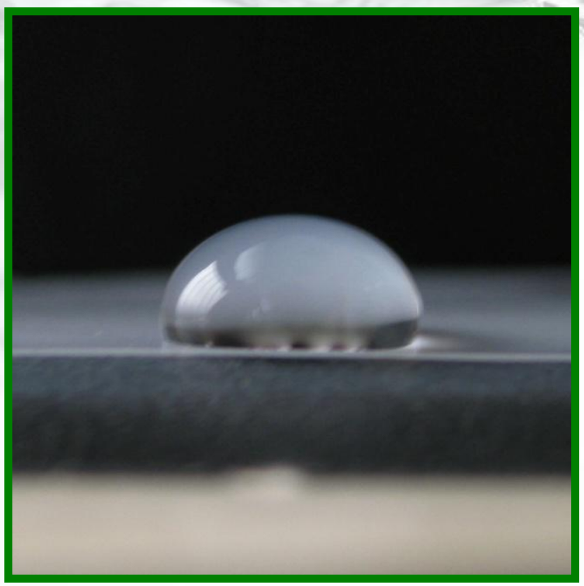
Bouncing drop

Investigate the motion of water droplets falling on a hydrophobic surface (e.g. coated with soot or teflon)

Hydrophobic Surfaces

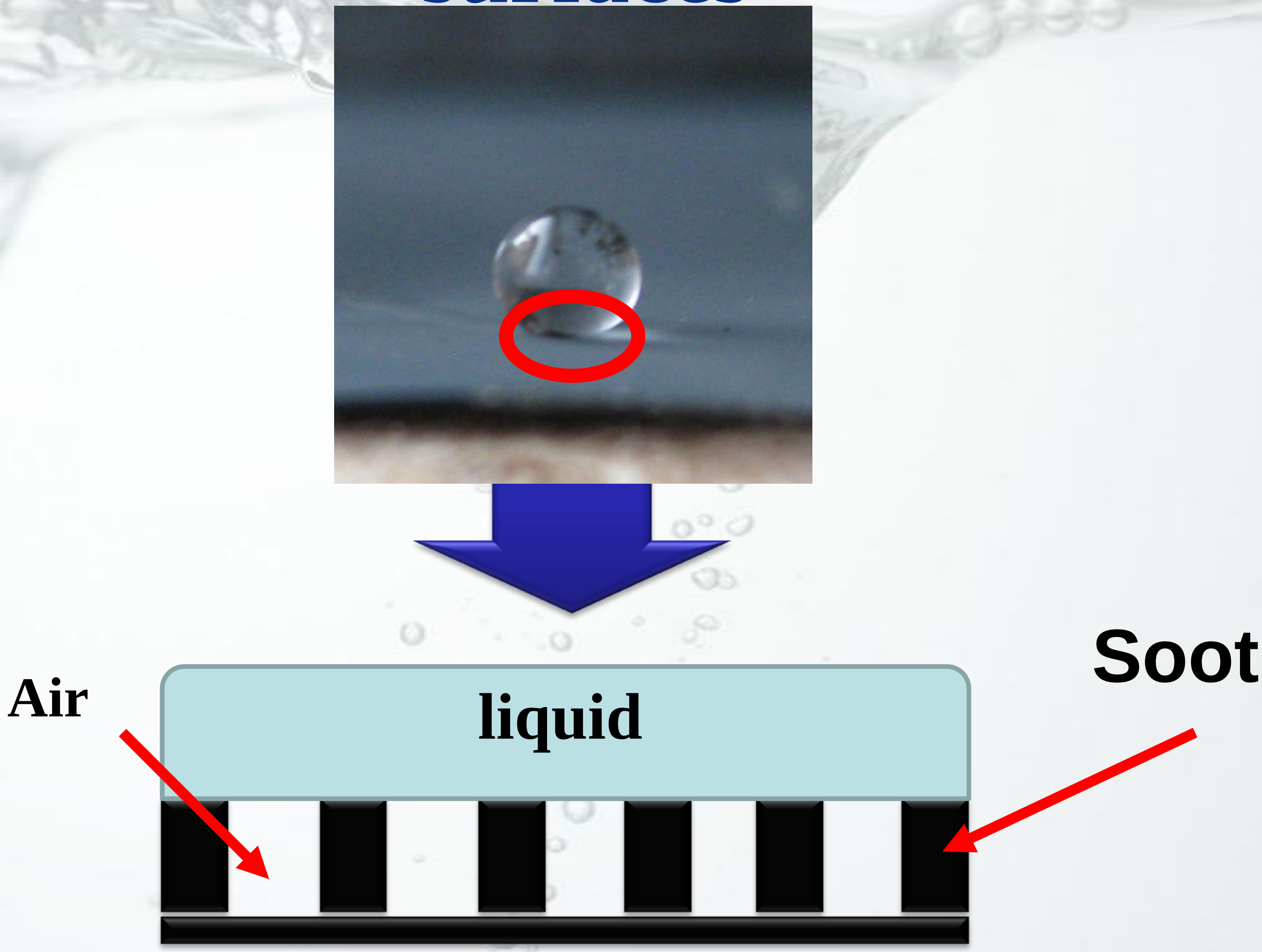


Teflon

Surface coated with soot

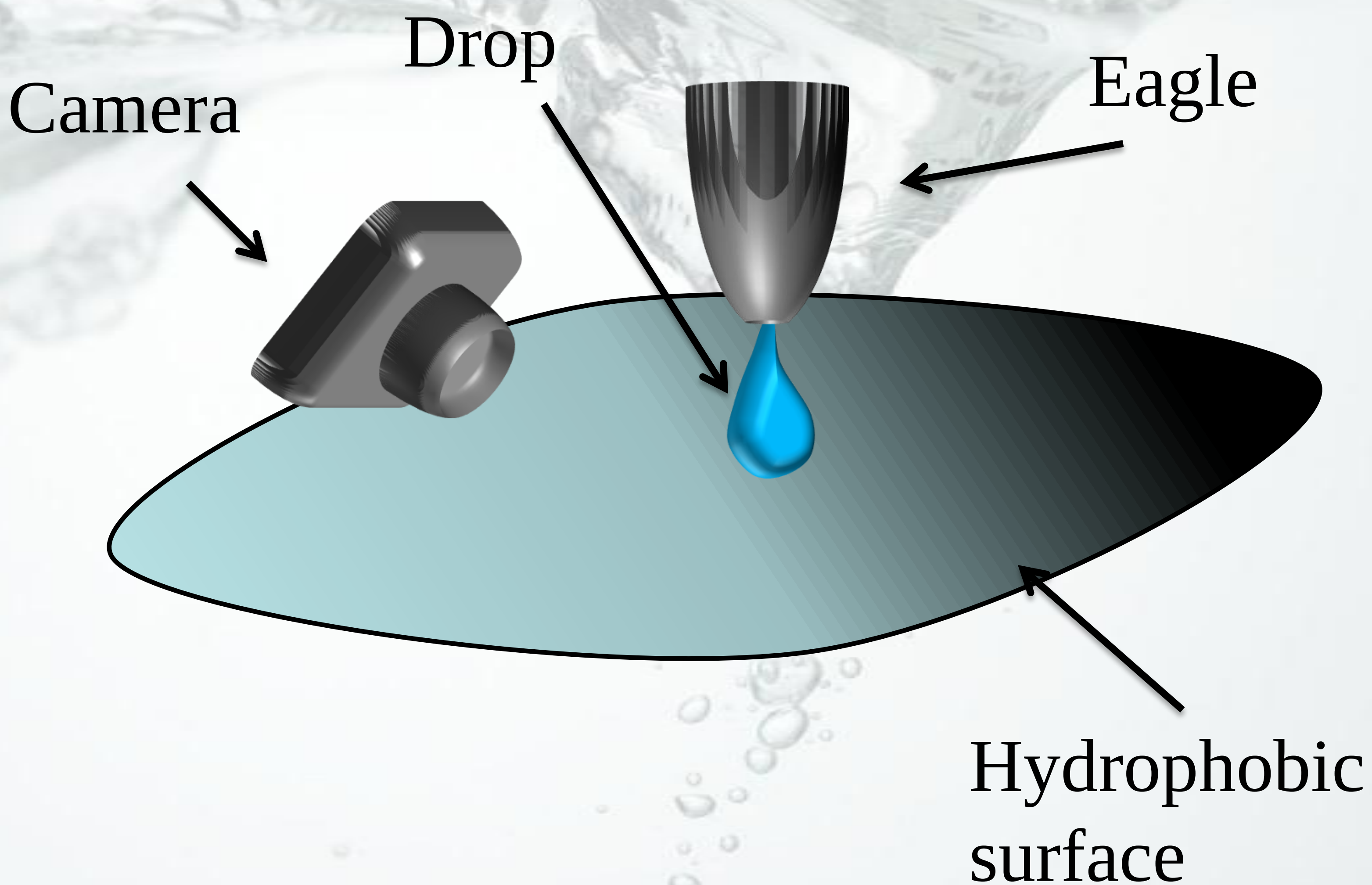
