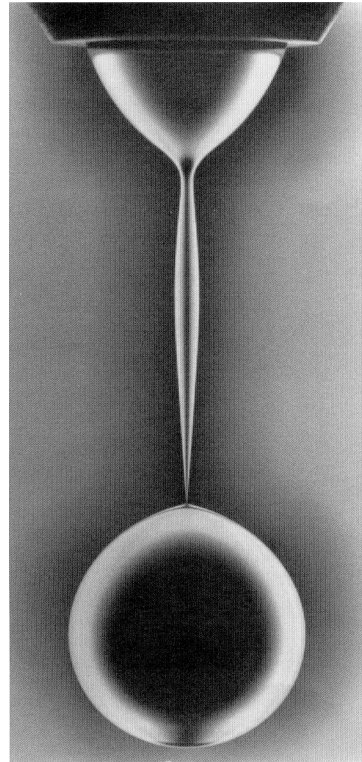


Fascinerende strukturer i vand og sand – og deres fysik

En masse spændende fysik til at tage og føle på...



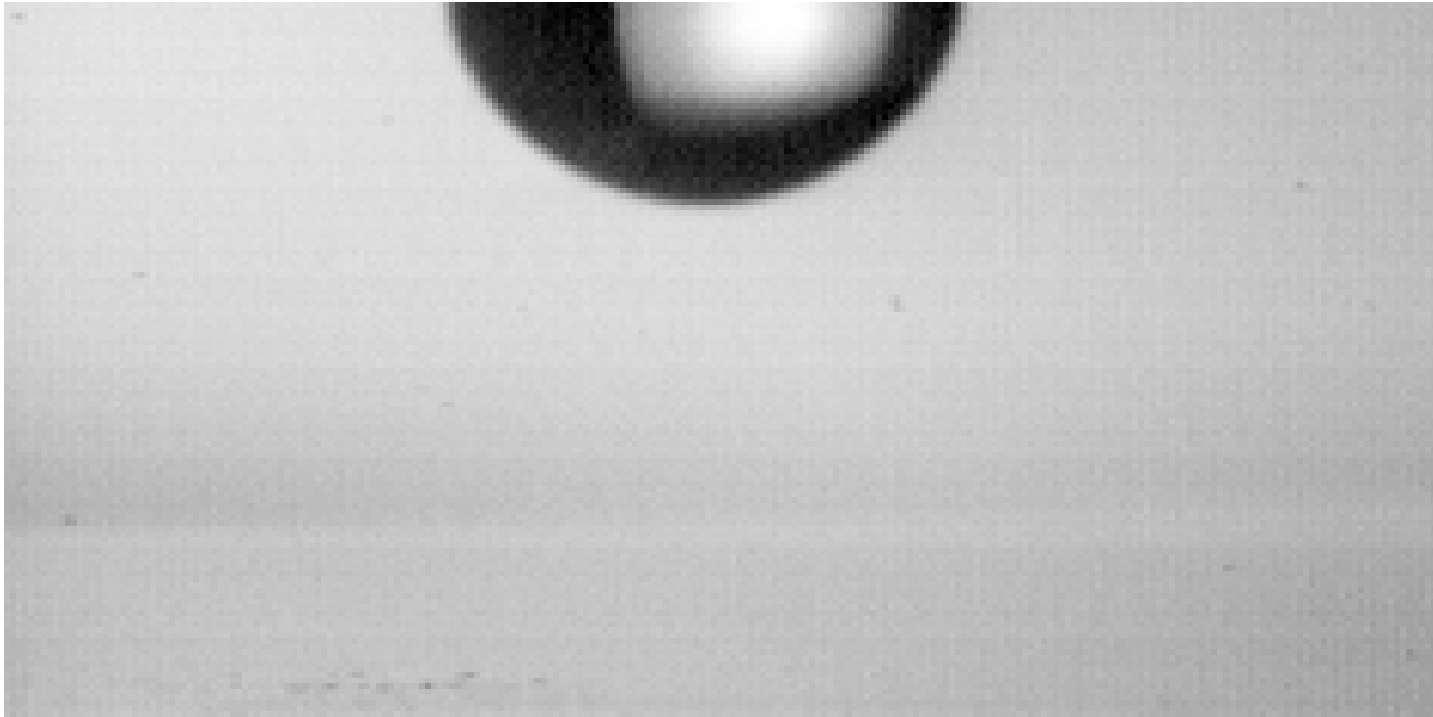
Følg med i en rivende udvikling...

Tomas Bohr

Væsker i ro og i bevægelse

- Overfladespænding
- Tyngde/kapillære bølger på en overflade - shockbølger
- Hvirvler, lift og separation - tornadoer og planetatmosfærer
- Instabiliteter (Rayleigh-Plateau, Kelvin-Helmholtz)

Vanddråber er elastiske



hydrofobt underlag

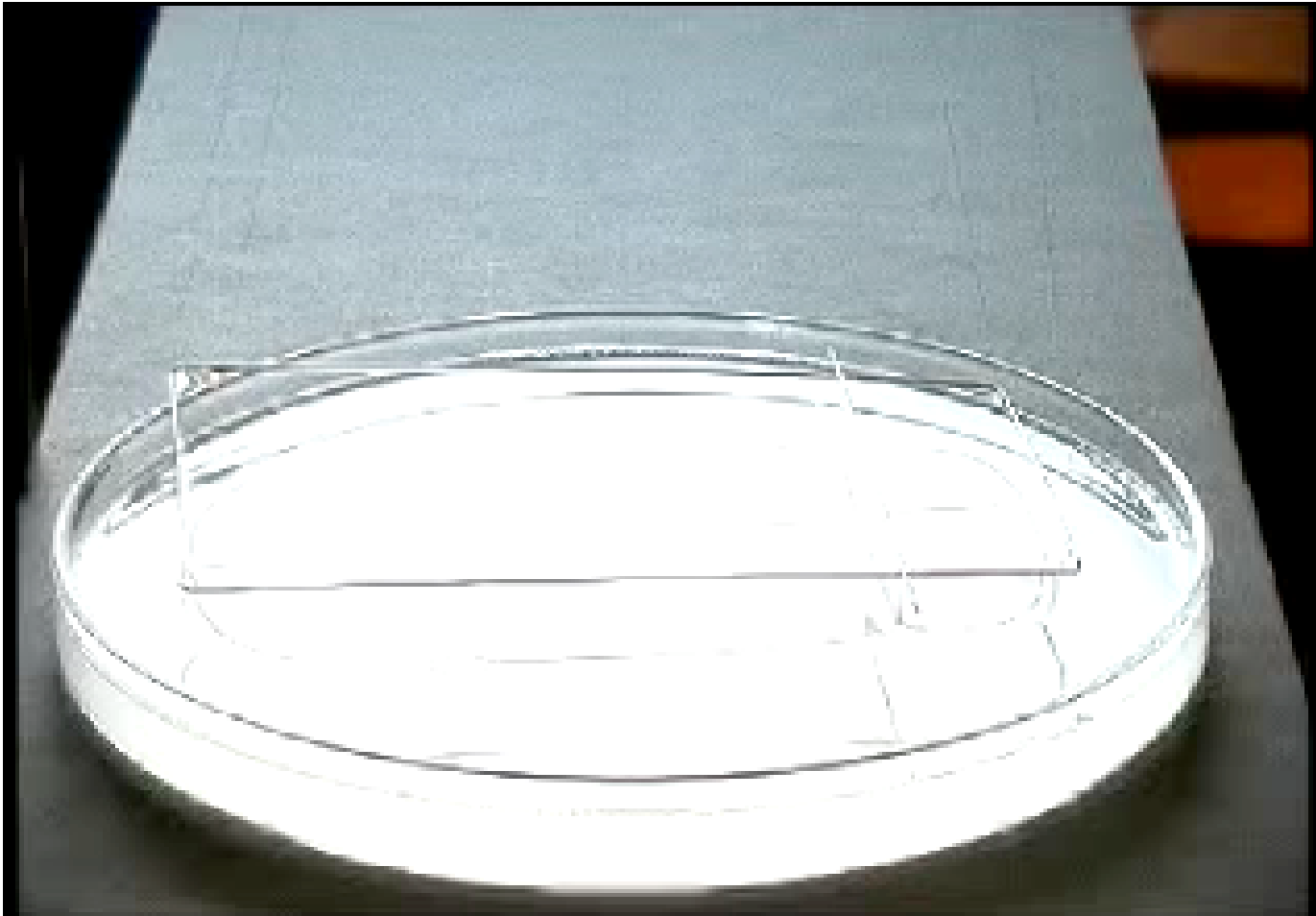
Christophe Clanet, Marseille

Tre basale postulater

1. *Henover en hvilken som helst linje i overfladen virker en kraft σ pr. længde (spænding), som trækker vinkelret på linjen*
2. *Det koster en vis konstant mængde energi (pr. overfladeenhed) σ at skabe en ny overflade*
3. *Over (under) trykket inden for en krum overflade er*

$$p_i - p_u = \sigma \cdot \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$

