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

Camera

Drop

Eagle

Hydrophobic surface
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

\[ E_{kinetic} + E_{surface} = \text{const} \]

\[ \frac{\partial}{\partial t} \left( E_{kinetic} + E_{surface} \right) = 0 \]
Characteristic oscillation

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

\( \omega_{\text{min}} \) is minimal drop’s frequency
\( \sigma \) is surface tension of the liquid
\( \rho \) is liquid density
\( R \) is drop radius
The dependence of the minimal drop’s frequency on the radius

\[ \omega_{\text{min}} = \sqrt{\frac{8\sigma}{\rho R^3}} \]  

(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

\[ c = \frac{h}{H} \]  \hspace{1cm} (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 than that of a cylinder
- So the cylinder divides into small droplets
The drop can sound

$R=1\text{mm}$

$H=15\text{mm}$

Air
Movie with wood
Movie with hot surface
Splash

R=1mm
H=350mm - $\infty$
\[ n = \frac{8mgH}{9\pi\sigma^2} \] (3)

- \( n \) is the number of small droplets
- \( m \) is the mass of the drop
- \( \sigma \) is surface tension
- \( H \) is the initial height of the drop
Setup for measuring surface tension

Design formula:

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

- \( \sigma \) is surface tension
- \( \rho \) is density of liquid
- \( V \) is volume of liquid
- \( D \) is diameter of needle
- \( N \) is drop’s number
- \( g \) is gravity acceleration

Number of drop

\( N = 1000 \)
The dependence of the minimal height of the drop on the surface tension

\[ H, \text{ sm} \]

\[ \sigma \cdot 10^{-3}, \text{N/m} \]
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 high frequency and have quantity
Thanks

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Experiments with a slanting surface