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Winterthur 2005

Team of AUSTRIA

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Problem No.: 6. Noise

When a droplet of water or other liquid falls on a hot surface, it produces a sound. On what parameters does the sound depend?

Reporter: Christina Koller

Structure

- experimental Setup
- variations
- theory
- conclusions

Experimental Setup

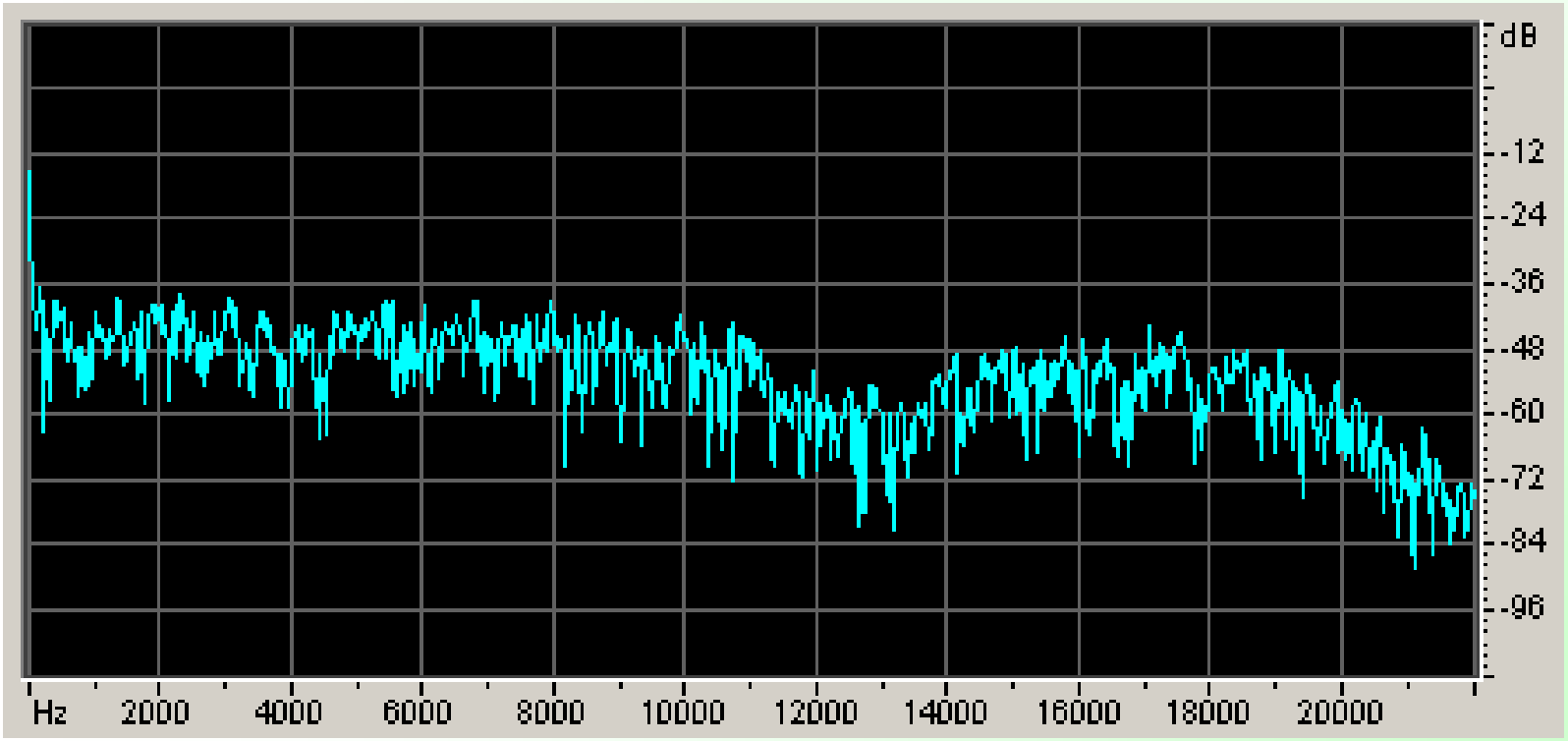
hotplate

pipette

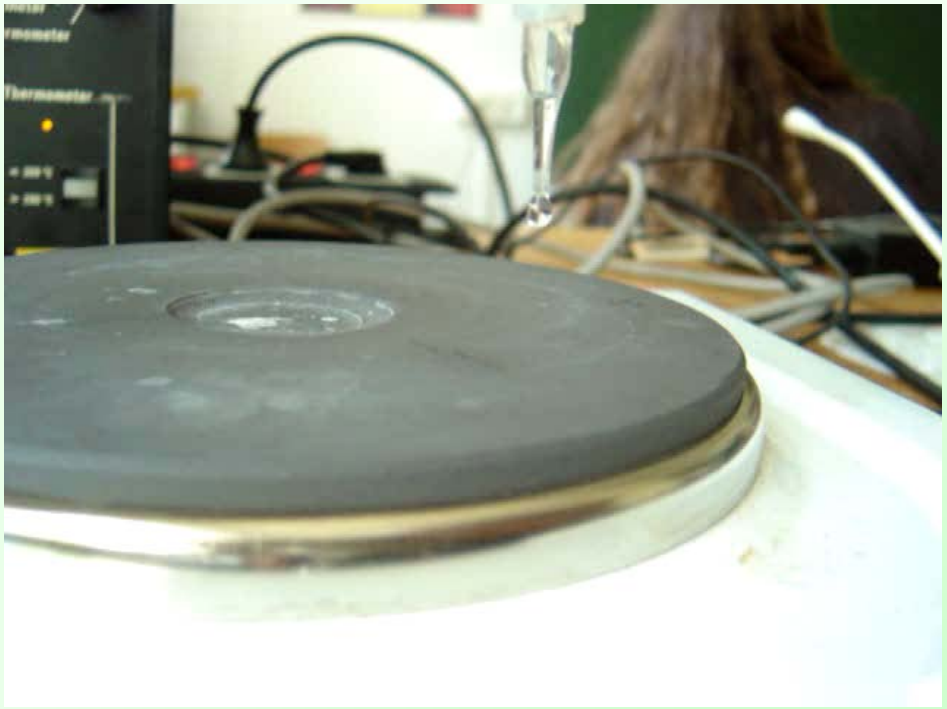
variations

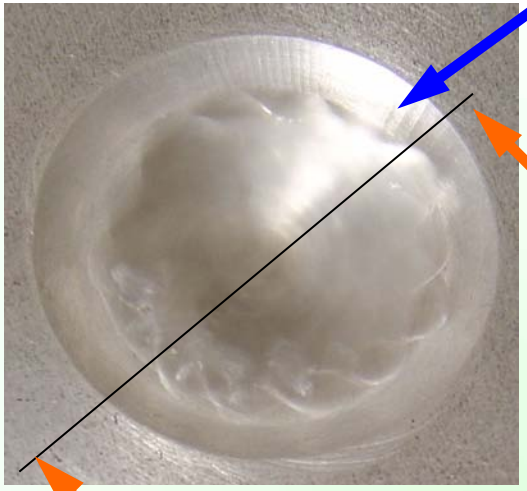
- size of the droplet 
- temperature 
- height of the outlet
- surface of the plate

