\Psi_{LV} + \Psi_{SV} - \Psi_{SL})$$

τ_A = reversible work of adhesion

- μ = drop mass
- g = gravitational acceleration
- w = maximum width of the contact area between the drop and the surface
- ψ = interfacial tension between the different phases (Solid, Liquid, Vapor)



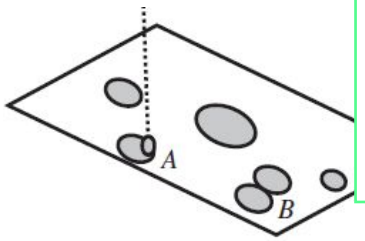
Sliding motion of a liquid drop [2]

References - Starting points

MOTIVATIONAL QUESTION: *how the ripple is formed?*

RUNNOF INITIATION

Initial situation: drops resting on an inclined surface

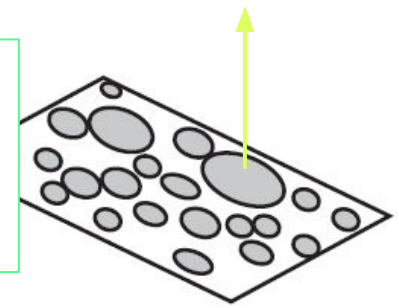


1°: New drops fall into the area already covered by the droplets

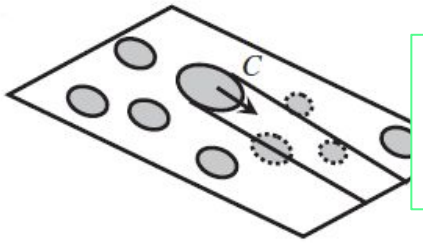
Drops fall stages:
1 – Impact
2 – Spreading
3 – Sliding

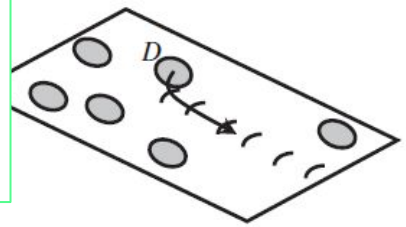
2°: DROPS COALESCENCE
neighboring drops get together – a **cluster** is formed

Cluster



3°: The cluster slides down the surface, attaching to other drops in its path





4º: The cluster leaves a **wetted trail** behind and other clusters have its movement deviated by it

Images from ref 1

Experimental Analyses

Phenomenon observation

How can we make the phenomenon follow the same pattern more than once?