Postulat 1: overflade spændingen forsøger at trække overfladen fra hinanden

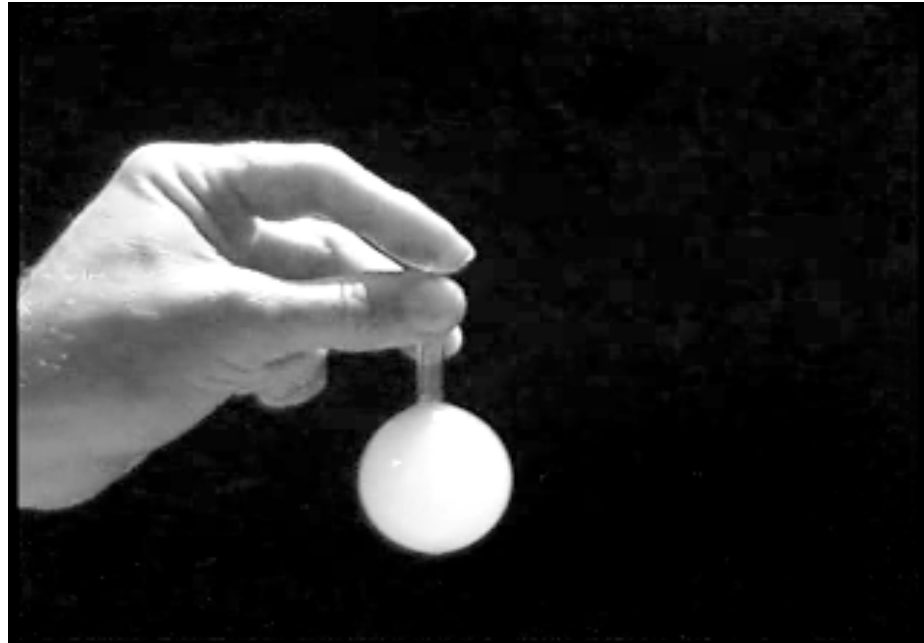


Overflade-
spænding er en
kraft pr. længde,
typisk milliNewton
pr. meter

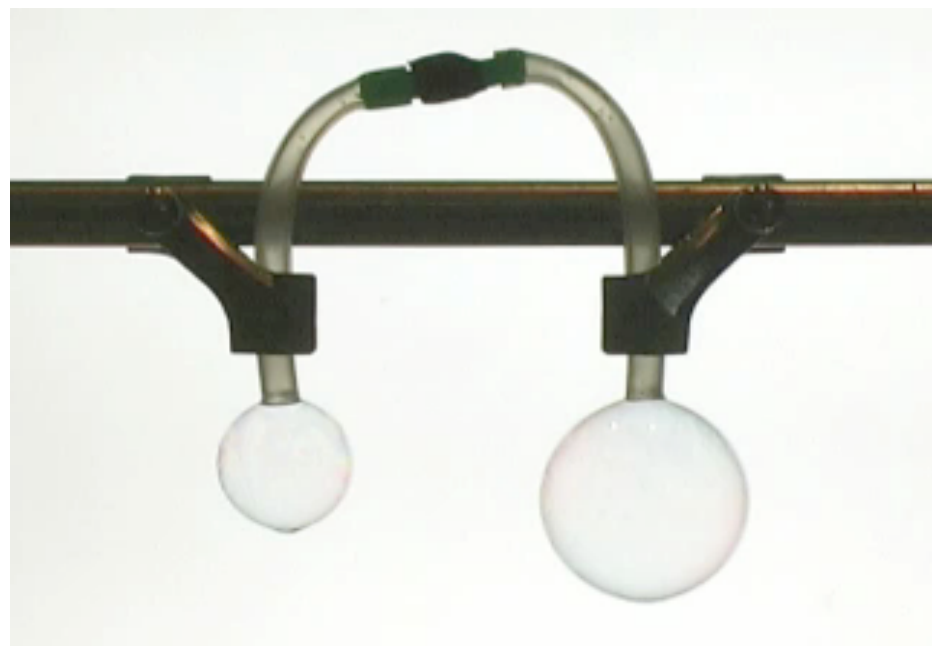
$$[\sigma]=MT^{-2}$$

Christophe Clanet, Marseille

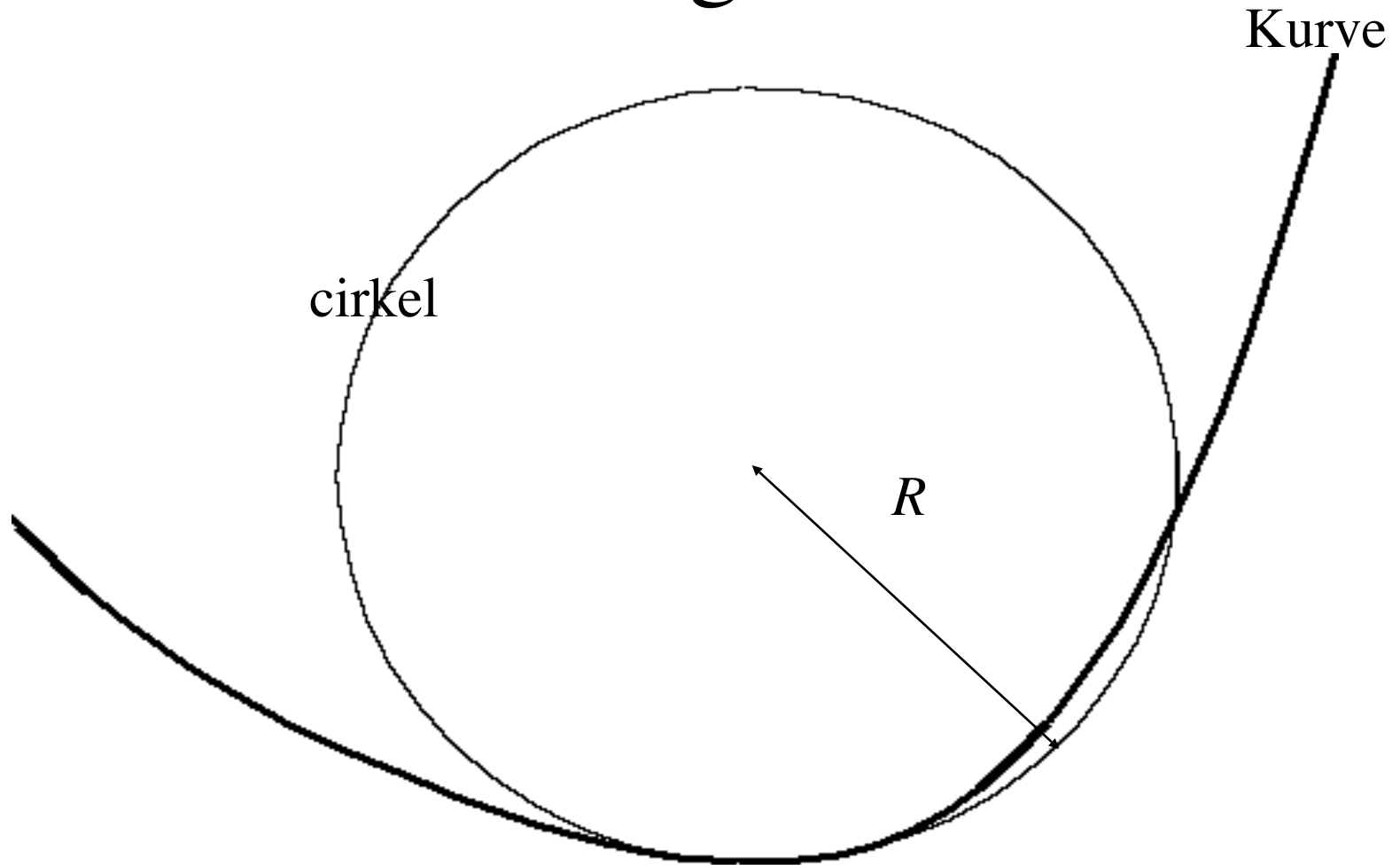
Der er overtryk i en sæbeboble



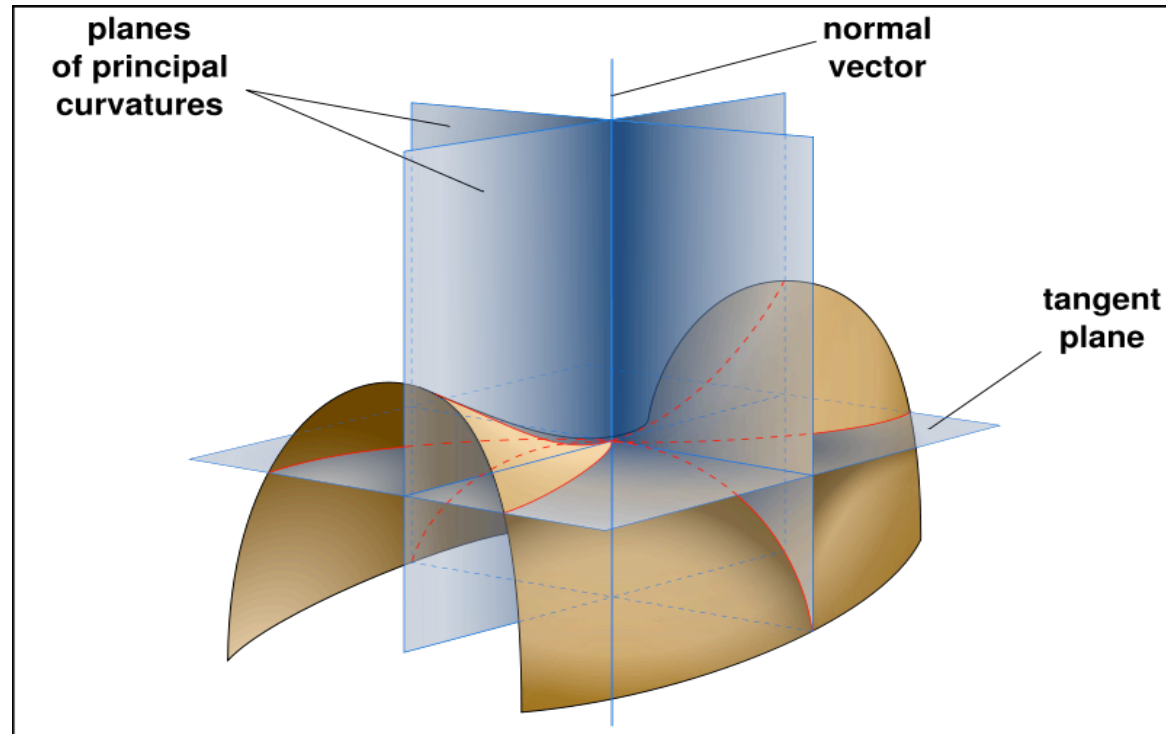
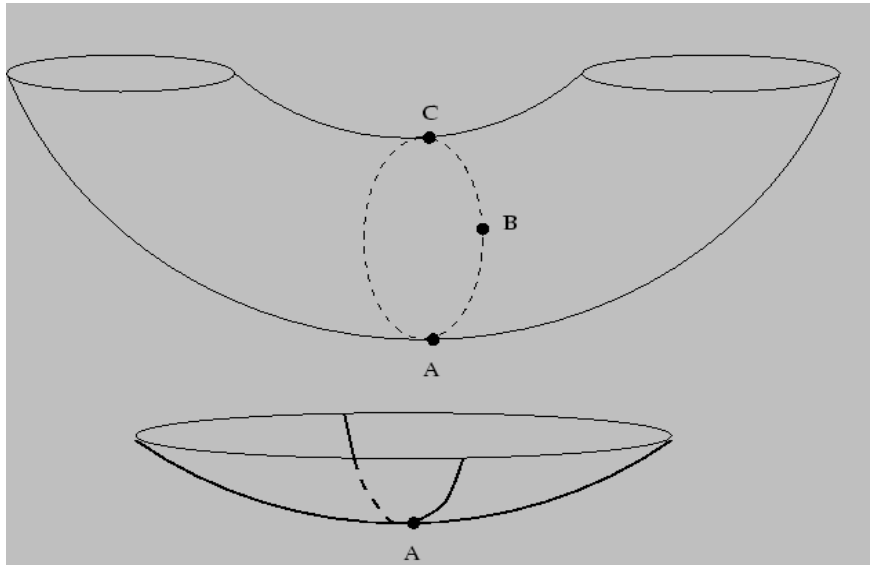
$$\textit{Overtryk} = p_i - p_u = \frac{4\sigma}{R}$$



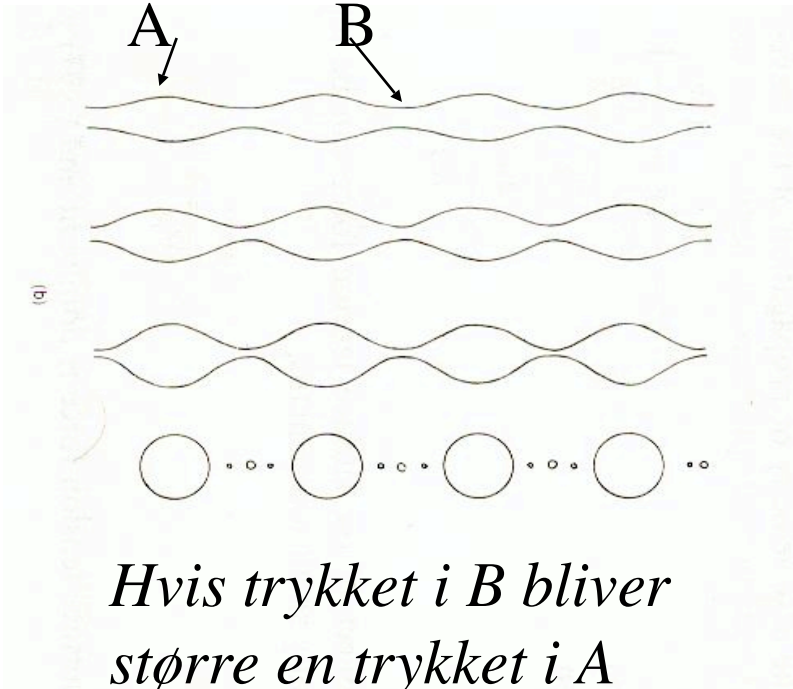
Krumningsradius



Hovednormalkrumningsradier



Rayleigh-Plateau Instabilitet



Hvis trykket i B bliver større en trykket i A bliver halsen B endnu tyndere og det giver en instabilitet