sound example

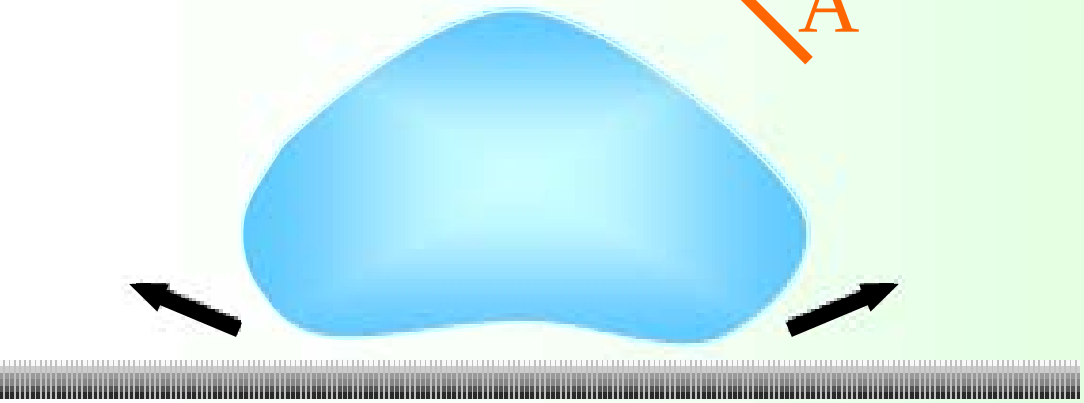


theory

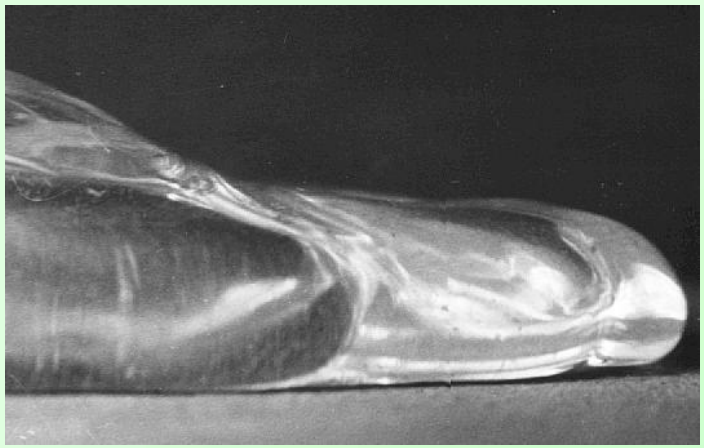




A-A

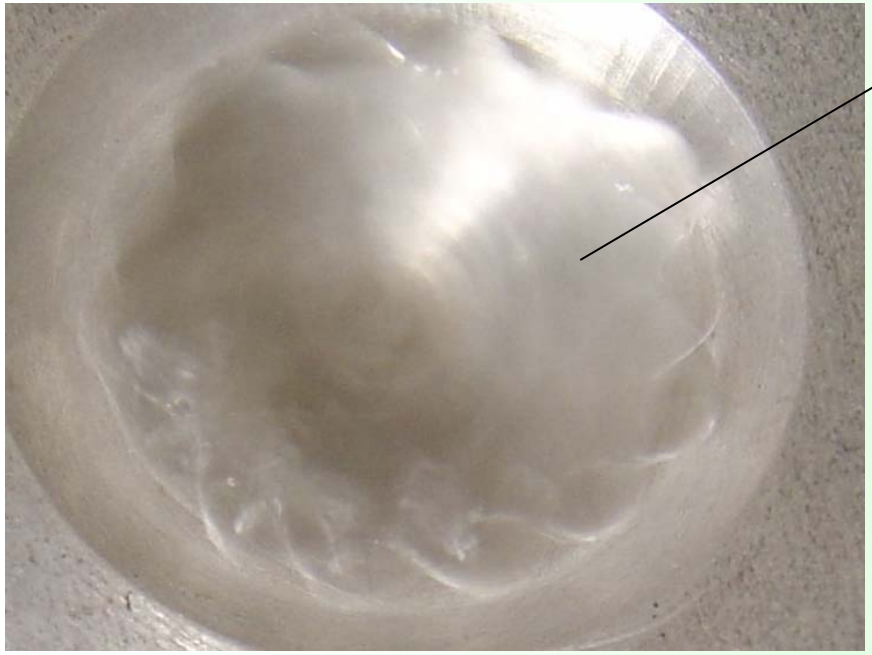


B



oscillation

convection currents



inside the droplet

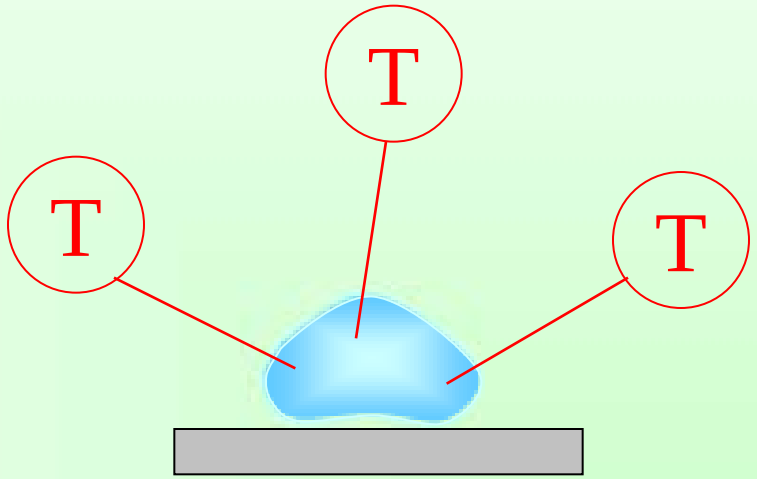