1. Water jet hits the surface

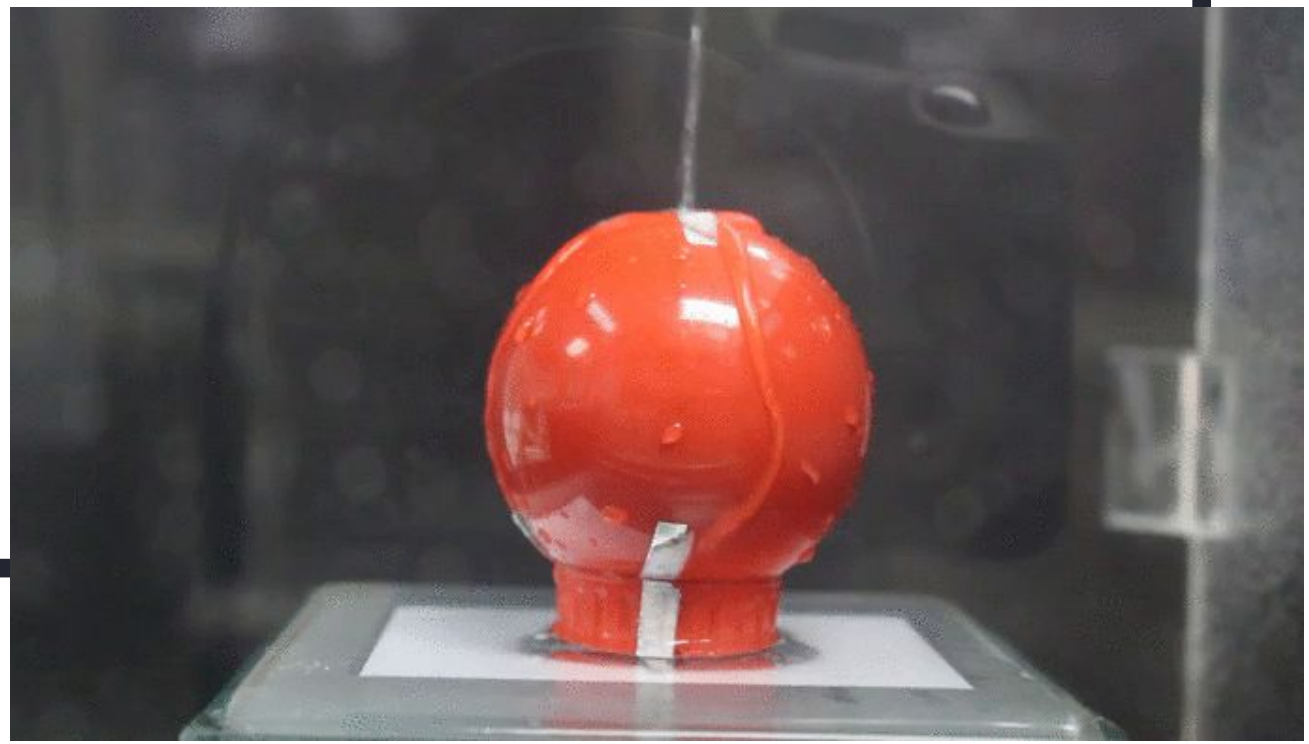
2. A **ripple** is formed

3. Water jet is **interrupted**

4. A wet trail is left behind

5. A new water jet (under the same conditions as the previous one) hits the surface

6. This water jet forms the same ripple that was observed before



Experimental analyses

Prediction of relevant parameters

Hypothesis: the ripples depends on the **adhesion** (1) and **cohesion forces** (2). If there is a **wetted trail** (3), probably it will be **the same**.