Natural materials

Structure of a superhydrophobic surfaces



Destroying of the surface structure

Experimental setup

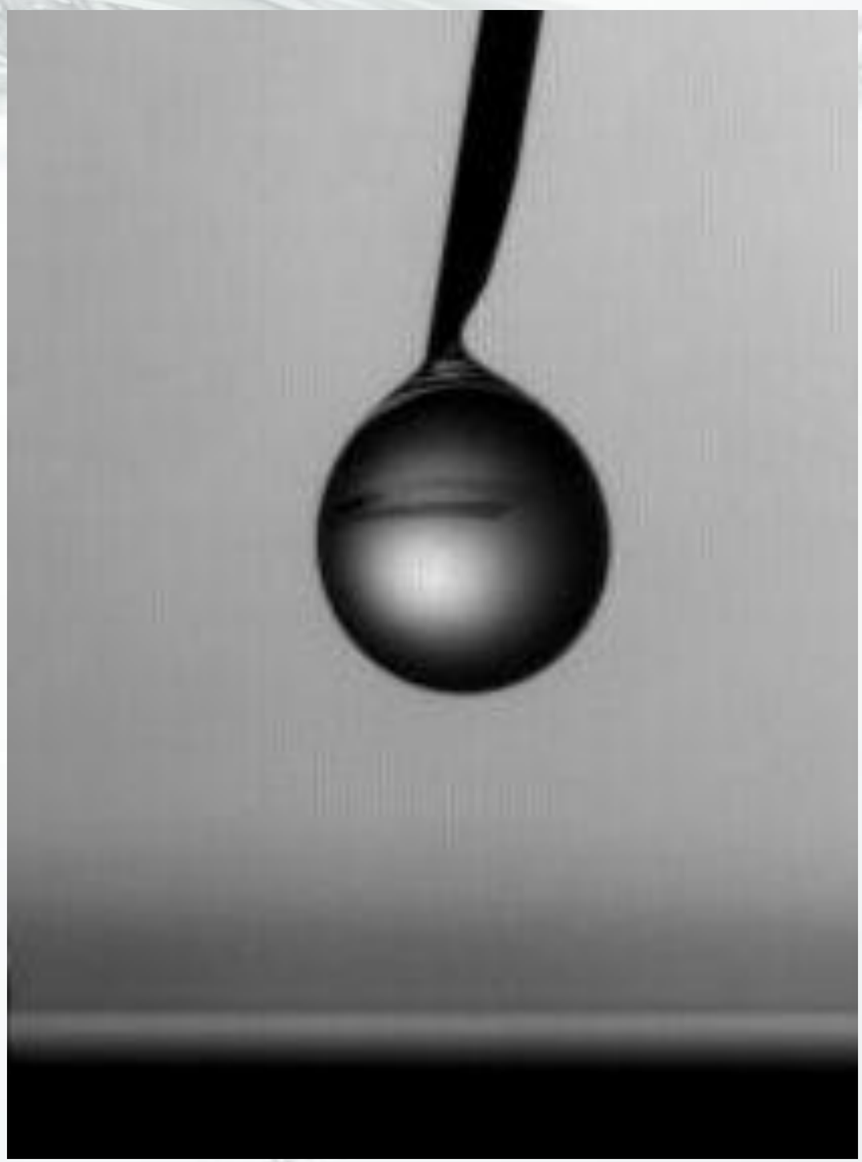


Stages in drop's behavior

1. Oscillation
2. Bounce without a break of the droplet
3. Bounce with a break of the droplet
4. Splash (destroying of the droplet)