$$(p_i - p_u) = \sigma \cdot \left(\frac{1}{r_1} + \frac{1}{r_2} \right)$$

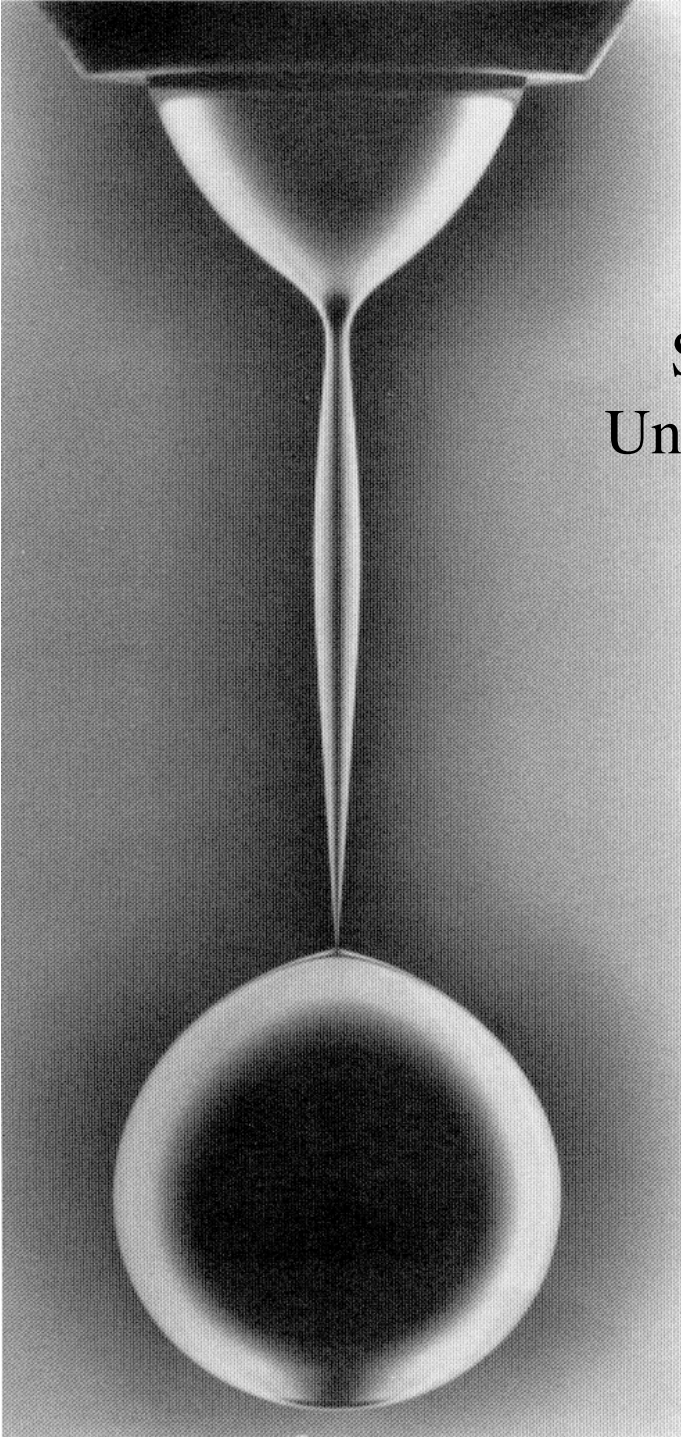


Dryppende
vandhane

Daniel Bonn

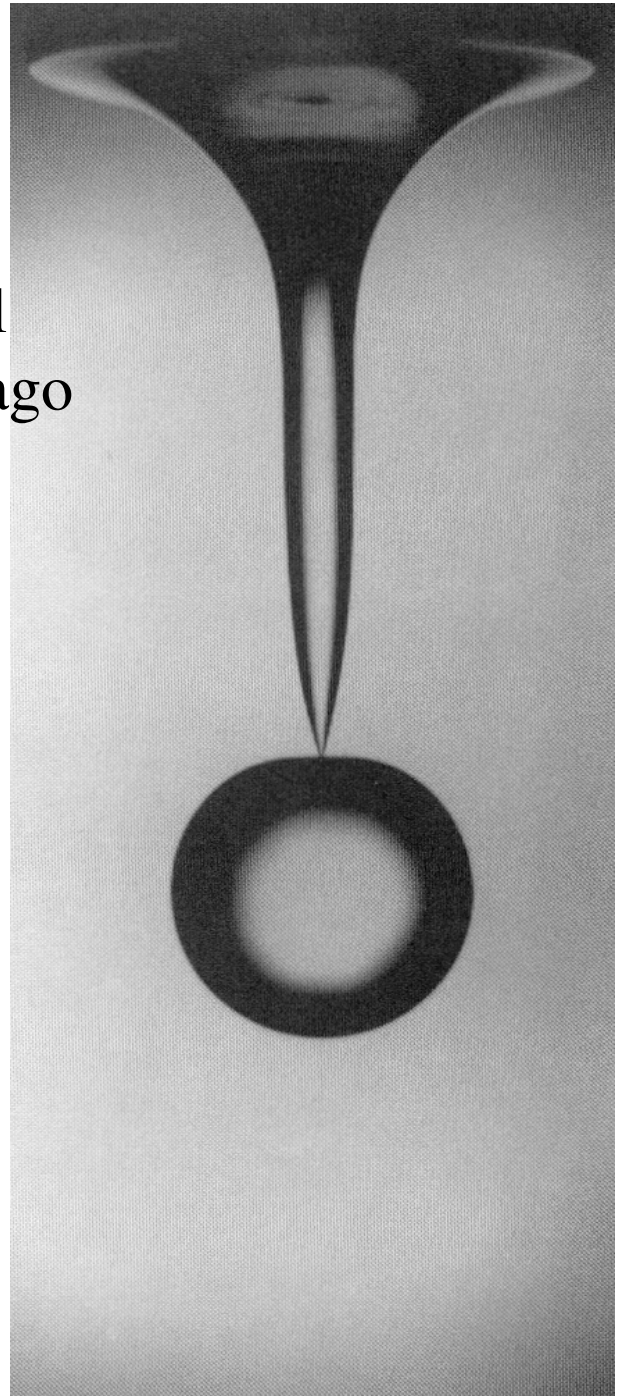


orte
t



Sidney R. Nagel
University of Chicago

det rigtige sted
på det rigtige
tidspunkt



Formen af en vandoverflade: overfladespænding vs. tyngde

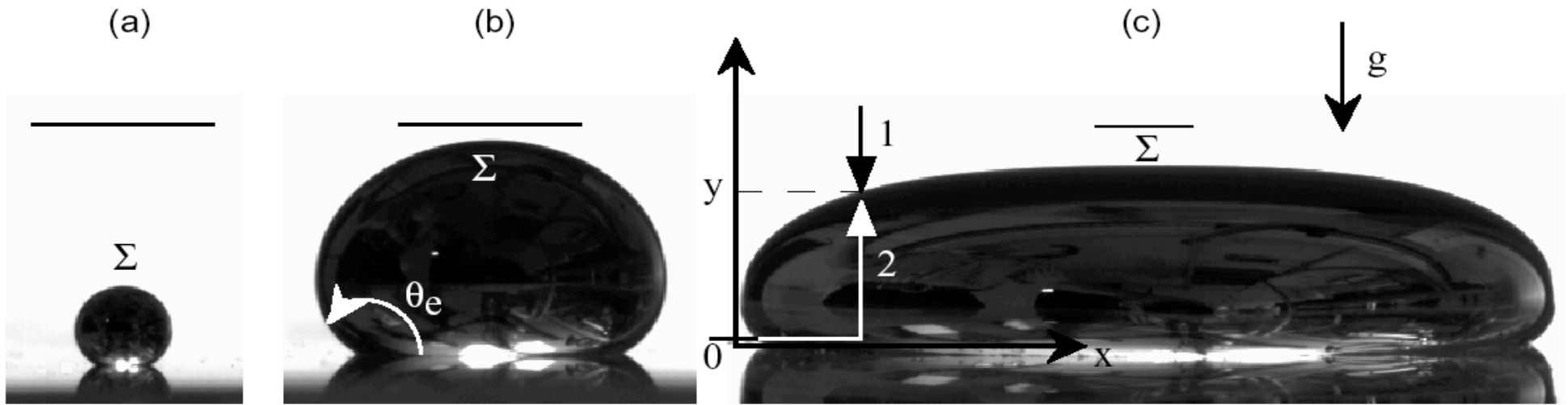


FIG. 3. Drops of mercury on plexiglass ($\theta_e \approx \pi$), with different volumes: (a) $\mathcal{V} = 0.35 \text{ mm}^3$, (b) $\mathcal{V} = 12.9 \text{ mm}^3$, (c) $\mathcal{V} = 426.5 \text{ mm}^3$, (the horizontal bar on each picture represents 1.7 mm).

Kapillarlængden

$$l_c = \sqrt{\frac{\sigma}{\rho g}}$$

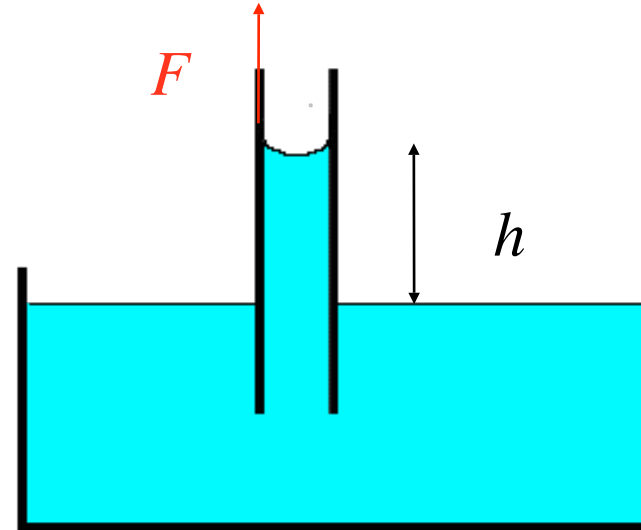
vand: $l_c \approx 2.7\text{mm}$

Hårrørsvirkning

Via Postulat 3:

$$\rho g h = \frac{2\sigma}{r} \Rightarrow$$

$$h = 2 \frac{\sigma}{\rho \cdot g} \frac{1}{r} = 2 \frac{l_c^2}{r}$$

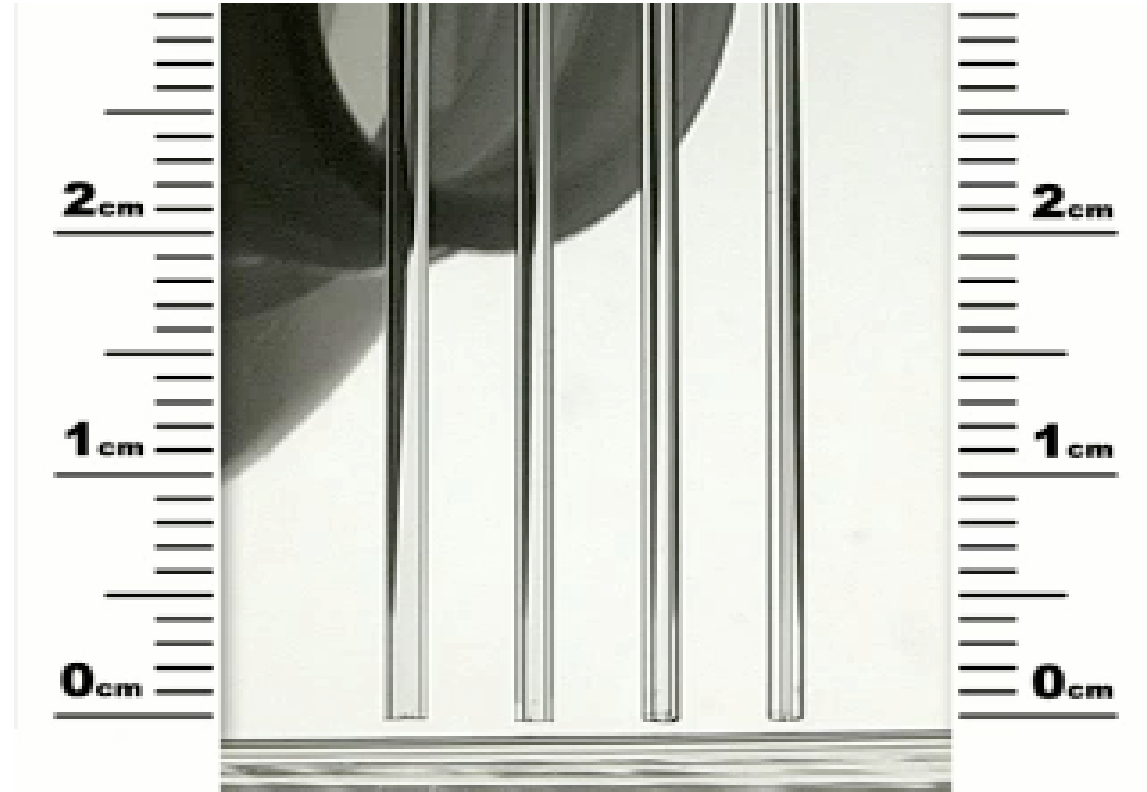


Via Postulat 1

Samlede kraft opad = $2\pi r \cdot \sigma$

Samlede kraft nedad = $\pi r^2 \cdot \rho \cdot g \cdot h$

Hårrørsvirkning

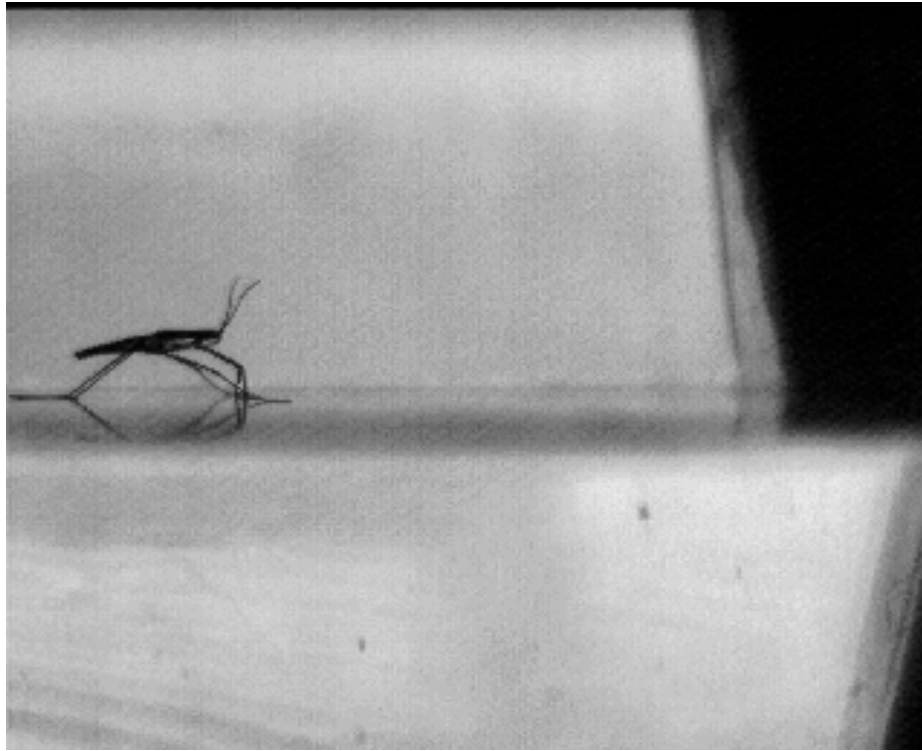


Bevægelse på vandoverflader



John Bush, MIT

Skøjteløbere



John Bush, MIT



Hydraulisk spring

- Overfladebølger
- Shockbølger
- Bølgebrydning
- Separation (hvirvler)
- Instabilitet
- Symmetribrud
- Overfladespænding