Adhesion force

Composition of the liquid

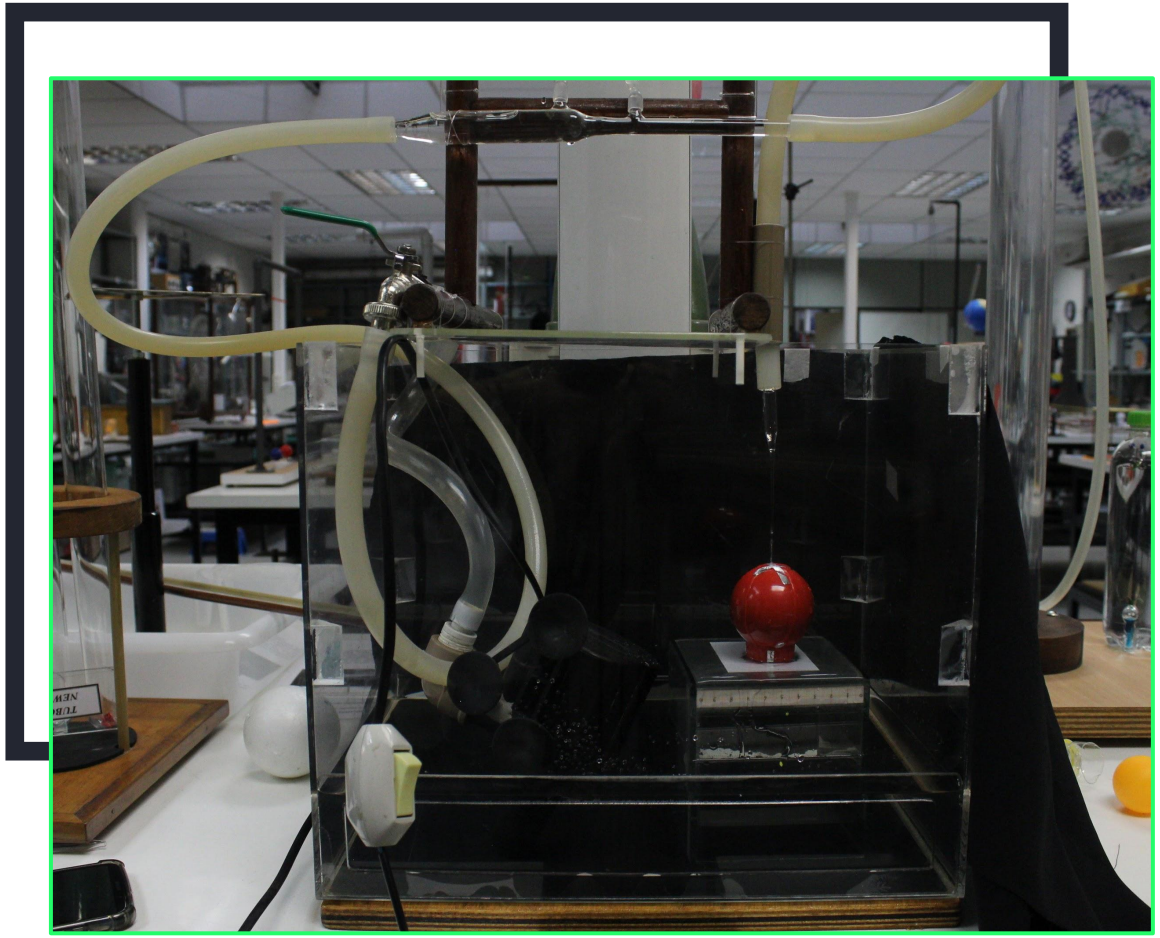
Rugosity of the surface

Experimental procedure

Methods and materials

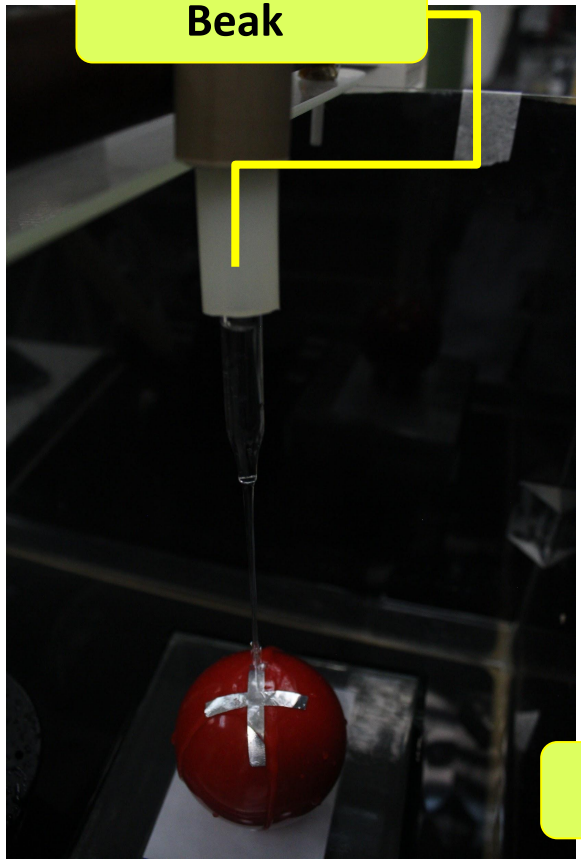
EXPERIMENTAL APPARATUS:

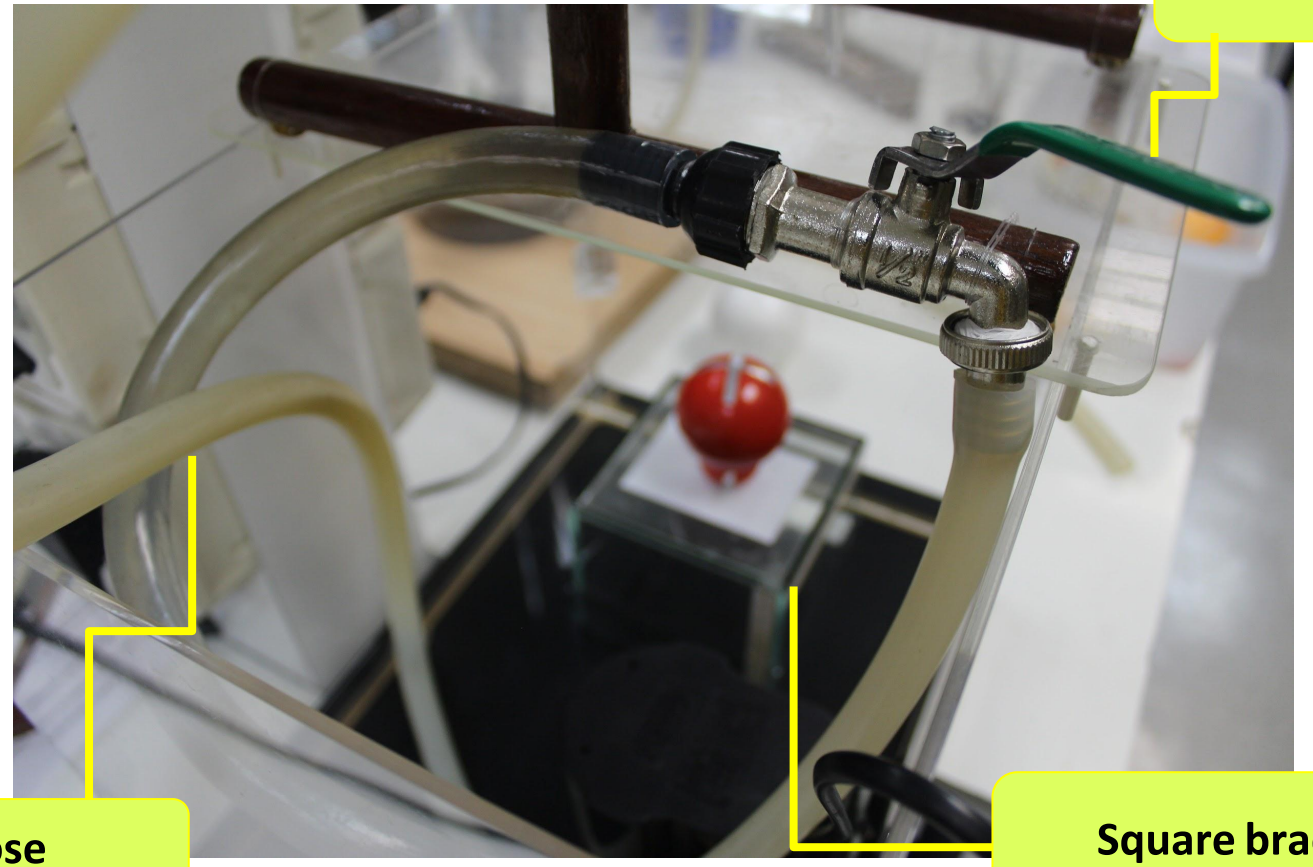
- **Transparent container;**
- **Water pump;**
- **Square bracket and a support for the balls**
- **Hose**
- **Beak**
- **Dosing tap**