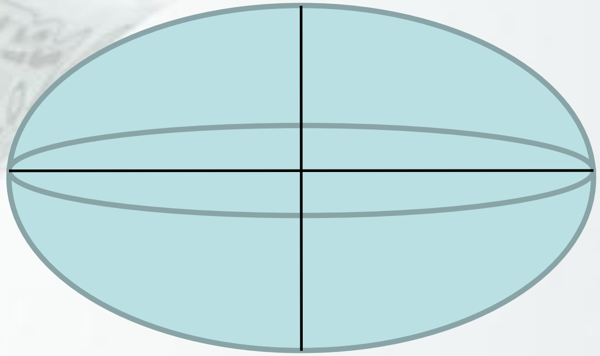
Oscillation

R=1mm
H=0-3mm



Characteristic oscillation

We have approximated the shape of the drop as an ellipsoid



$$E_{kinetic} + E_{surface} = const$$

$$\frac{\partial \left(E_{kinetic} + E_{surface} \right)}{\partial t} = 0$$

Characteristic oscillation

$$\omega_{\min} = \sqrt{\frac{8\sigma}{\rho R^3}} \quad (1)$$

$\omega_{\min}$ **is minimal drop's frequency**

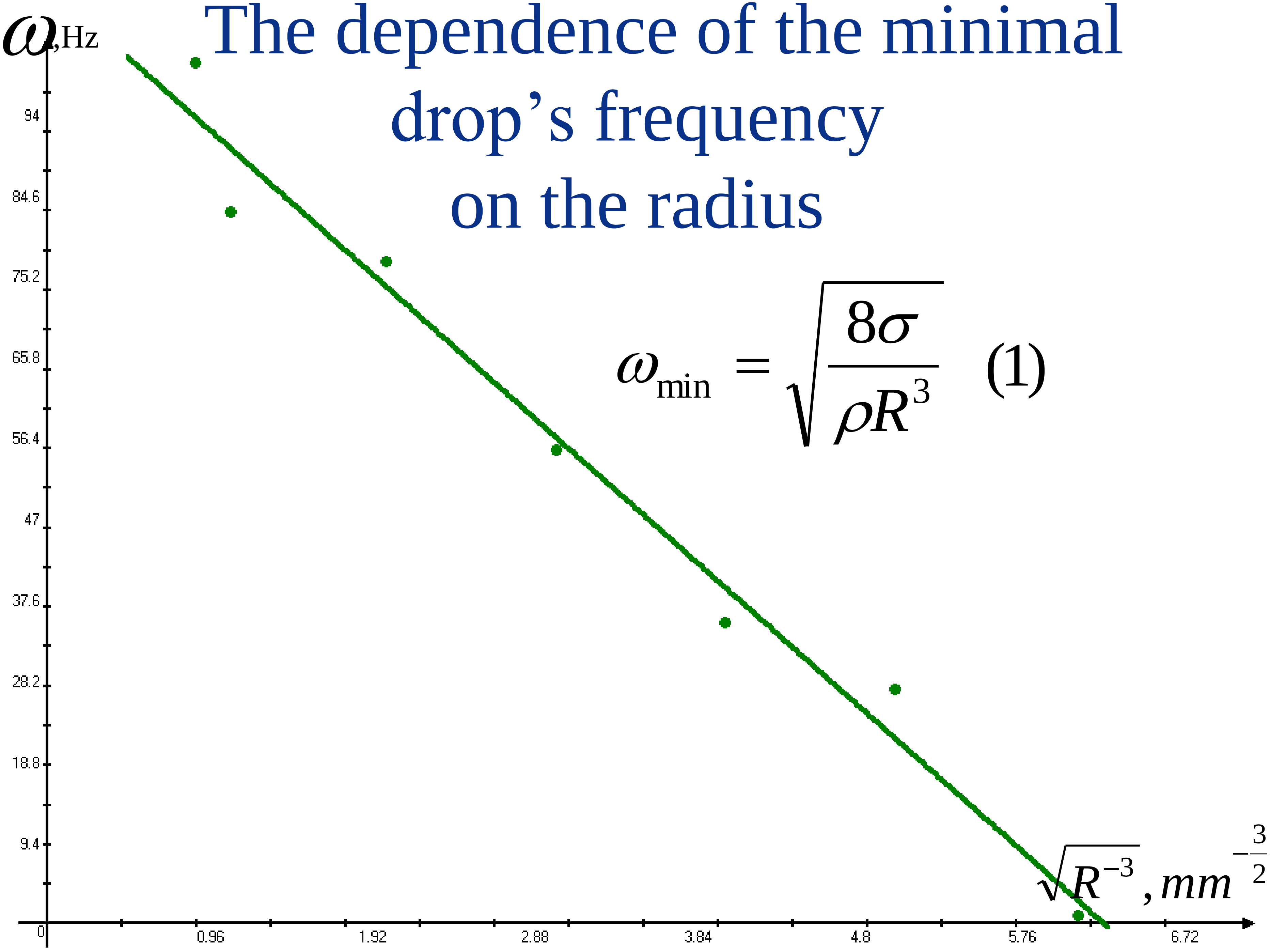
σ **is surface tension of the liquid**

ρ **is liquid density**

R **is drop radius**

The dependence of the minimal drop's frequency on the radius

$$\omega_{\min} = \sqrt{\frac{8\sigma}{\rho R^3}} \quad (1)$$



The Conditions for oscillation

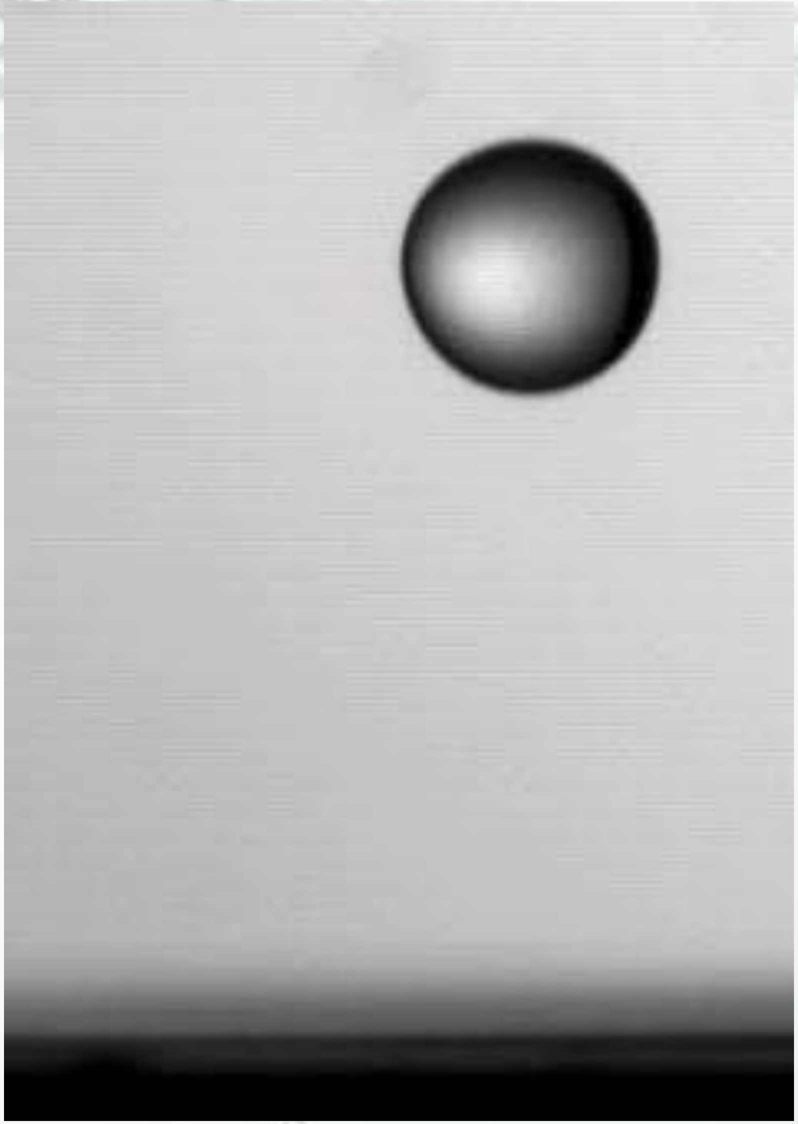
$$H \leq 3R$$

H is the initial height of the drop

R is drop radius

Bouncing

R=1mm