Overladebølger

$$\omega^2 = gk(1 + l_c^2 k^2) \tanh(kh)$$

$$l_c^2 = \sqrt{\frac{\sigma}{\rho g}}$$

Shockbølger

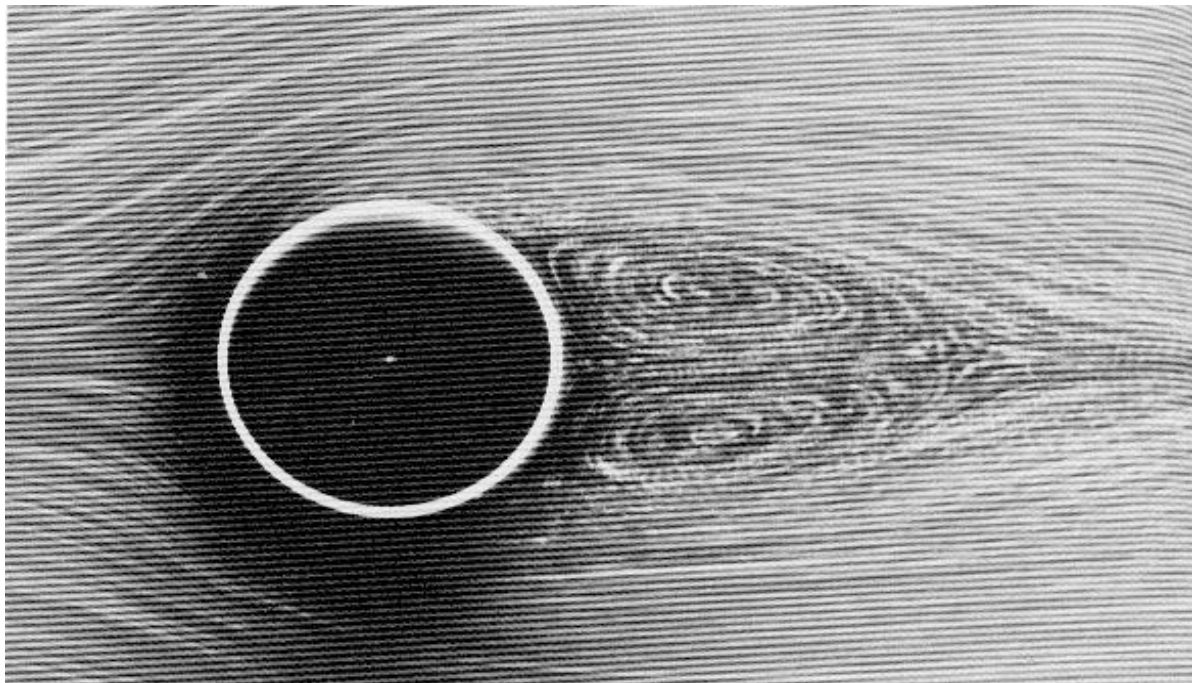
$$U_{gas} > U_{lyd}$$

supersonic

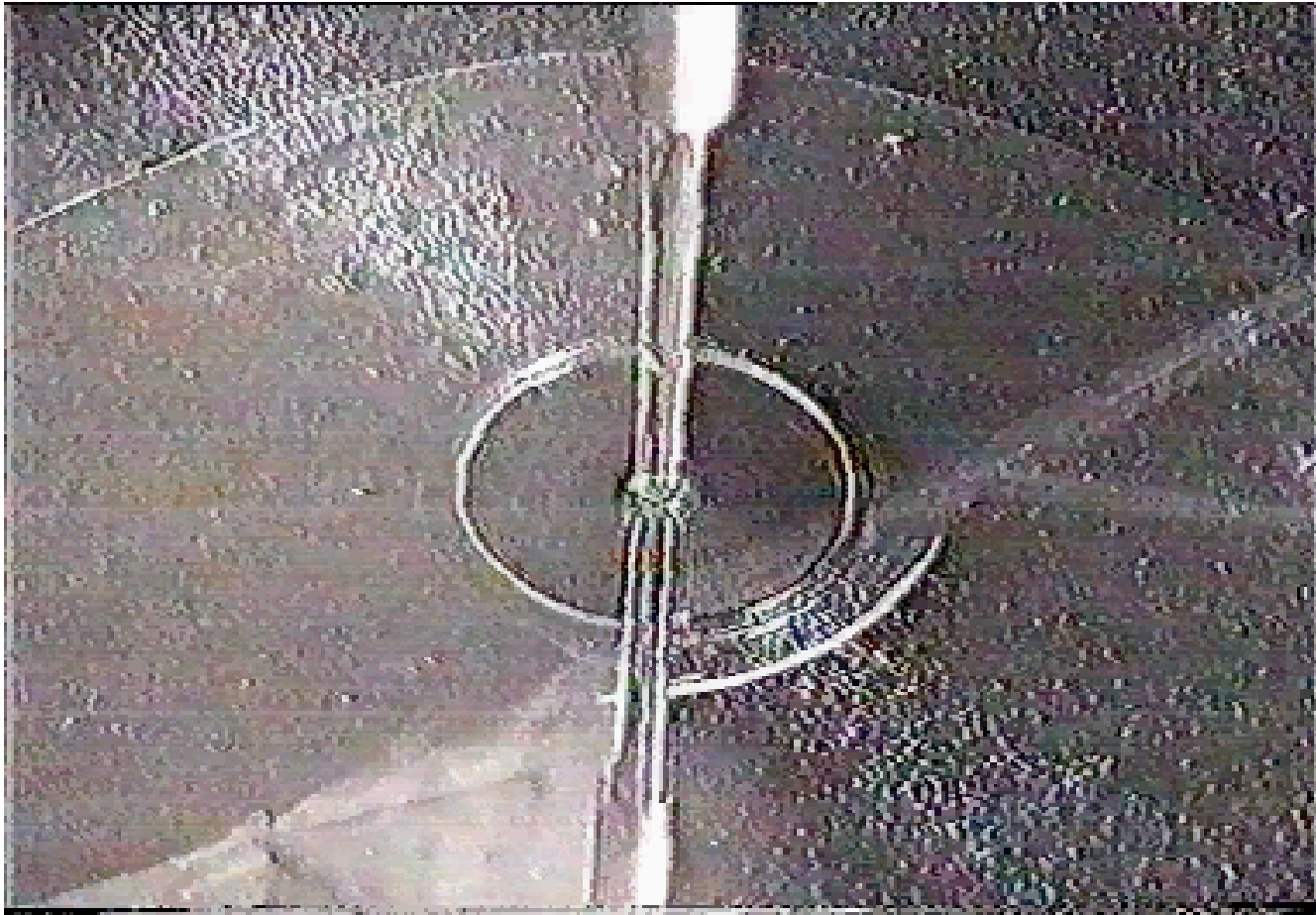
$$U_{gas} < U_{lyd}$$

subsonic

Separation i grænselaget rund om en cylinder

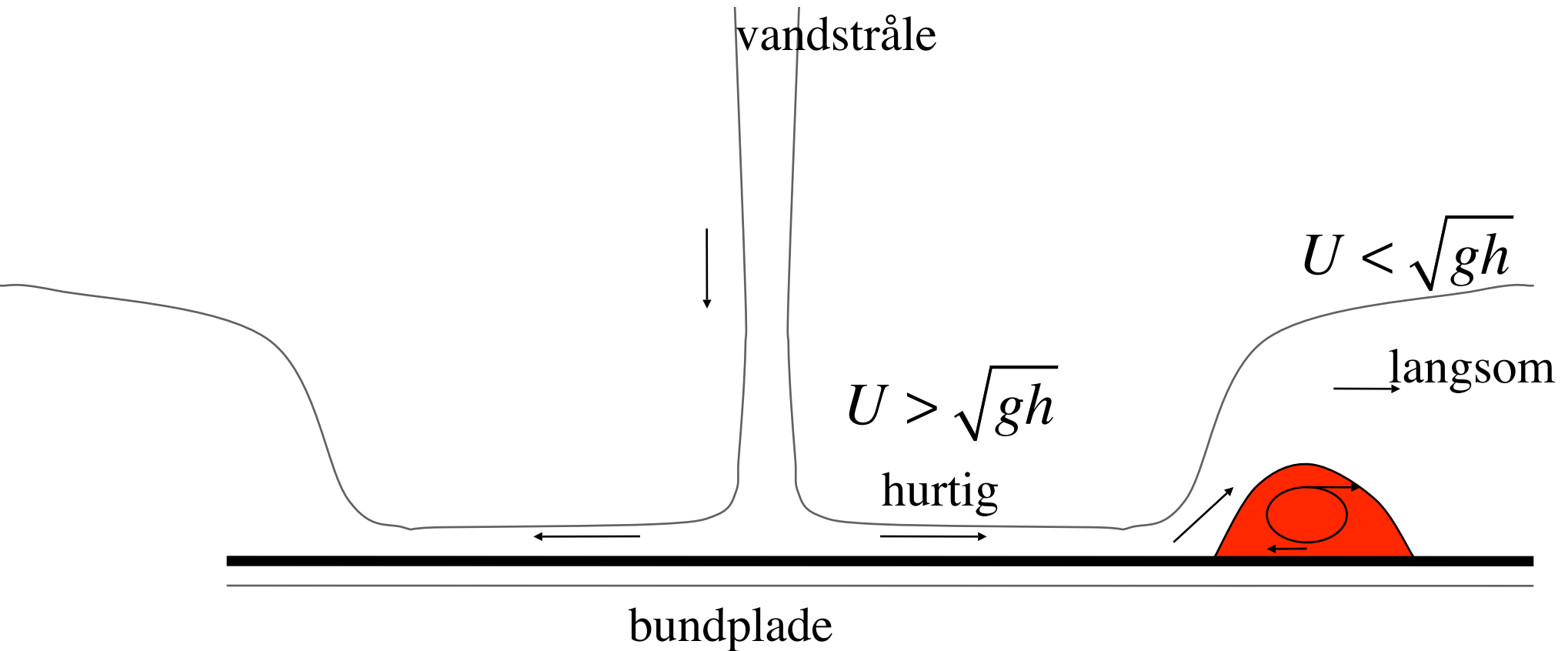


Et hydraulisk spring

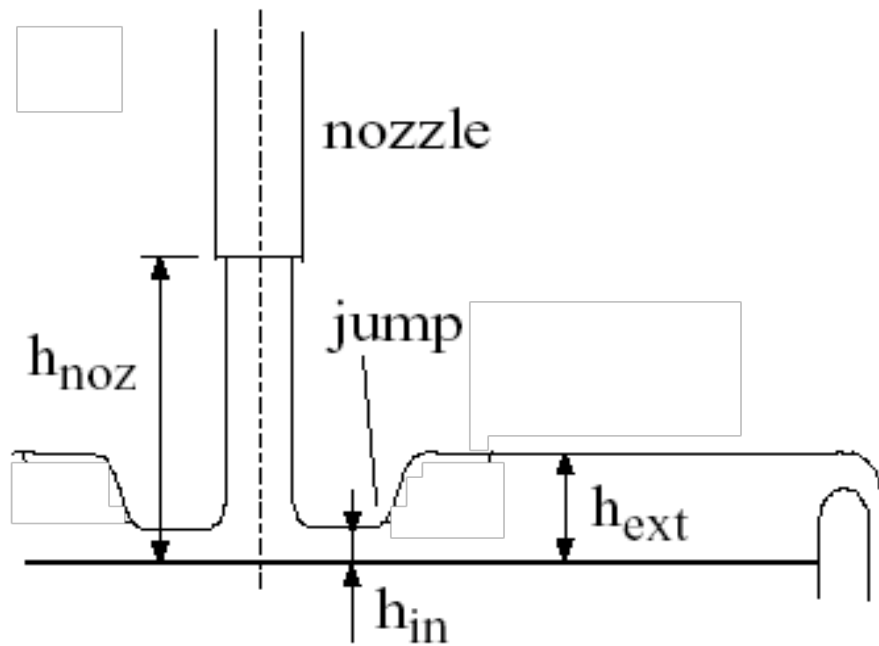


Kig i køkkenvasken (overlad ikke opvasken til konen!)