Experimental procedure

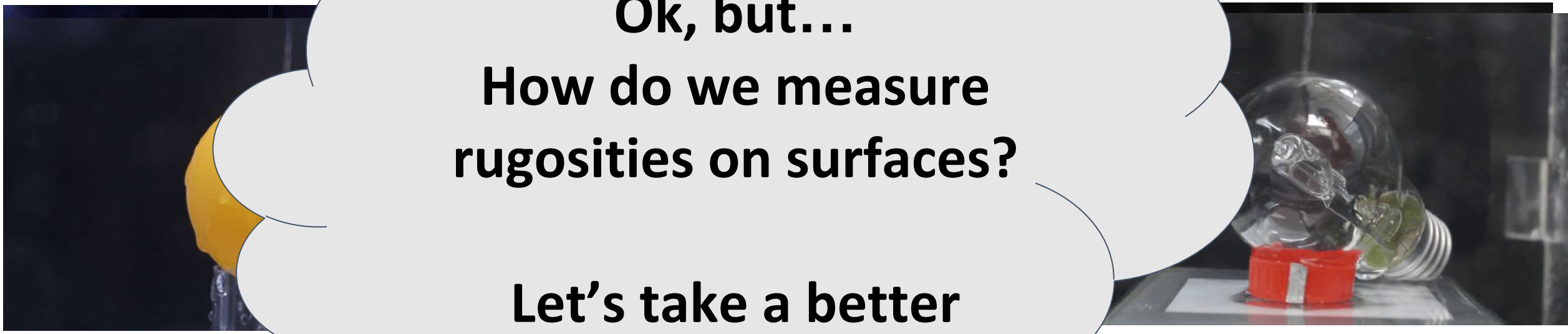
Methods and materials





Experimental procedure

Proceedings - Surfaces



Ok, but…
How do we measure rugosities on surfaces?

Let’s take a better look!