H=3-14mm



Coefficient of restitution

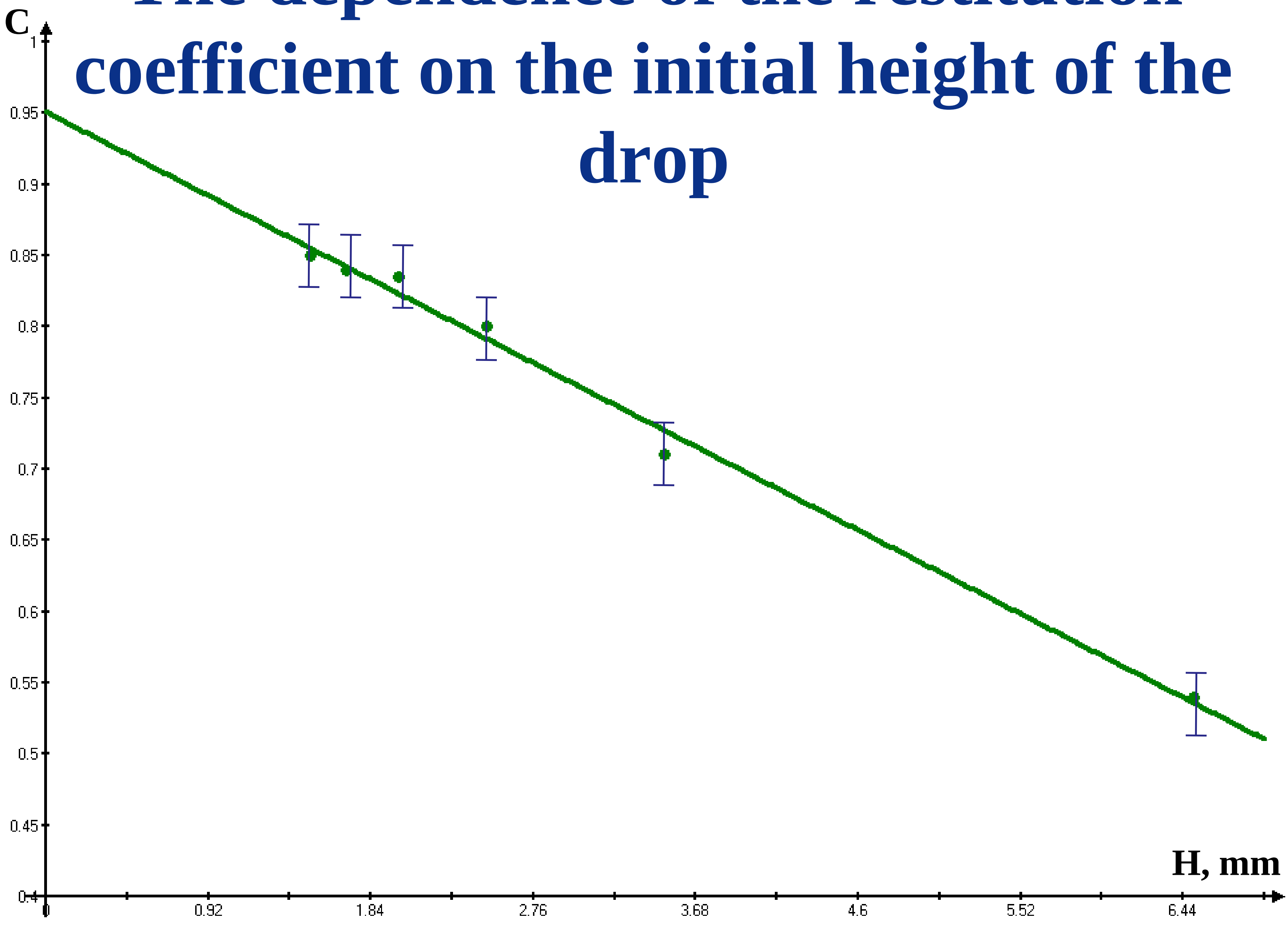
$$c = \frac{h}{H} \quad (2)$$

C is the coefficient of restitution

h is the height of the bounce

H is the initial height of the drop

The dependence of the restitution coefficient on the initial height of the drop



Bounce with a break of the droplet

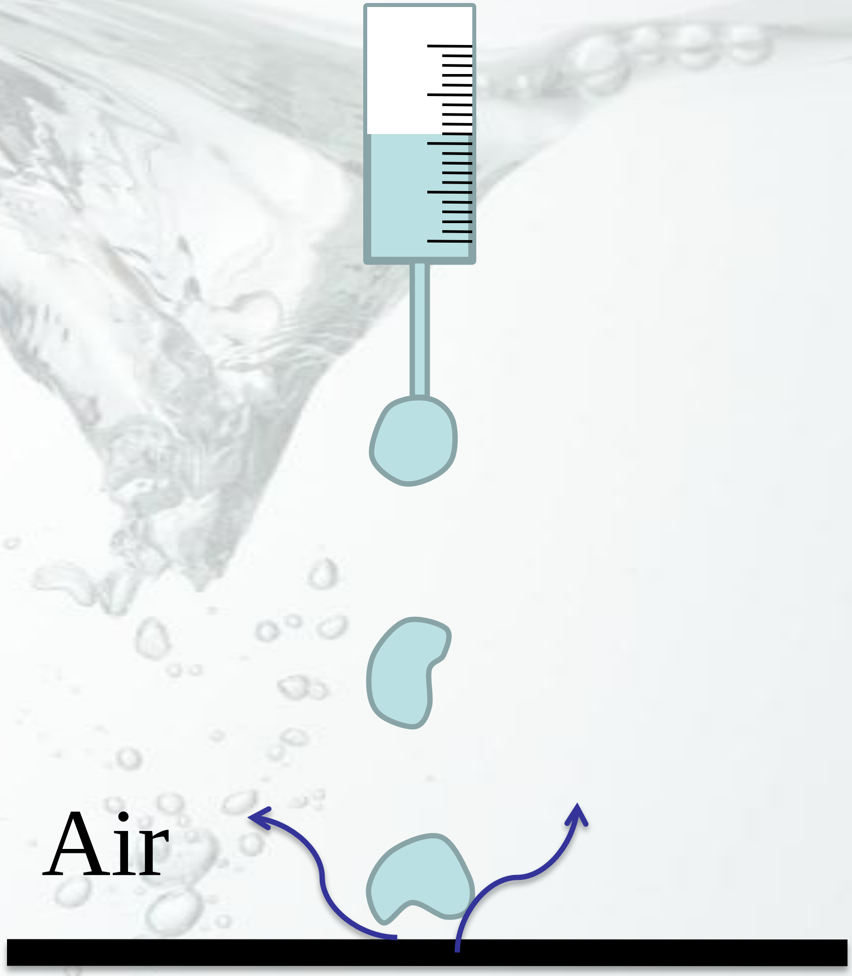
R=1mm
H=14-350mm

Why does the drop break?