Det hydrauliske spring skyldes **separation**



Type I - Type II transition



External height, h_{ext} is controlled

Ellegaard et al. 1998

hydraulic jump in ethylene glycol (anti freeze) on glass plate - seen from below

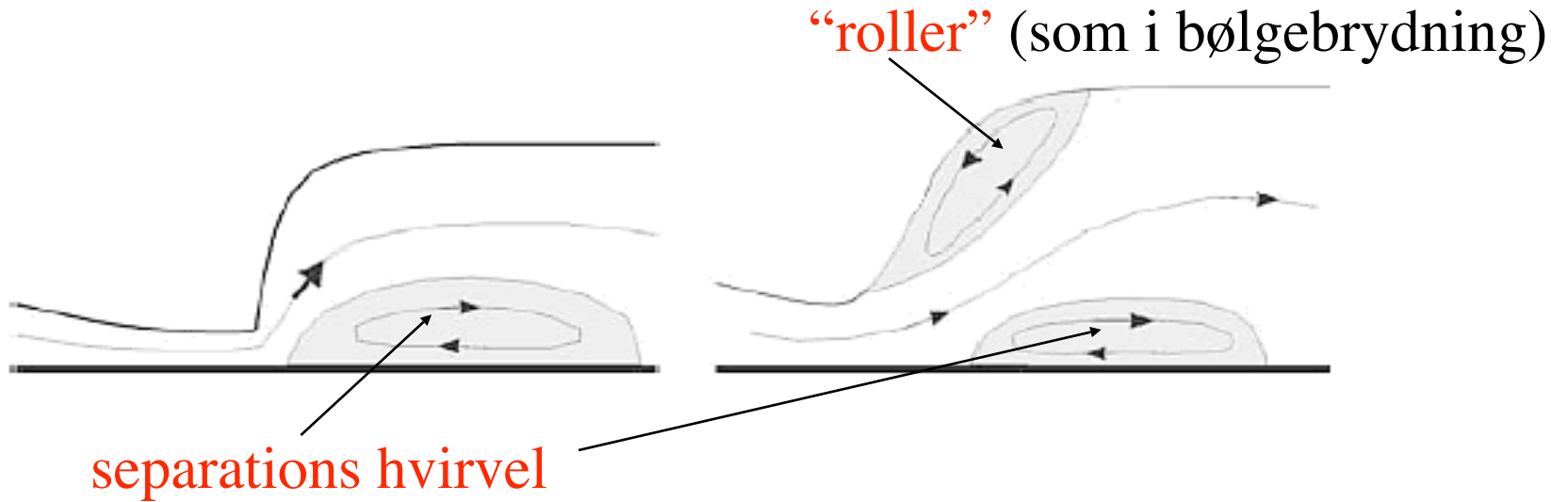


Clive Ellegaard

Type I



Type II



Bølgebrydning



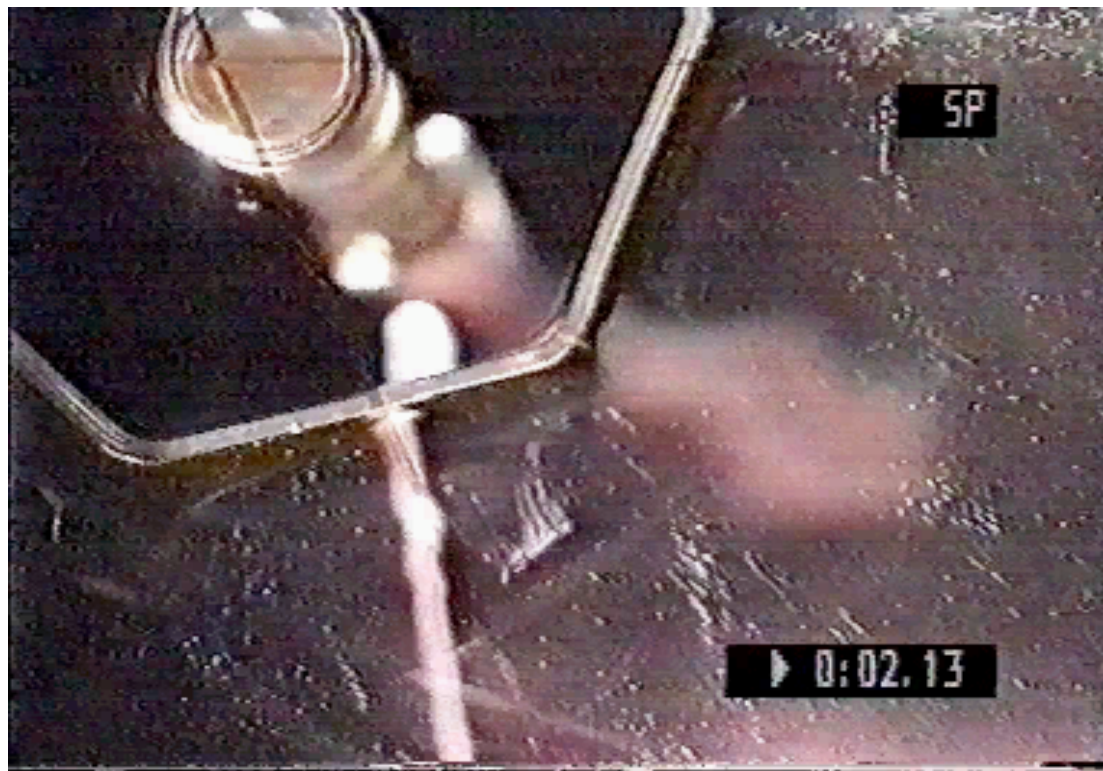
En gang til ...



Multistabilitet: Skabelse af nyt hjørne



Strømning nær et hjørne - “roller”-hvirvlen går i stykker



Overfladespænding vigtig for hjørnerne:

prøv at tilsætte sæbe når I skal se eksperimenterne

Separation på en anden måde...