Table tennis ball

Lamp

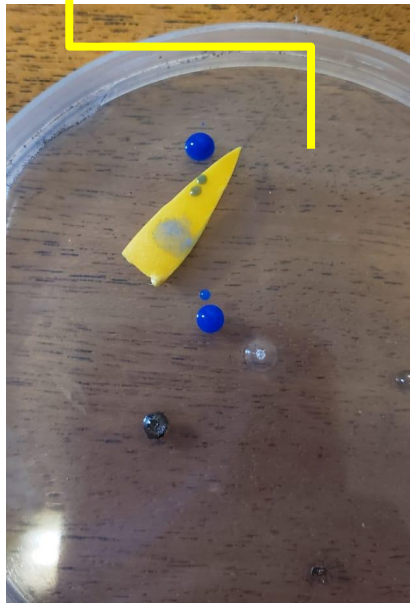
Experimental procedure

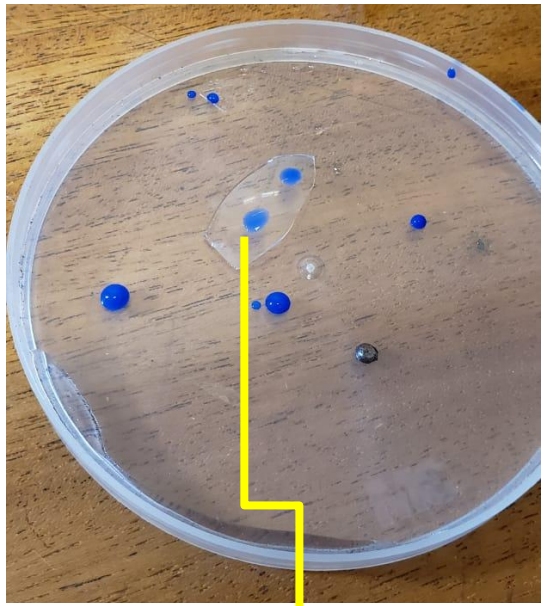
Microscope Analyses

microscope

dropper

table tennis ball





lamp

Experimental procedure

Microscope Analyses

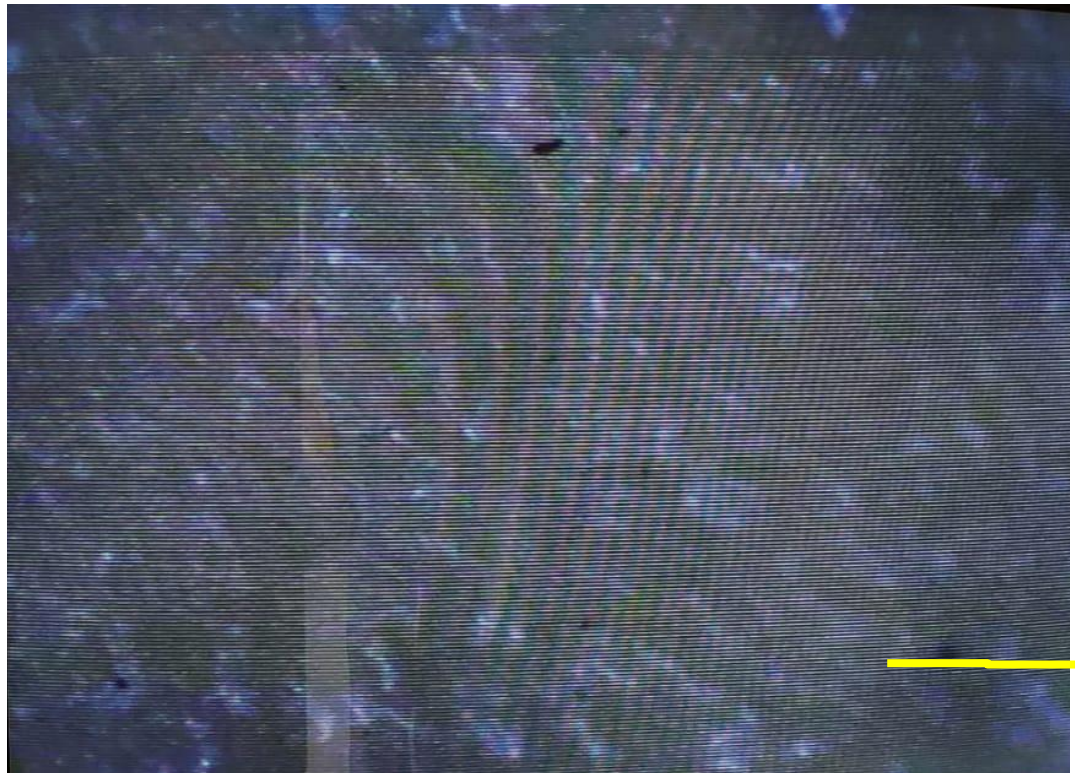
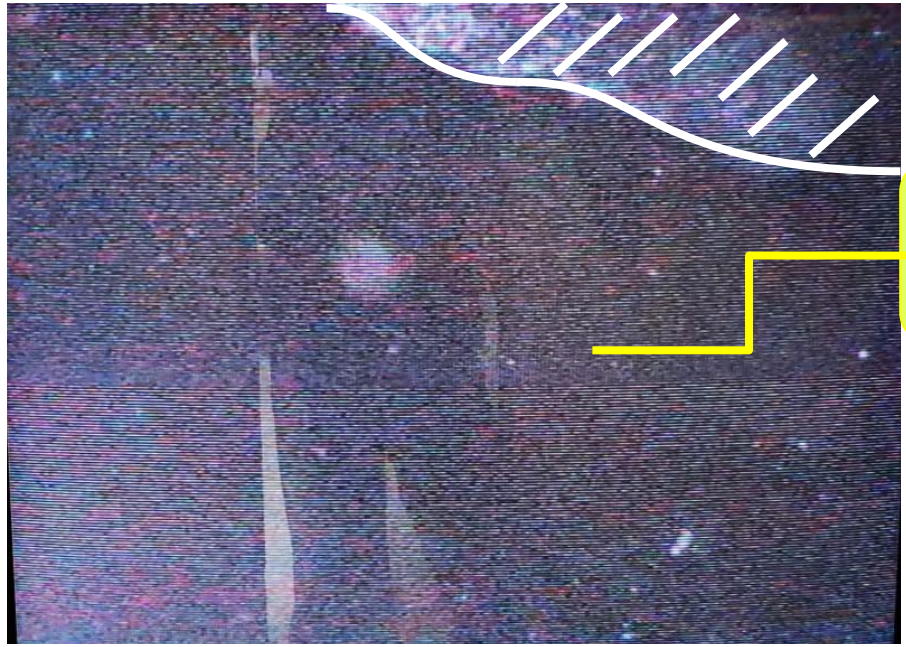