isothermal

temperature of the plate: 330° - 370°

waterdroplet: 91°

ethanoldroplet: 71°

acetonedroplet: 48°



R > a

$$R(t) = R_0 \cdot (1 - \frac{t}{\tau_1})^2$$

R << a

$$R(t) = R_0 \cdot (1 - \frac{t}{\tau_2})^{\frac{1}{2}}$$

a … capillary length

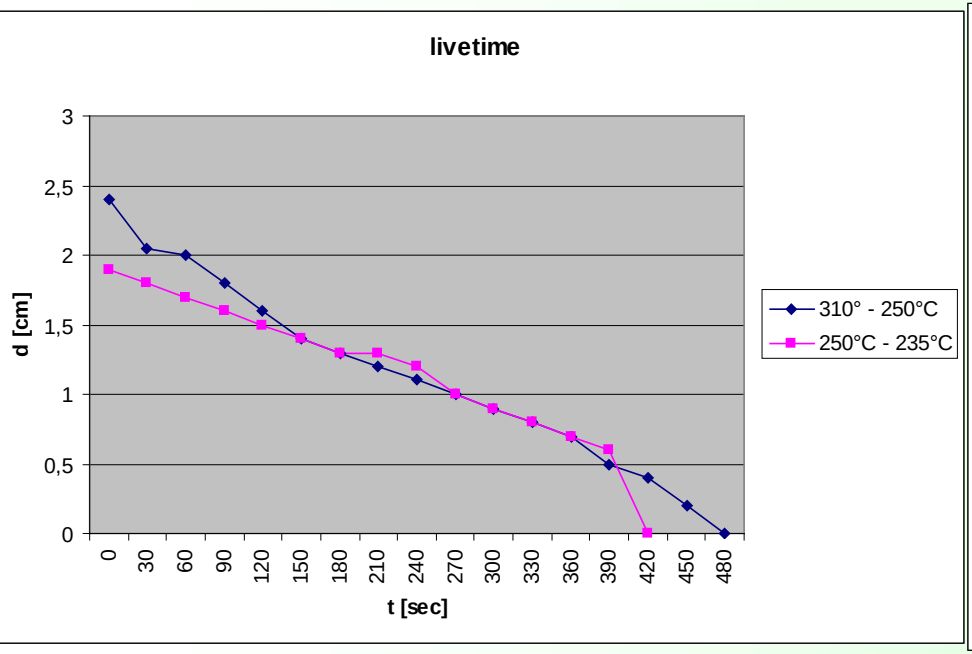
t… time

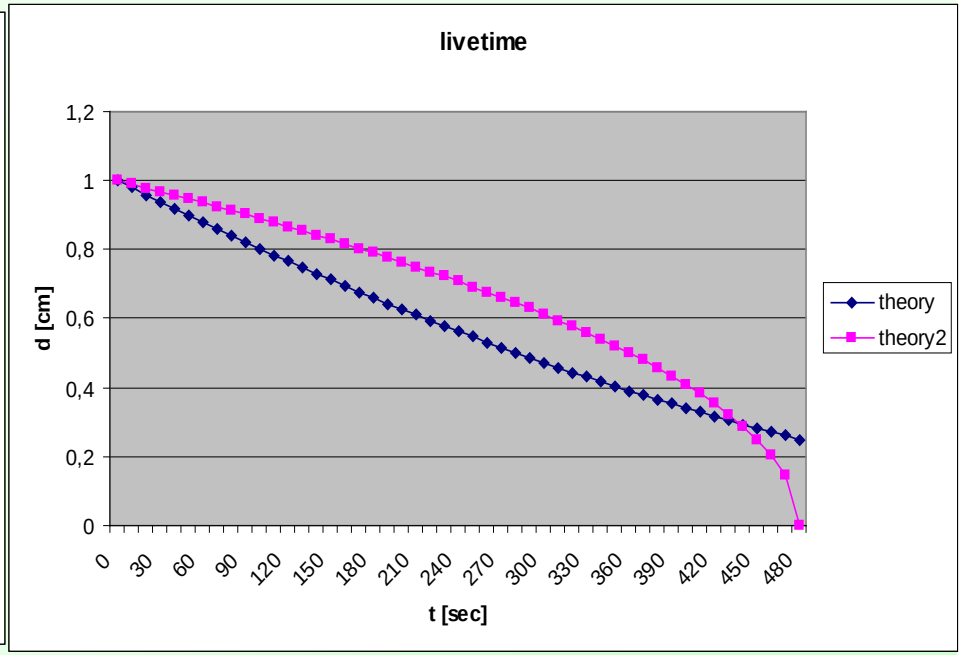
$R_{(t)}$ *… radius*

τ_1, τ_2 *… lifetime*

$R_{(o)}$ *… radius (t = 0)*

Life time of a droplet





Life time