Sandriller på Råbjerg Mile

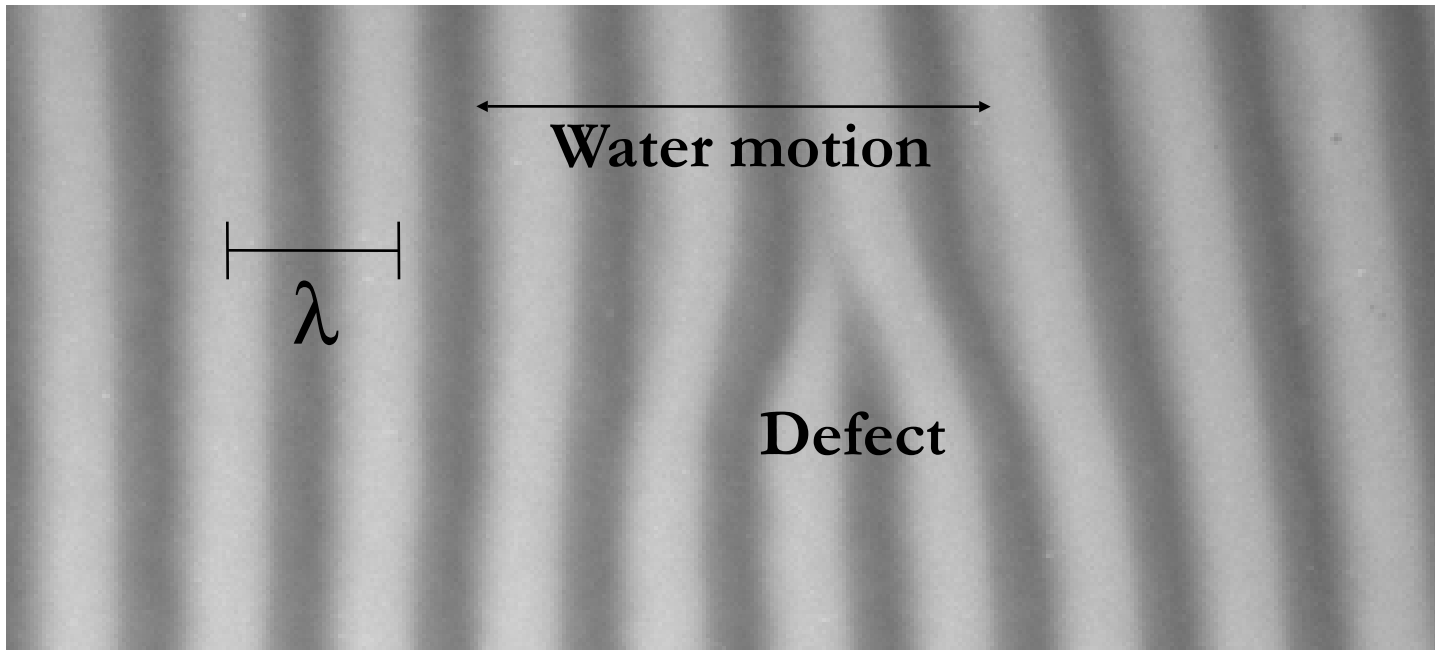




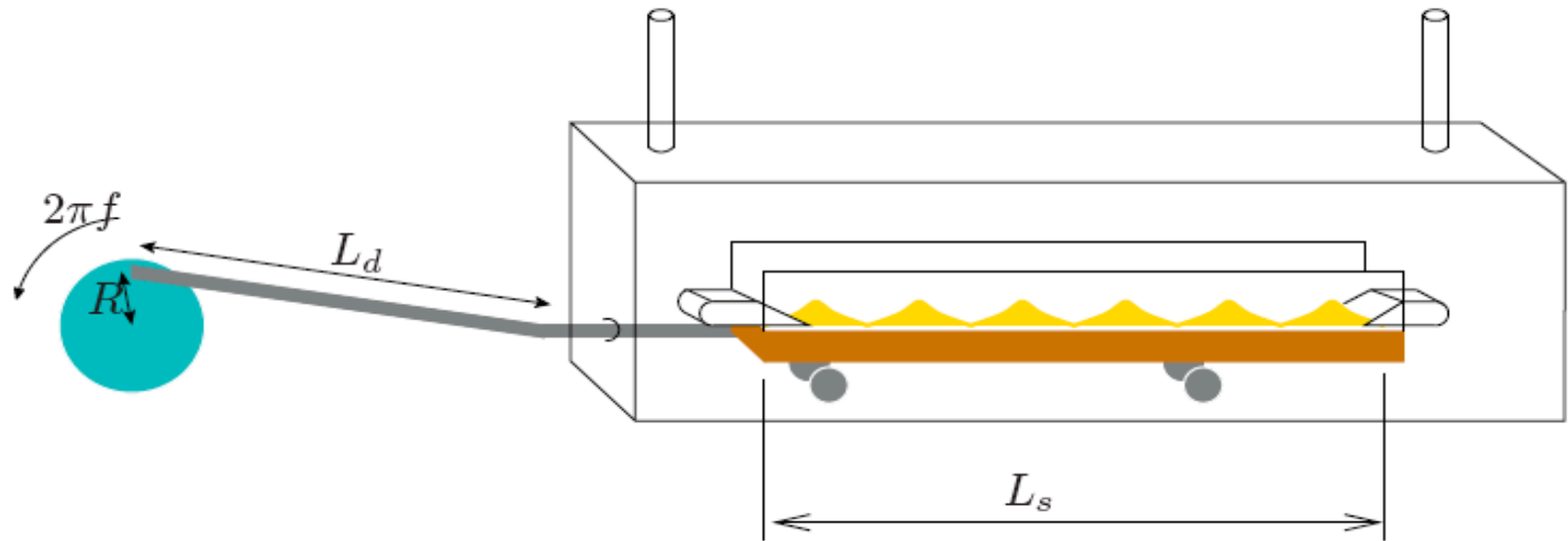
Separation i aktion på DTU

Ripples under oscillating water

$$\lambda \approx 1.33a \quad (\text{Almost) no dependence on frequency}$$



1-d rillekar



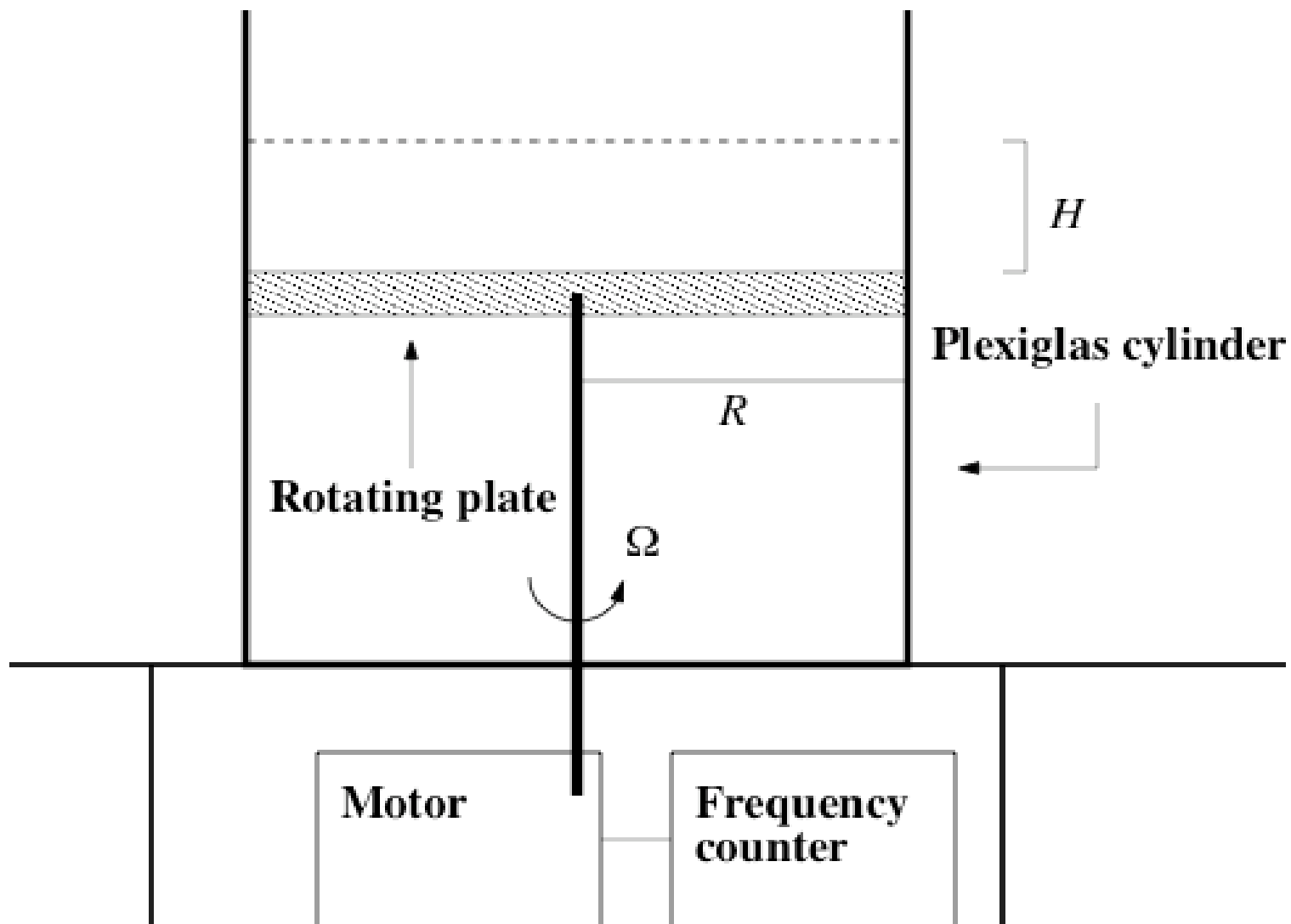
13-02-07, 23:59:15,5- Trig nr. 0

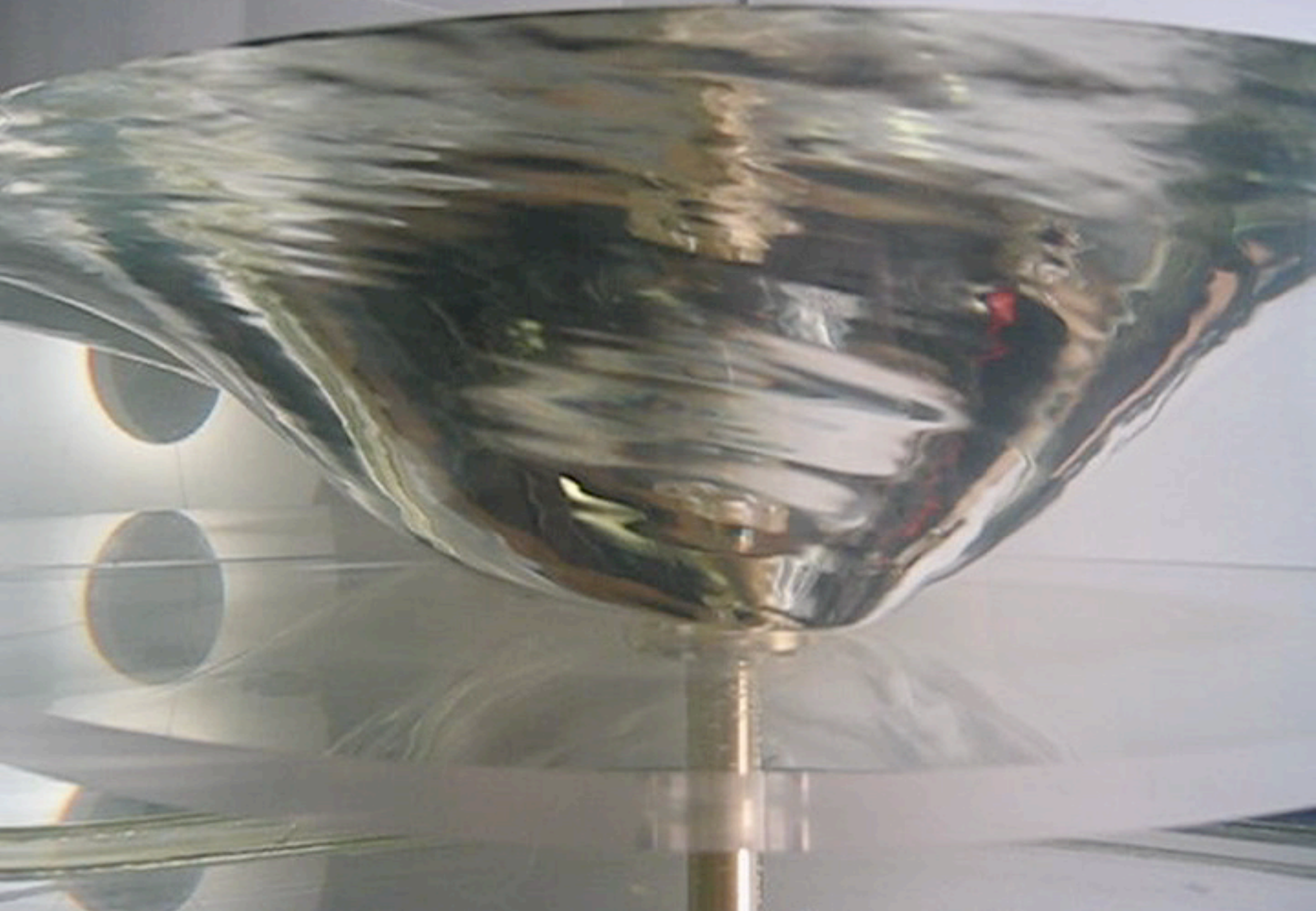
NB1. feb. 13th 2007
Storhelength 70cm
 $f \sim 0.80$ Hz

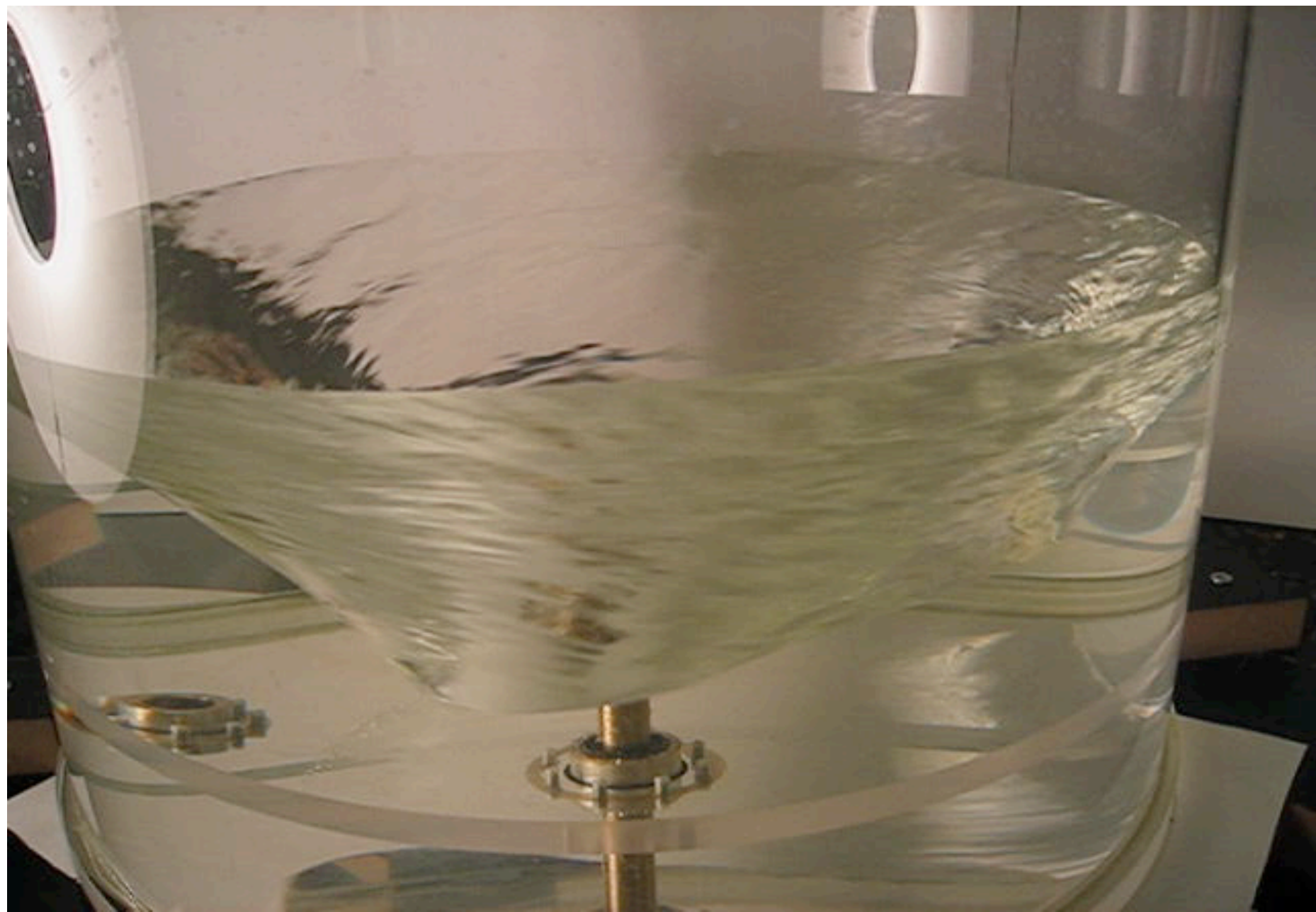
8 9 10 11 12 13 14 15 16 17 18 19 20

Roterende systemer

- Geofysik - jorden og atmosfæren
- Planetarisk fysik
- Tornadoer
- Accelereret koordinatsystem (centrifugal og coriolis- kræfter)





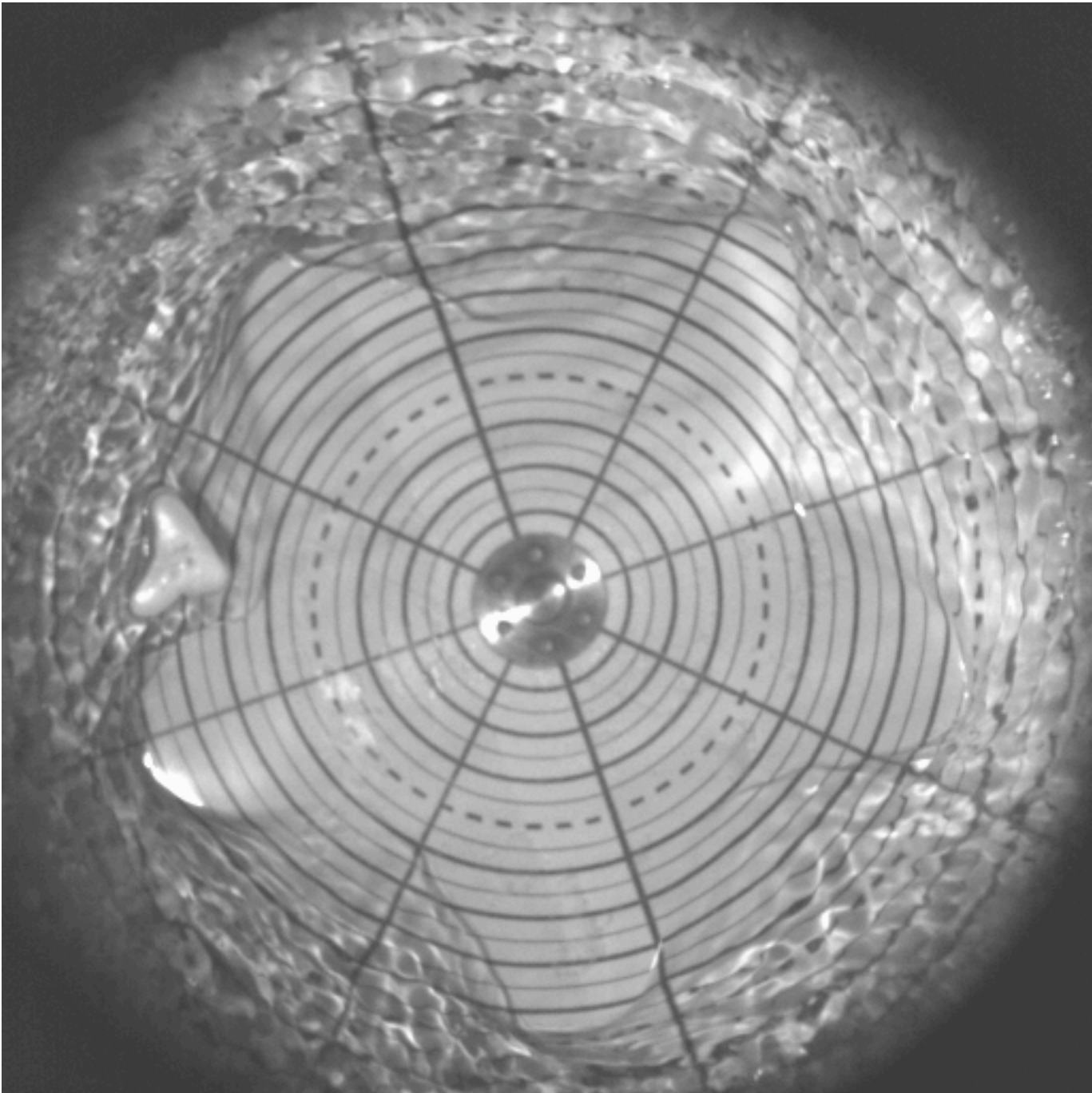












Published online: 19 May 2006; | doi:10.1038/news060515-17

Geometric whirlpools revealed

Recipe for making symmetrical holes in water is easy.

Philip Ball

Bizarre geometric shapes that appear at the centre of swirling vortices in planetary atmospheres might be explained by a simple experiment with a bucket of water.

Researchers at the Technical University of Denmark in Lyngby have created similar geometric shapes (holes in the form of stars, squares, pentagons and hexagons) in whirlpools of water in a cylindrical bucket¹. The shapes appear easily enough once the bucket is spinning at a rate of one to seven revolutions per second, they say.

Tomas Bohr and colleagues made plexiglass buckets, 13 and 20 centimetres across, with metal bottoms that could be rotated at high speed by a motor. They filled the bucket with water and spun the bottom to whip up the liquid into a whirlpool that rose up the sides of the container.

This set-up is very similar to the rotating bucket that Isaac Newton used in the seventeenth century to investigate centrifugal forces.

The researchers found that once the plate was spinning so fast that the water span out to the sides, creating a hole of air in the middle, the dry patch wasn't circular as might be expected. Instead it evolved as



As a bucket of water speeds up, the hole changes shape from a three-sided star to a pentagon.