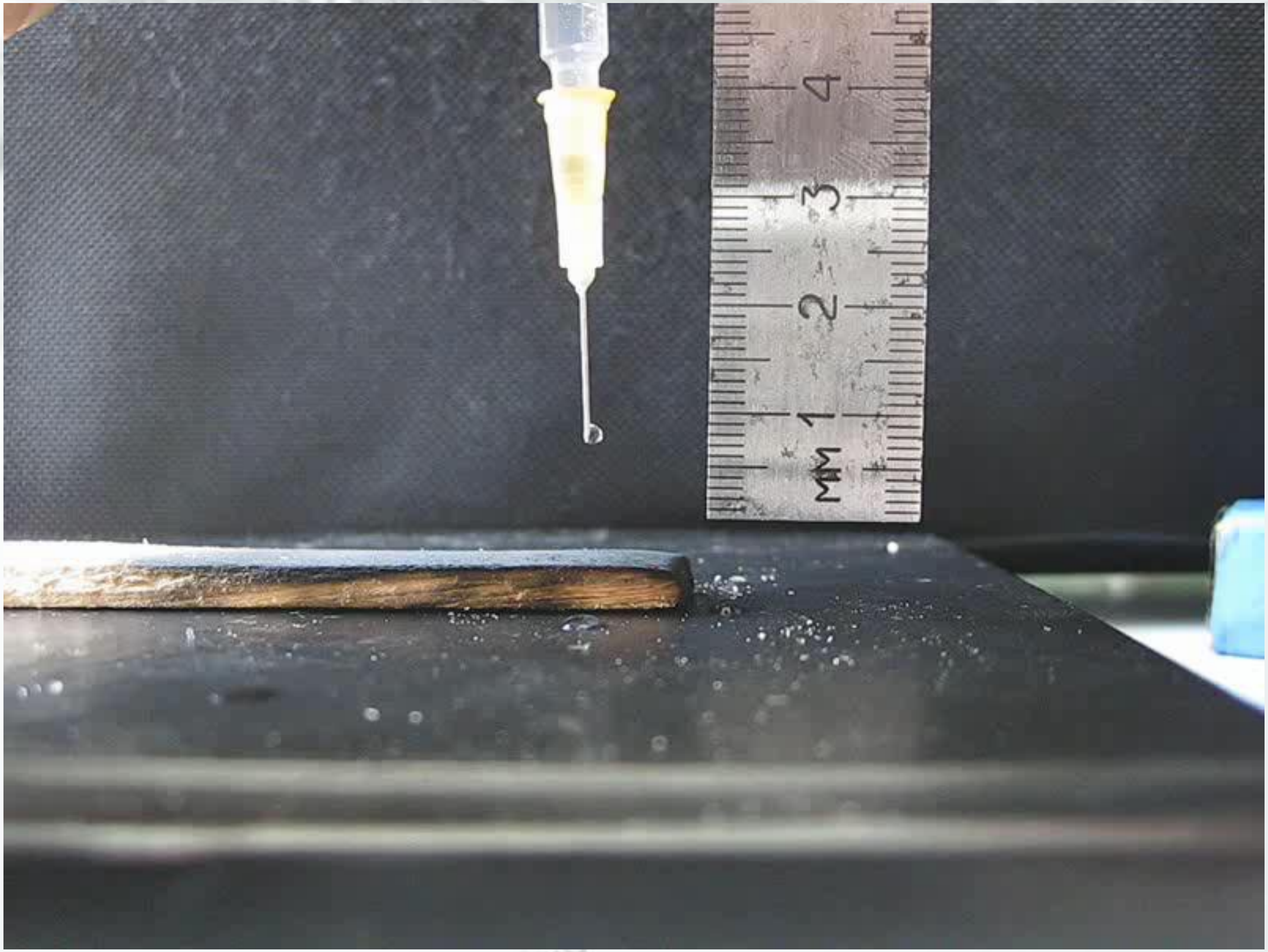
- ✓ The surface energy becomes more after contact with surface because of the shape changing
- ✓ Liquid “wants” to make it’s energy less
- ✓ The surface energy of droplets is less then of a cylinder
- ✓ So the cylinder divides into small droplets

The drop can sound

R=1mm
H=15mm



Movie with wood



Movie with hot surface

Splash

R=1mm
H=350mm -∞

Splash

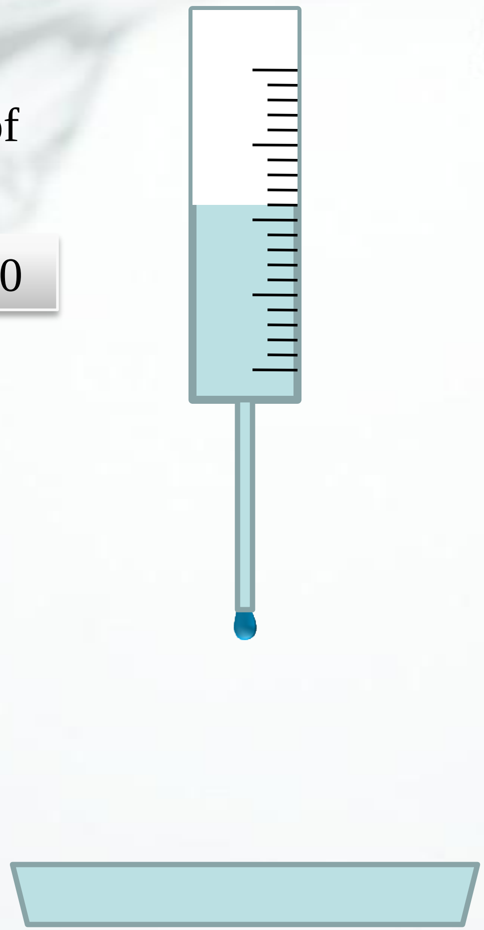
$$n = \frac{8mgH}{9\pi\sigma^2} \quad (3)$$

n is number of small droplets
m is the mass of the drop
σ is surface tension
H is the initial height of the drop