Table tennis surface

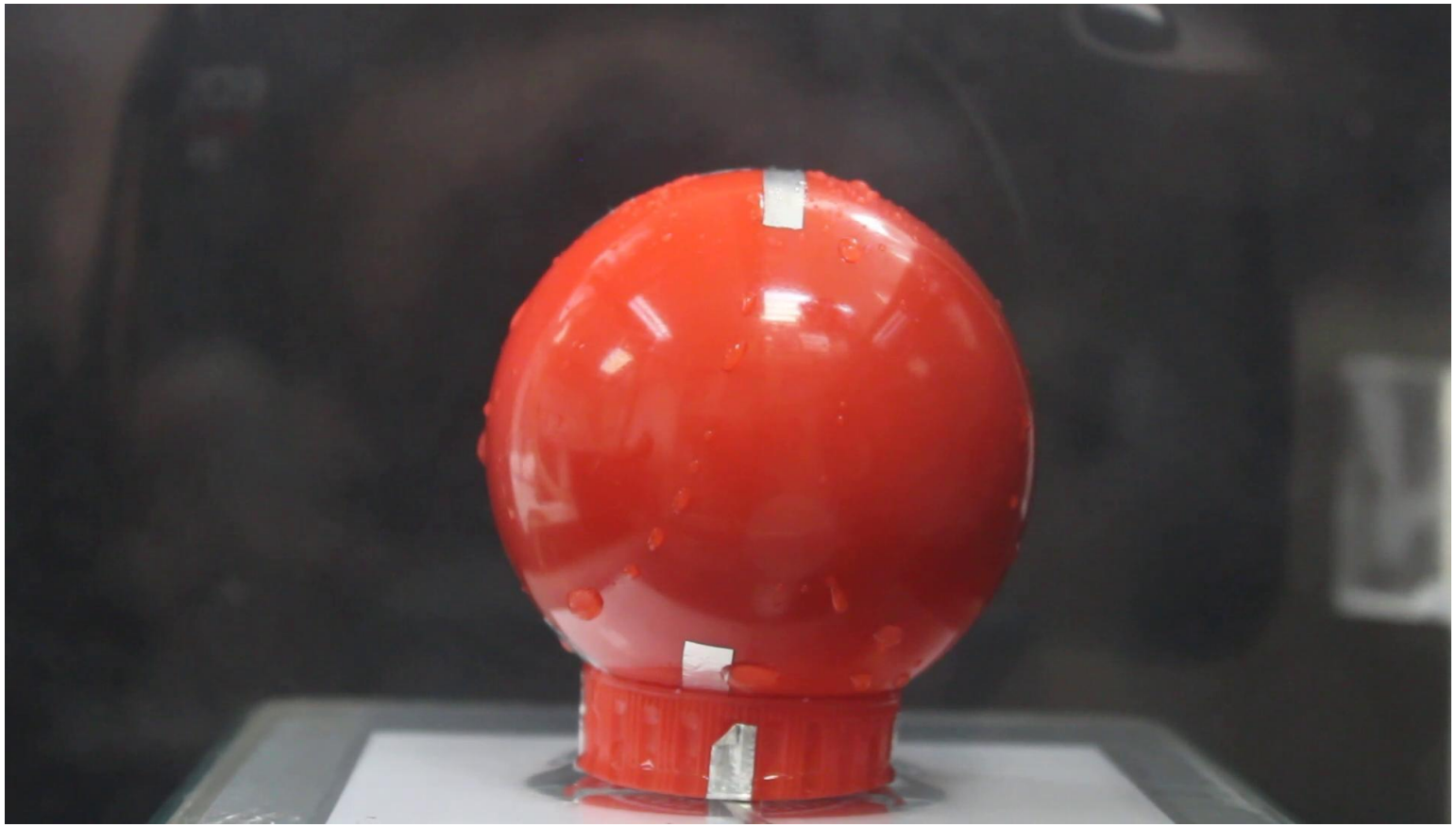


Glass surface

Experimental procedure

Wetted trail

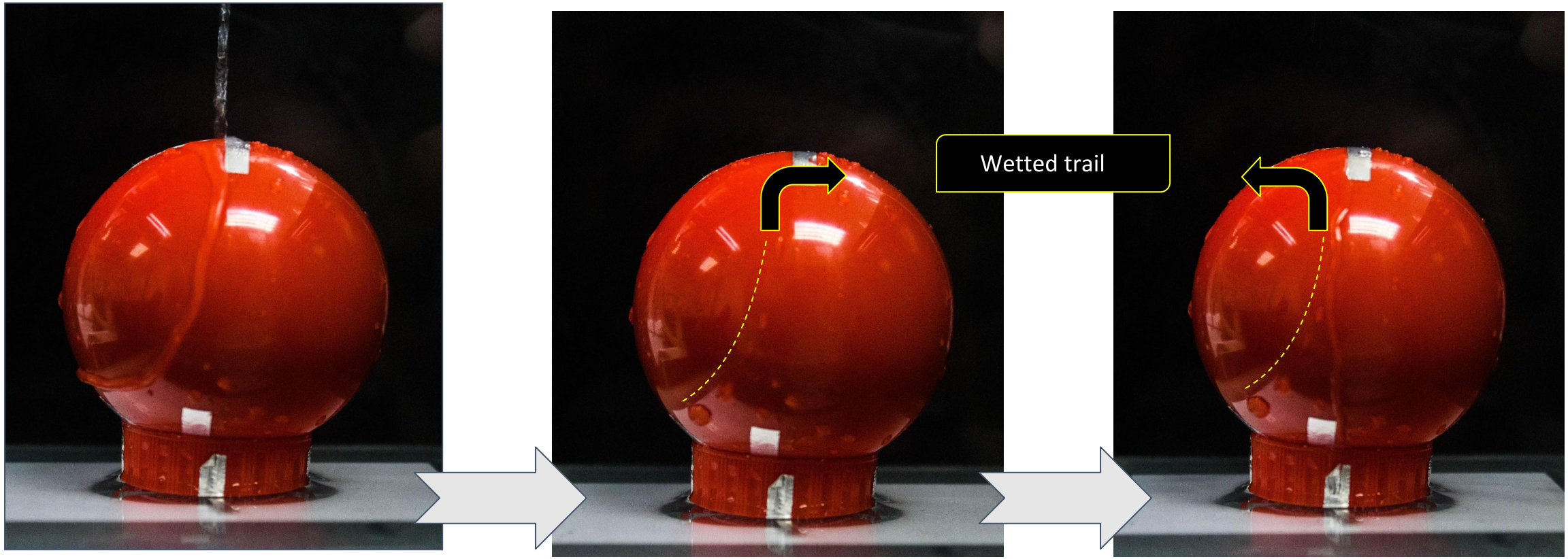
Cohesion force → **Wetted trail**



Experimental procedure

Wetted trail

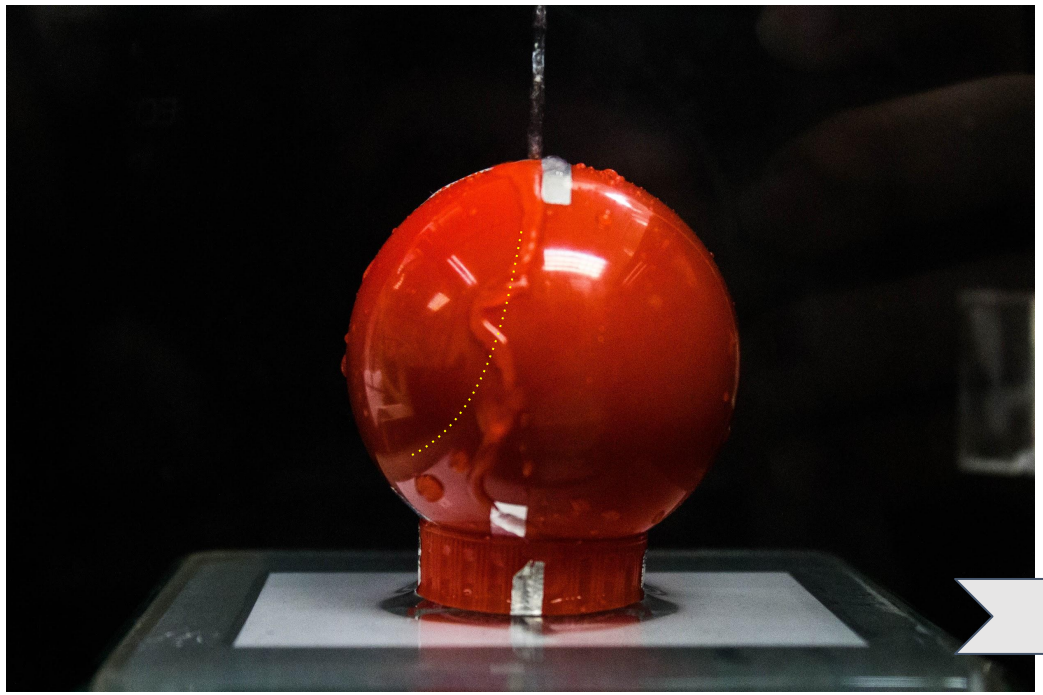
Cohesion force → **Wetted trail**

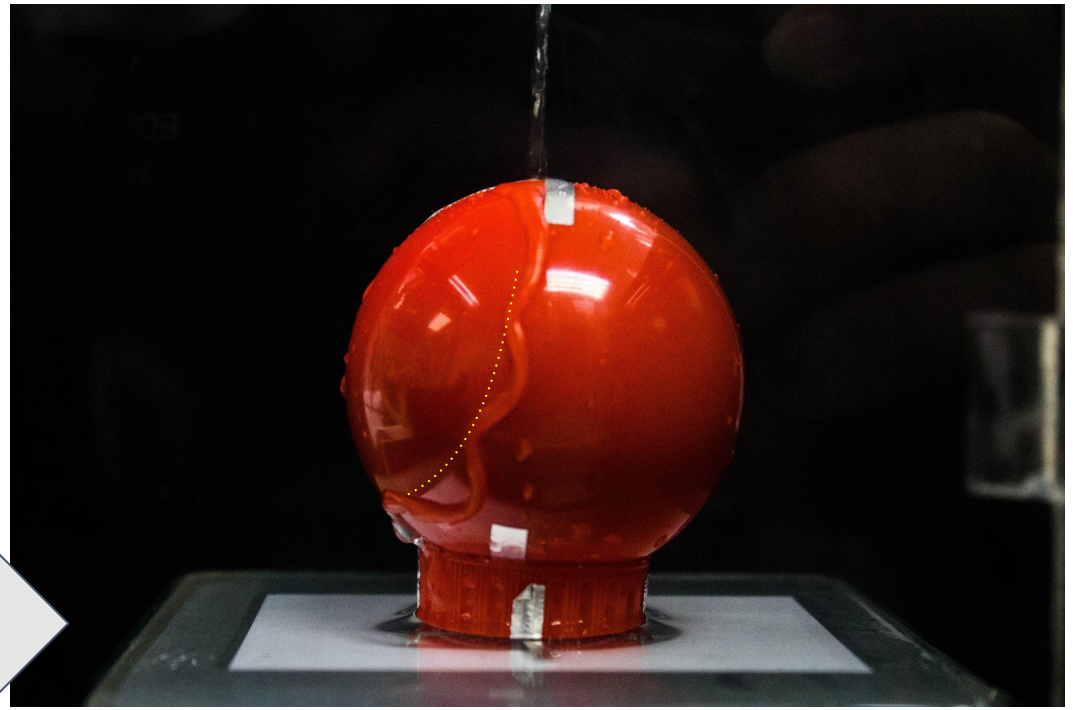


Experimental procedure

Wetted trail

Cohesion force → **Wetted trail**





Experimental procedure

Water with detergent

What happens when we add **detergent** to **water**?

Adhesion Force (water/surface)

↓

attraction of liquid molecules to the molecules in the surface

Conclusion

Relevant parameters

What **properties** of the **fluid** and the **surface** can be deduced from observations?