Credit T.R.N. Jansson

...Features

Subscribe

Send to a friend

Printer format

e-alerts

Recommend to your library

live newsfeeds

RELATED STORIES

[Puzzle of leaping liquid solved](#)
06 April 2006

[Swimming in syrup is as easy as water](#)
20 September 2004

[Liquids fold according to density-viscosity ratio](#)
15 September 2003

[Bounce ballet on film](#)
20 June 2002

[Pattern of life](#)
30 May 2000

EXTERNAL LINKS

[Paper](#)

[Bohr lab](#)

[For polygons in hurricane eye walls](#)

[For Saturn's polar hexagon \(in French\)](#)

From
Nature's
homepage

Polygons in Hurricanes Ivan & Isabella

J. P. Kossin & W. P. Schubert: *Bull.
Amer. Met. Soc.* (2004)



(NASA)

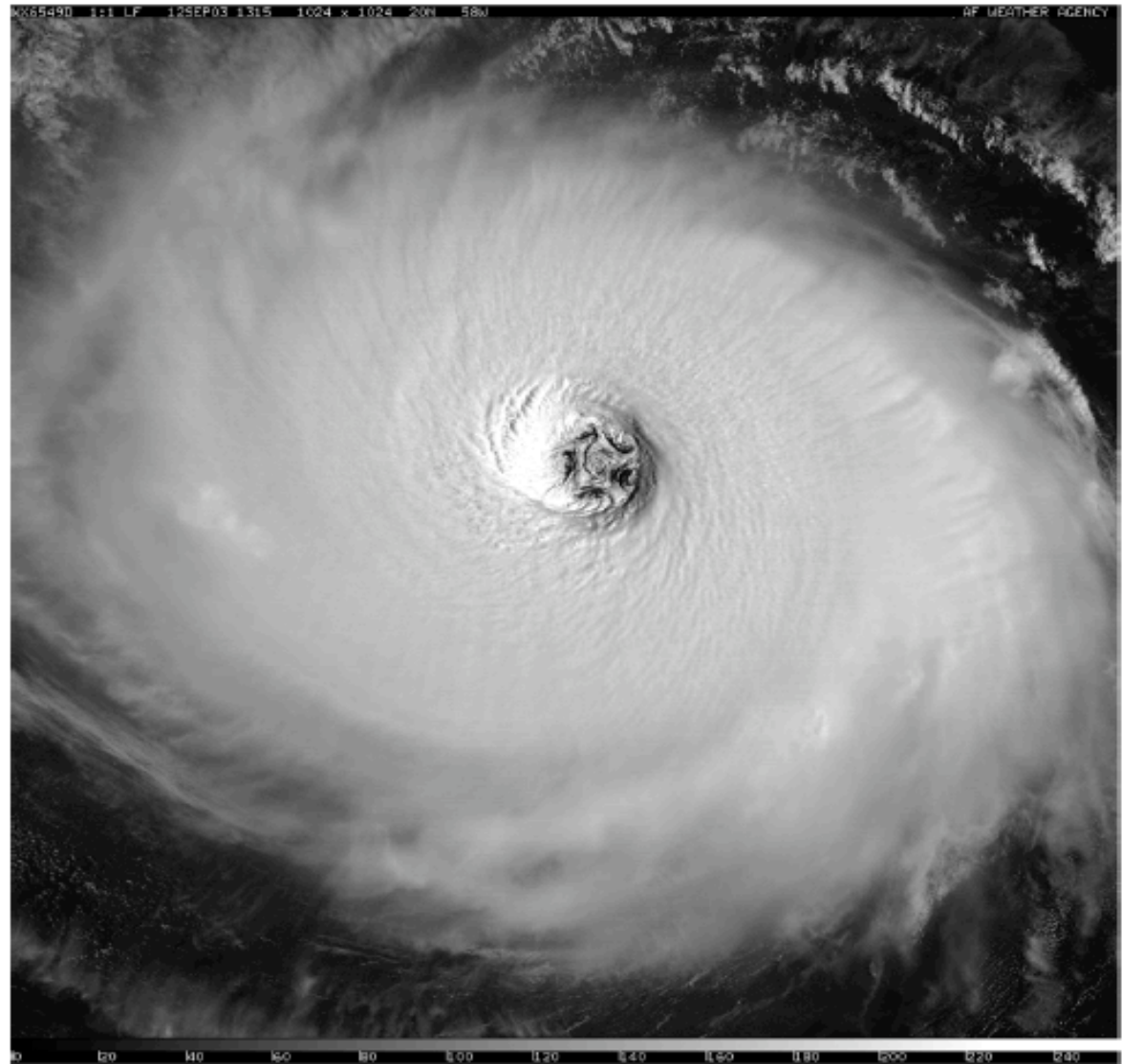
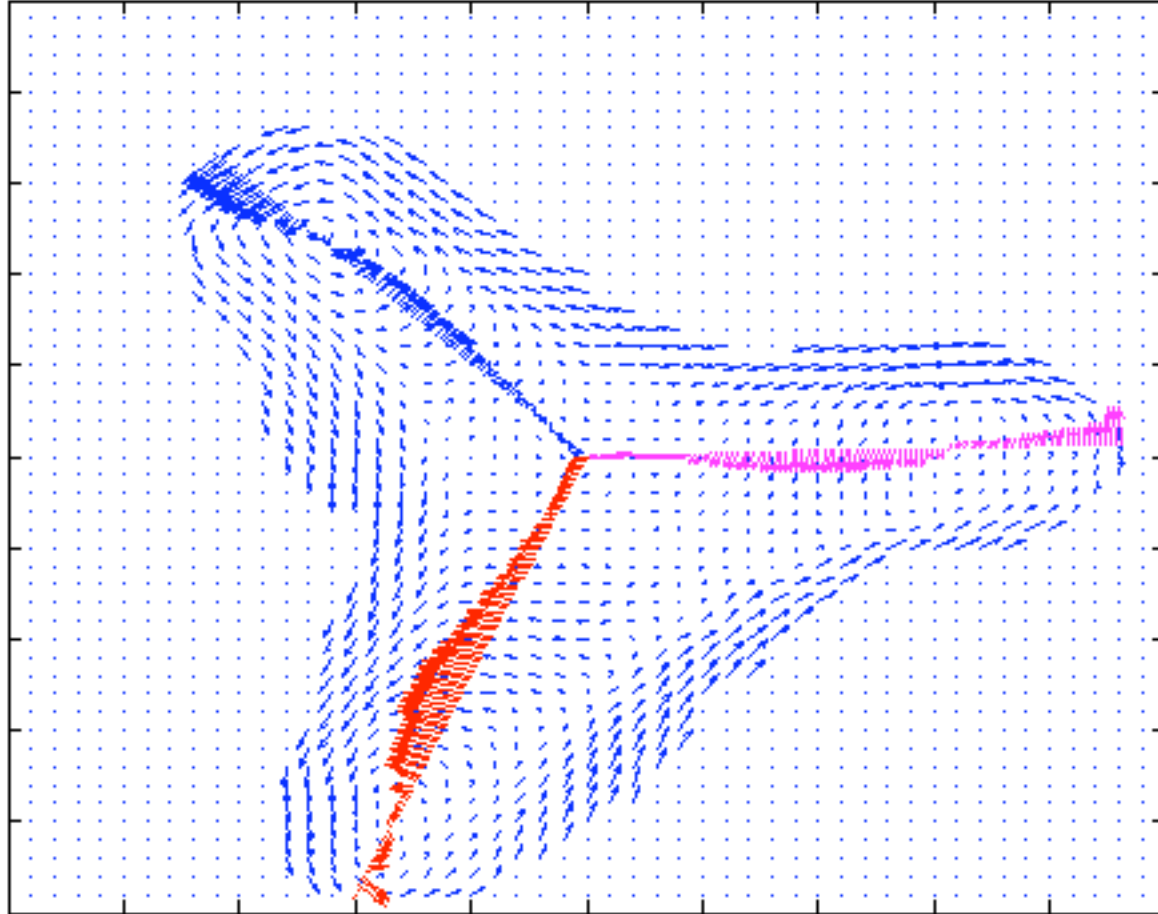


FIG. 1. Defense Meteorological Satellite Program (DMSP) image of Hurricane Isabel at 1315 UTC 12 Sep 2003. The starfish pattern is caused by the presence of six mesovortices in the eye—one at the eye center and five surrounding it.