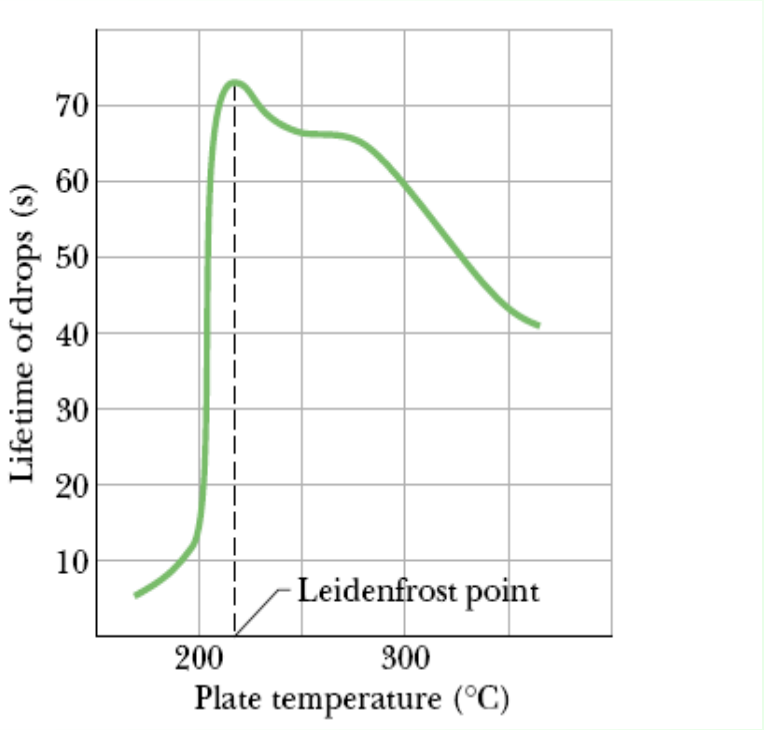
R > a

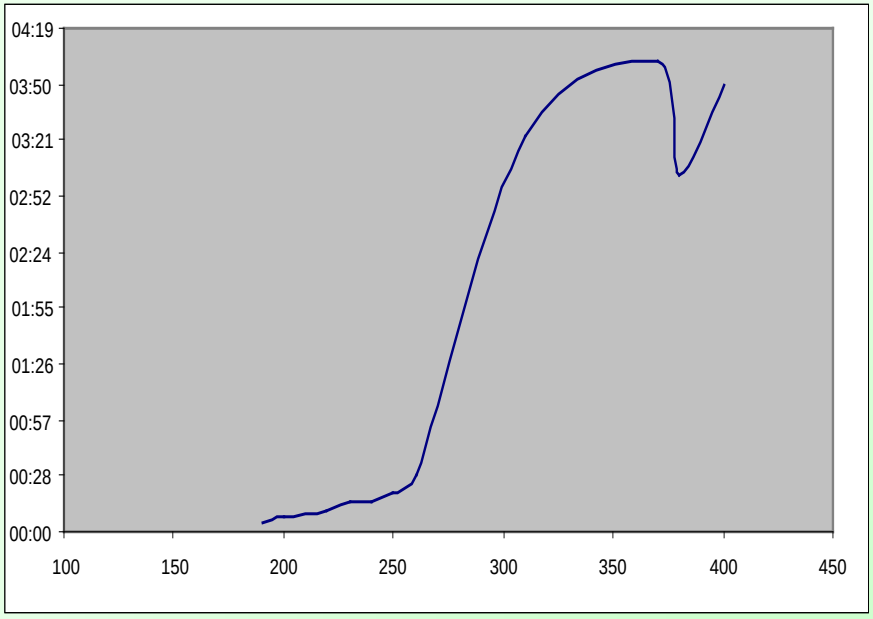
$$\tau_1 \propto (\Delta T)^{-\frac{3}{4}} \qquad (3)$$

R << a

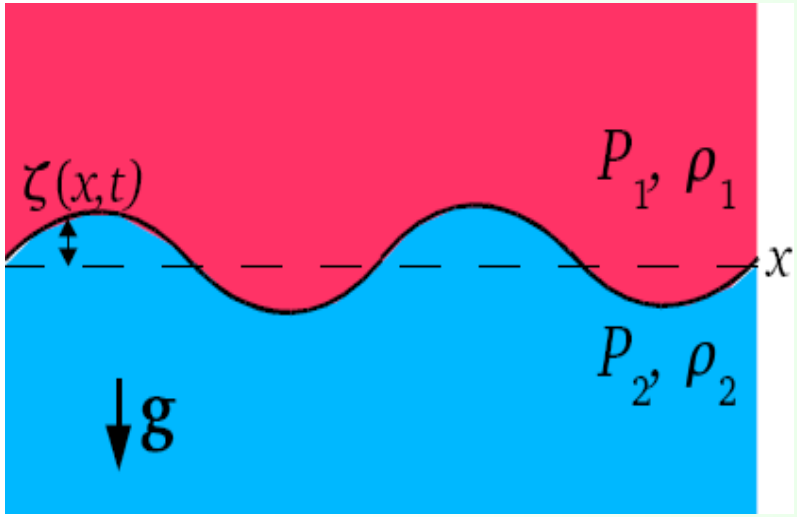
$$\tau_2 \propto (\Delta T)^{-1} \qquad (4)$$