Setup for measuring surface tension

Number of drop

N=1000

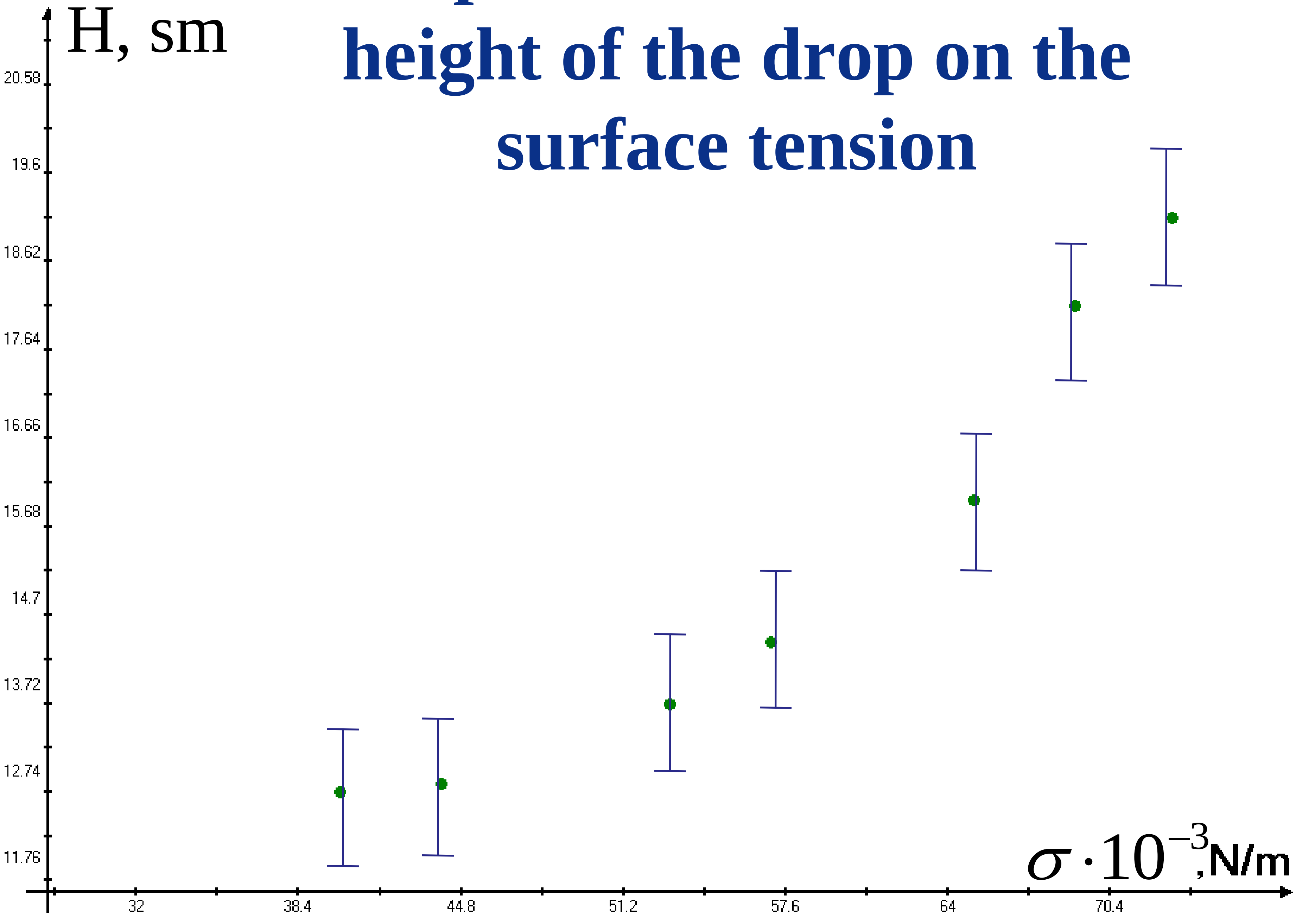


Design formula:

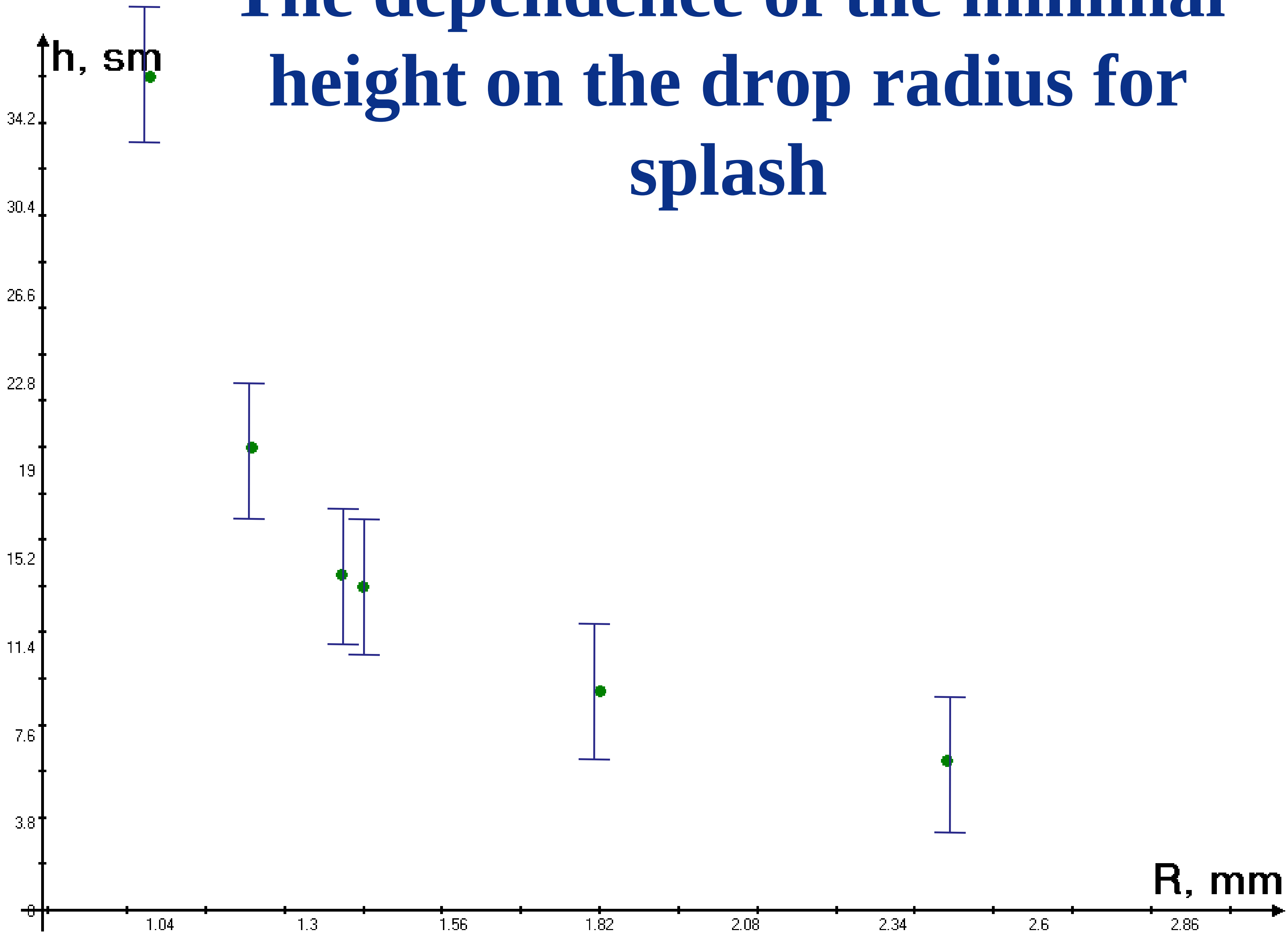
$$\sigma = \frac{\rho V g}{N \pi D}$$

σ is surface tension
ρ is density of liquid
V is volume of liquid
D is diameter of needle
N is drop's number
g is gravity acceleration

The dependence of the minimal height of the drop on the surface tension



The dependence of the minimal height on the drop radius for splash



Summary

- I have investigated all the stages we can observe in drops motion on a hydrophobic surface
- I have made a theoretical and quantitative experimental research
- I have investigated experimentally such parameters as the initial height of drop, drop radius, liquid surface tension, and type

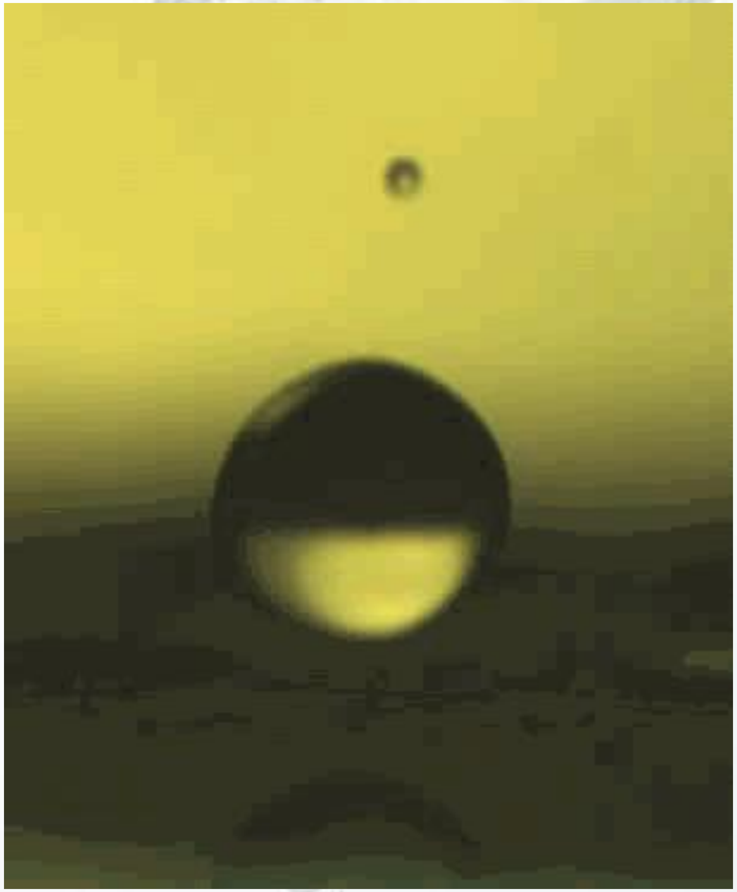
Summary

- I have also said about such parameter as viscosity and its influence on the bouncing, but I haven't made the experimental research.
- I have found such an event like a drop’s sound of a very hi frequency and have quantety

Thanks

- To Jakub Krolikowski, Polish scientist and my friend
- To Mathilde Reyssat from ESPCI (Paris, France)

Thank you for your attention!



Experiments with a slanting surface