PROPERTIES OF THE FLUID

Adhesion and cohesion force

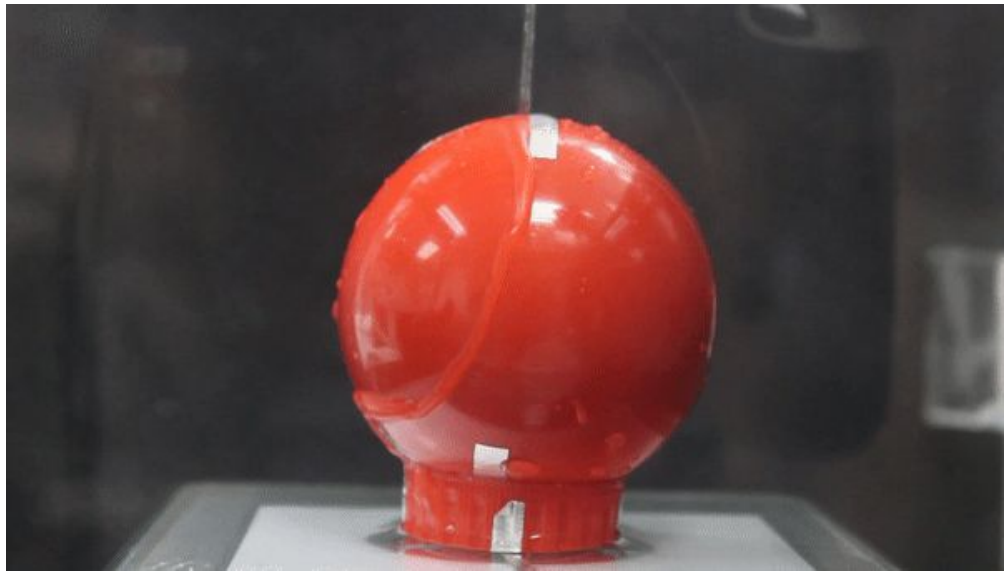
PROPERTIES OF THE SURFACE

Wetted trail

Conclusion

Closure

- In normal situations: cohesion force > adhesion force
- Detergent effect on water decrease cohesion force

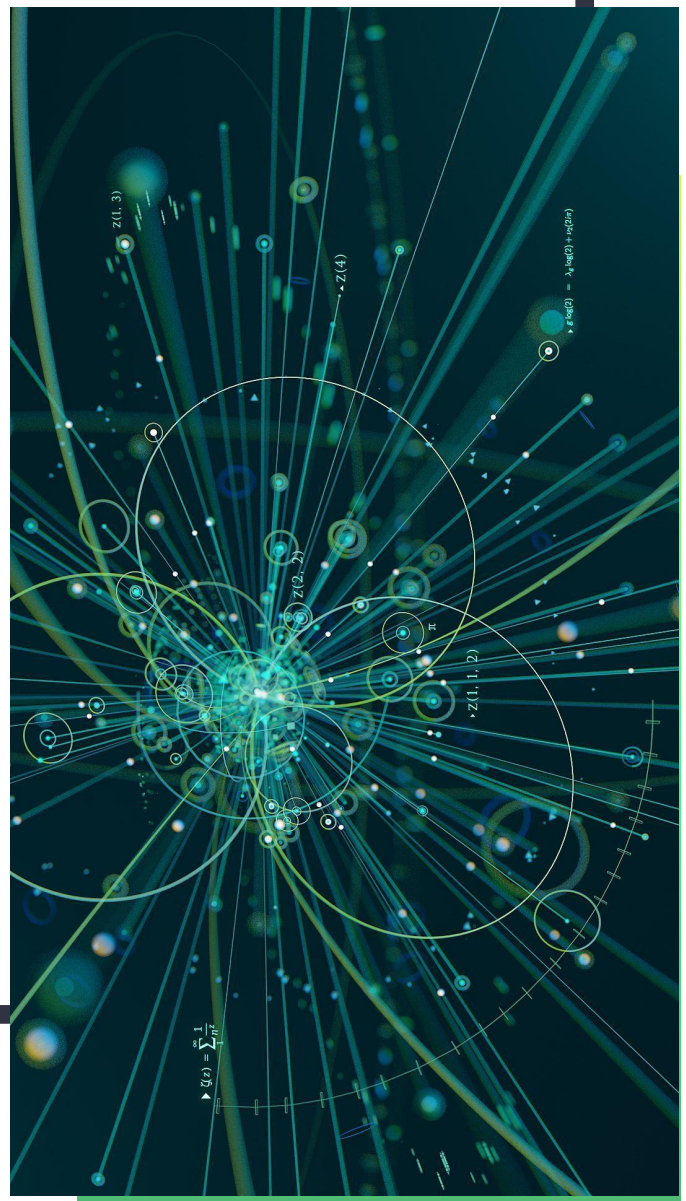


- Rugosities on surface favor ripples formation

- Wetted trails are needed if we want to reproduce the ripple

REFERENCES

- [1] Runoff initiation from raindrops falling onto planar inclined surface by D. Nezlobin, H. Rubin, H. Lavee, P. Sarah, E. Sachs
- [2] The sliding of liquid drops on solid surfaces by Douglas A. Olsen, Powell A. Joyner, and Marvin D. Olson



ACKNOWLEDGMENTS

- Caroline Araújo
- Claudio Hiroyuki Furukawa
- Nestor Caticha
- Ricardo Correa