Leidenfrost curve





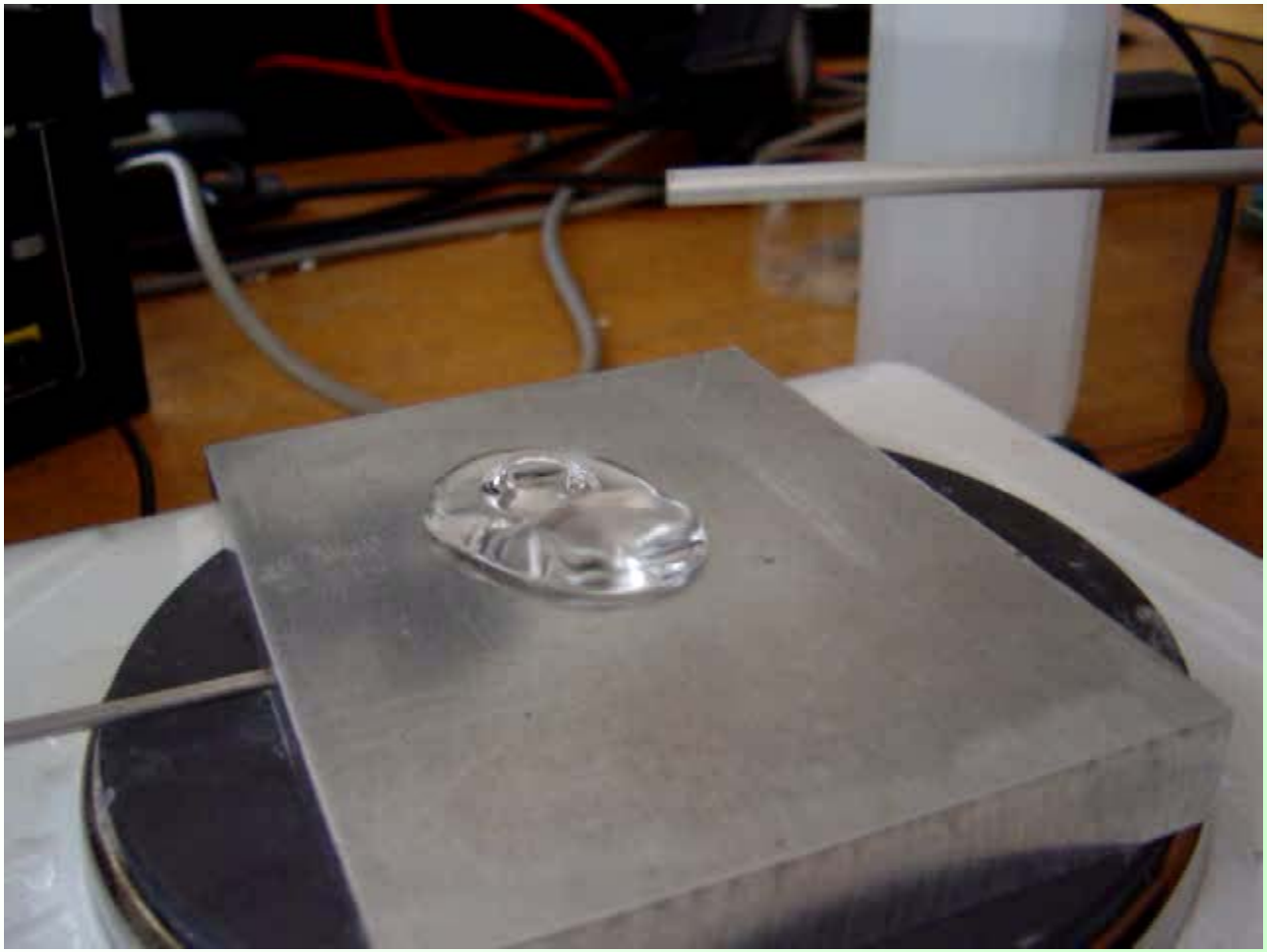
Rayleigh Taylor instability



ξ ... displacement of surface

g ... gravity field

P ... pressure



pertubation: $z = \varepsilon \cdot (1 + \cos(k \cdot r))$

pressure difference: $\Delta P = P_A - P_B$

$$k = \frac{\pi}{R_C}$$

$$\Delta P = 2 \cdot \rho \cdot g \cdot \left[1 - \frac{3 \cdot (a \cdot k)^2}{2} \right]$$

critical radius: $R_C = 3{,}84h$

r ... radial coordinate

conclusion

main parameters:

- temperature of the plate
- structure of the plate
- size of the droplet
- height of the outlet