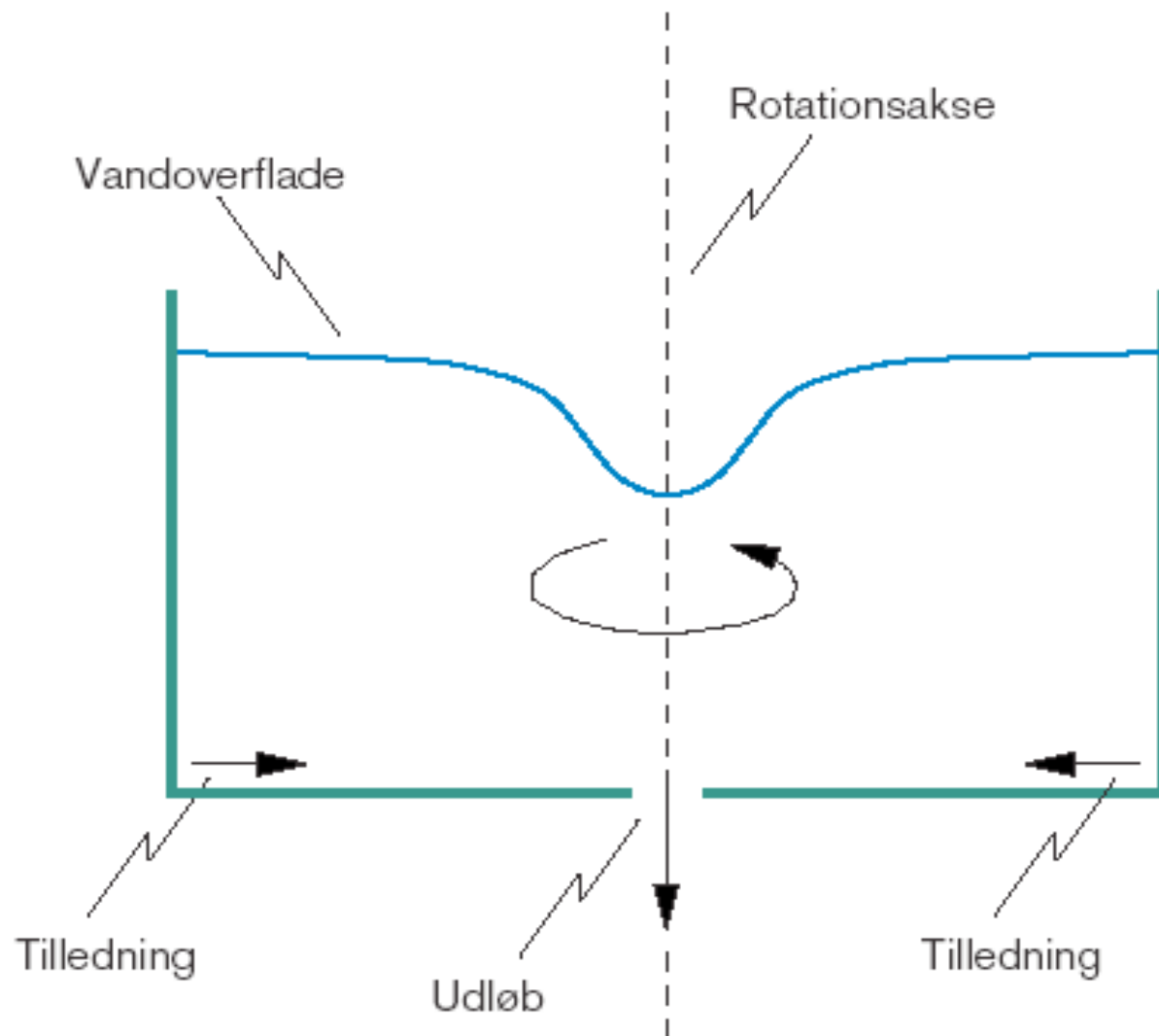
Kelvin-Helmholtz

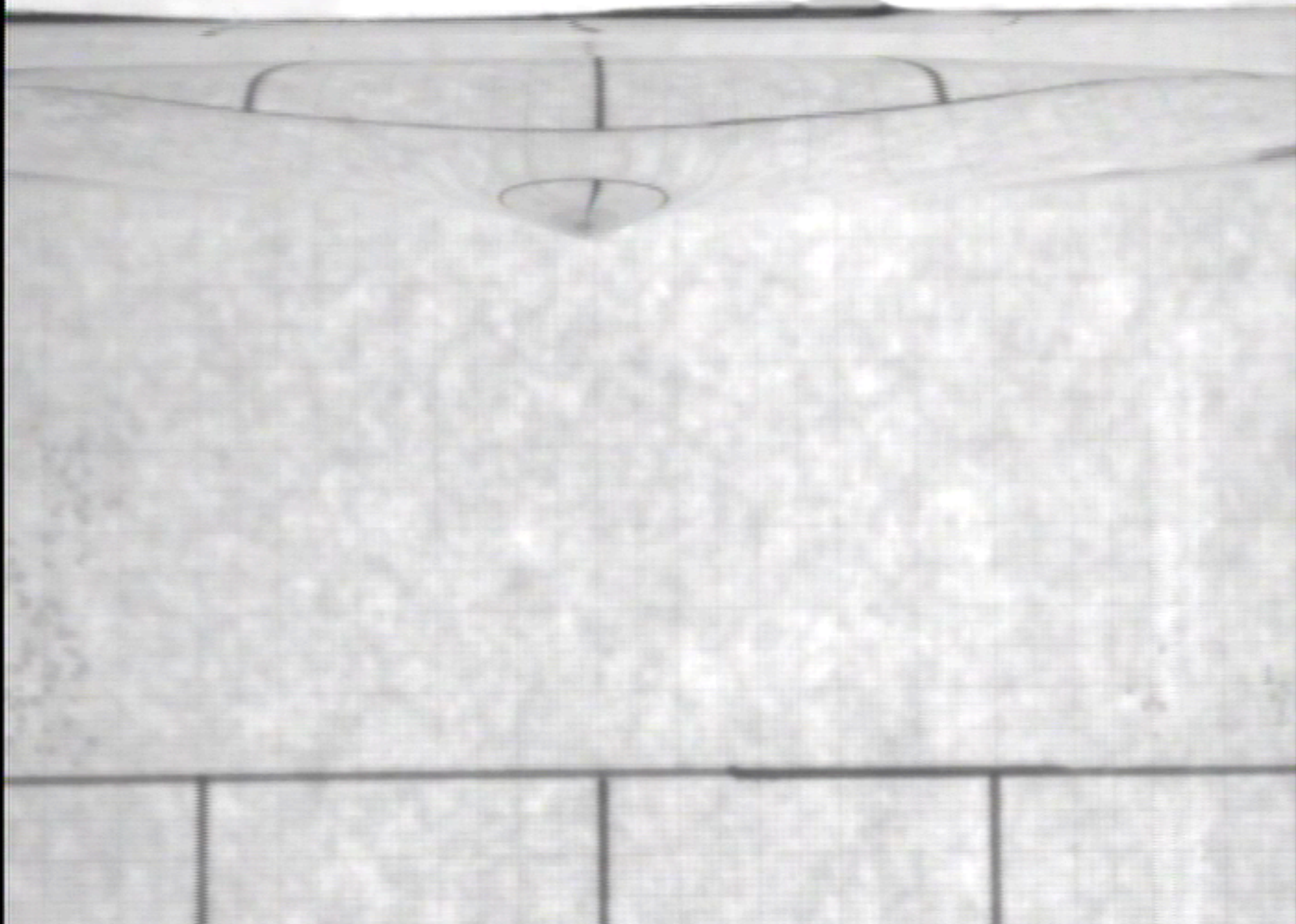


PIV-analysis of wet triangle

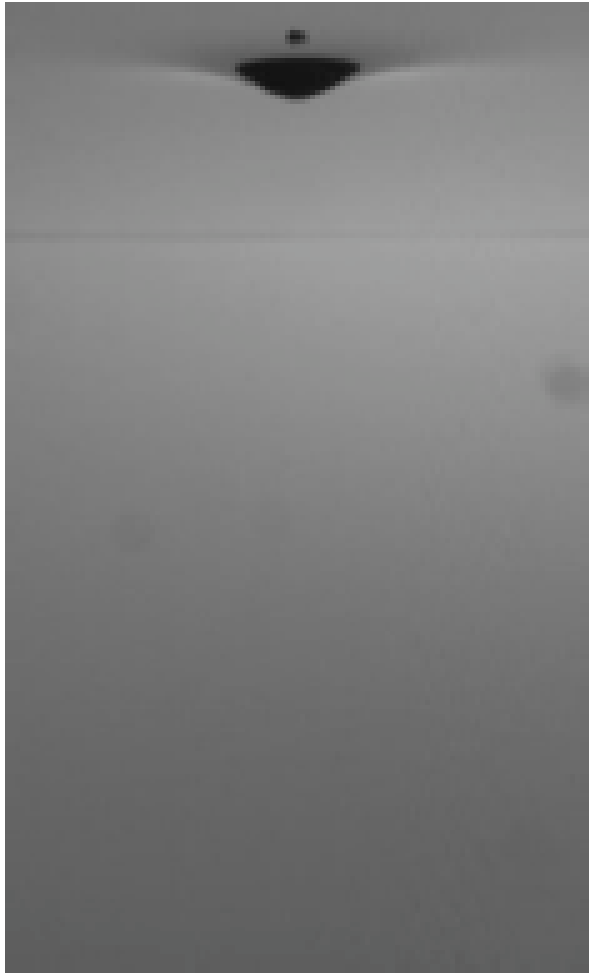


Bathtub vortex experiment

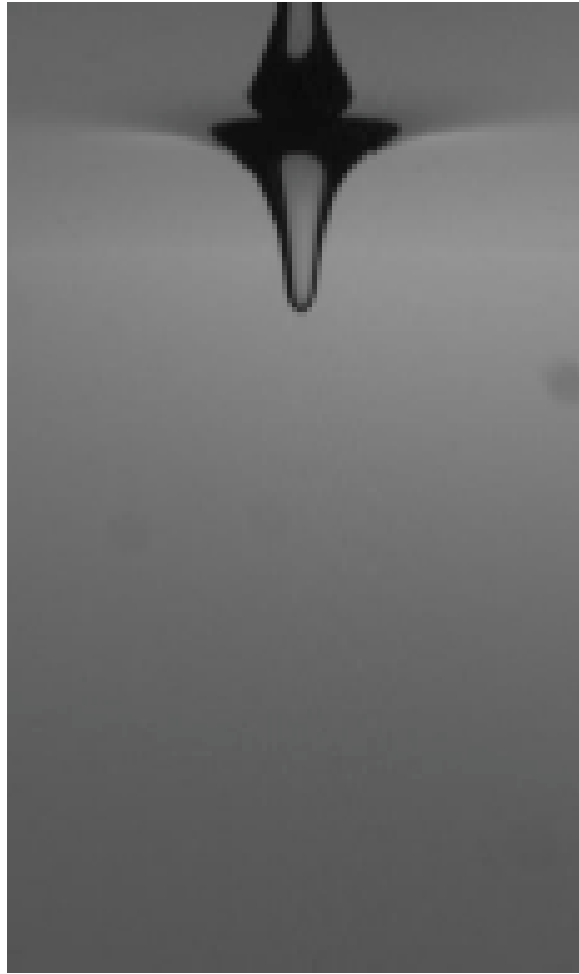




Bathtub vortex in a cylindrical, rotating container with outflow



(a)



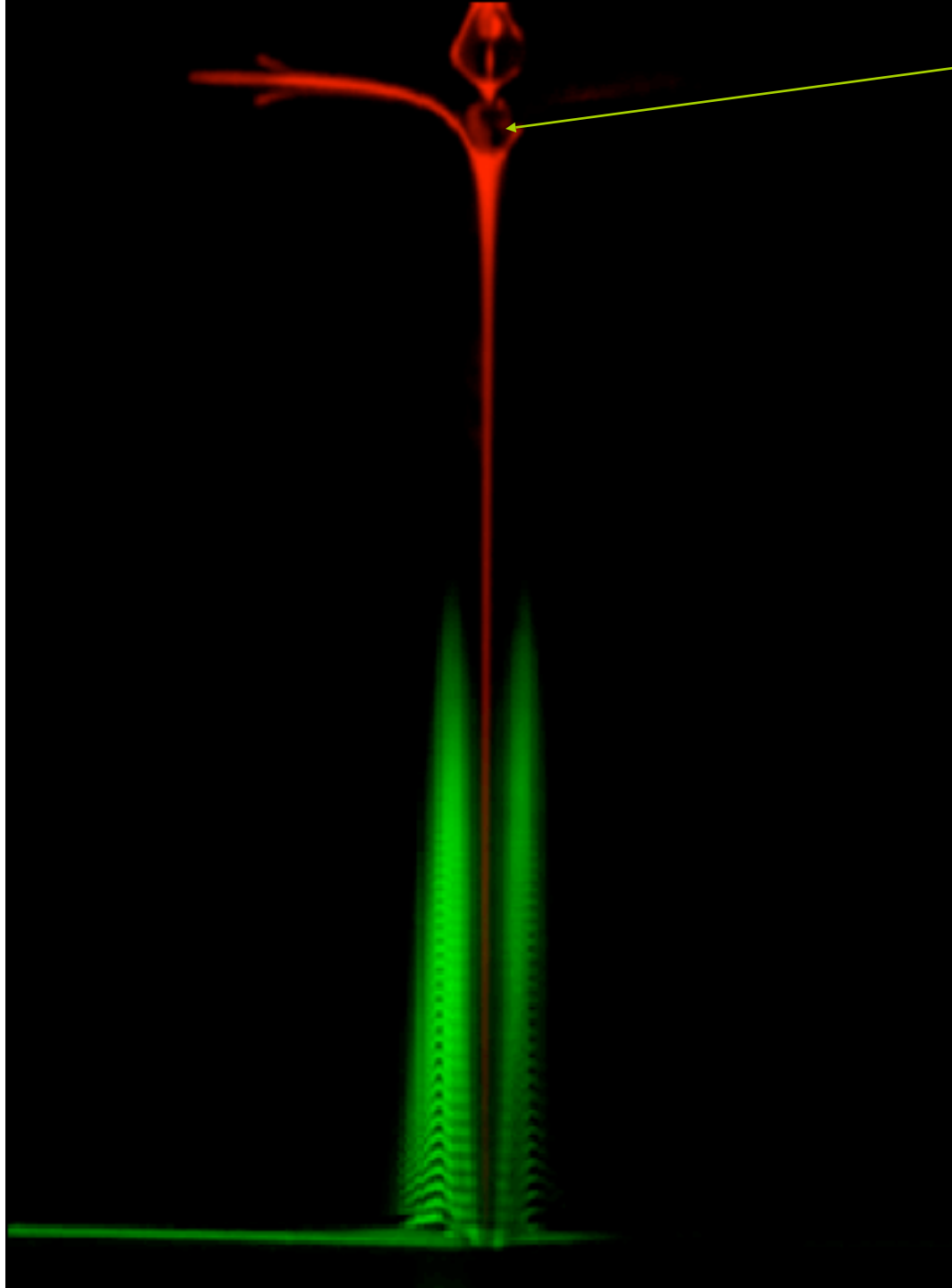
(b)



(c)

Anders Andersen

Strømning
omkring en
badekars-
hvirvel

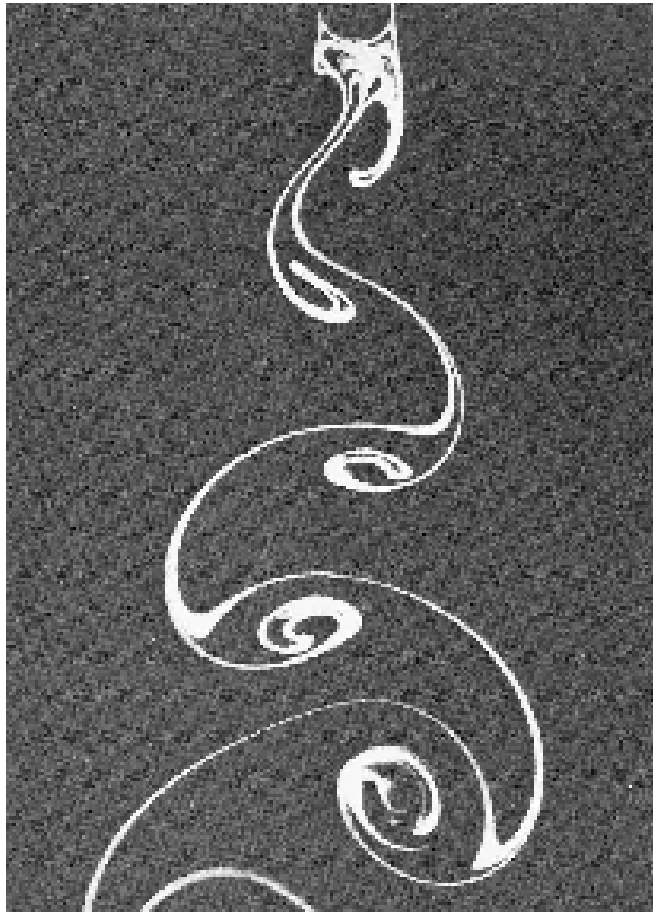


vandoverflade

*Anders
Andersen*

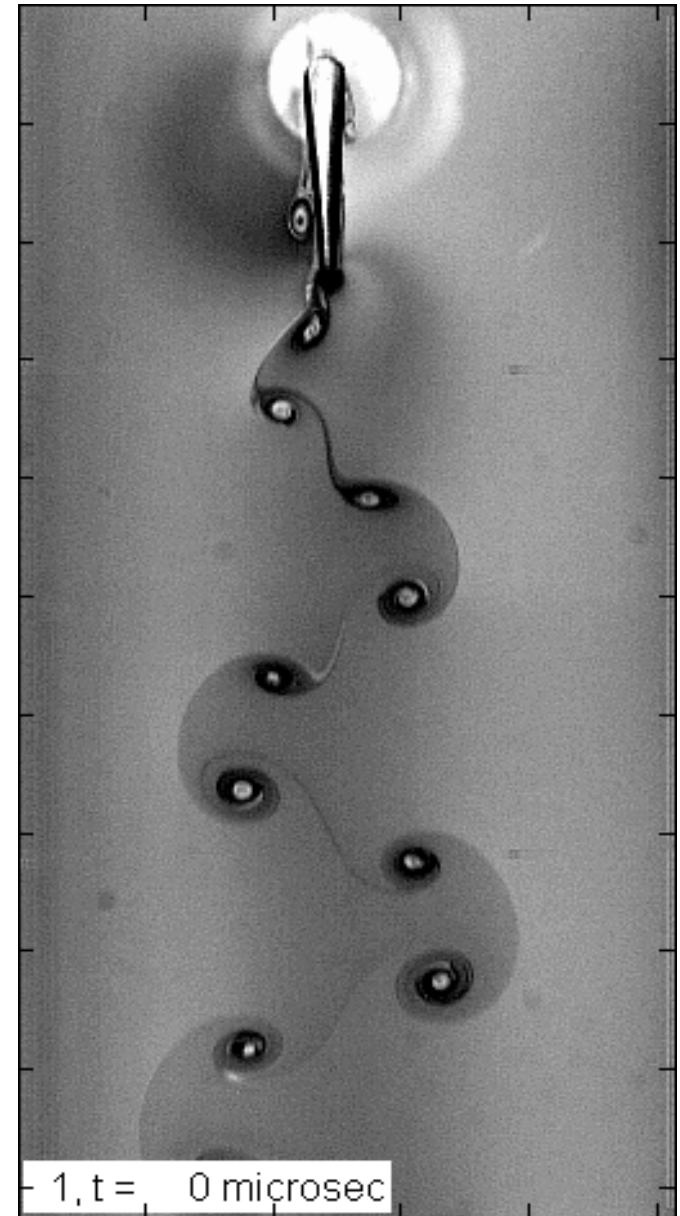
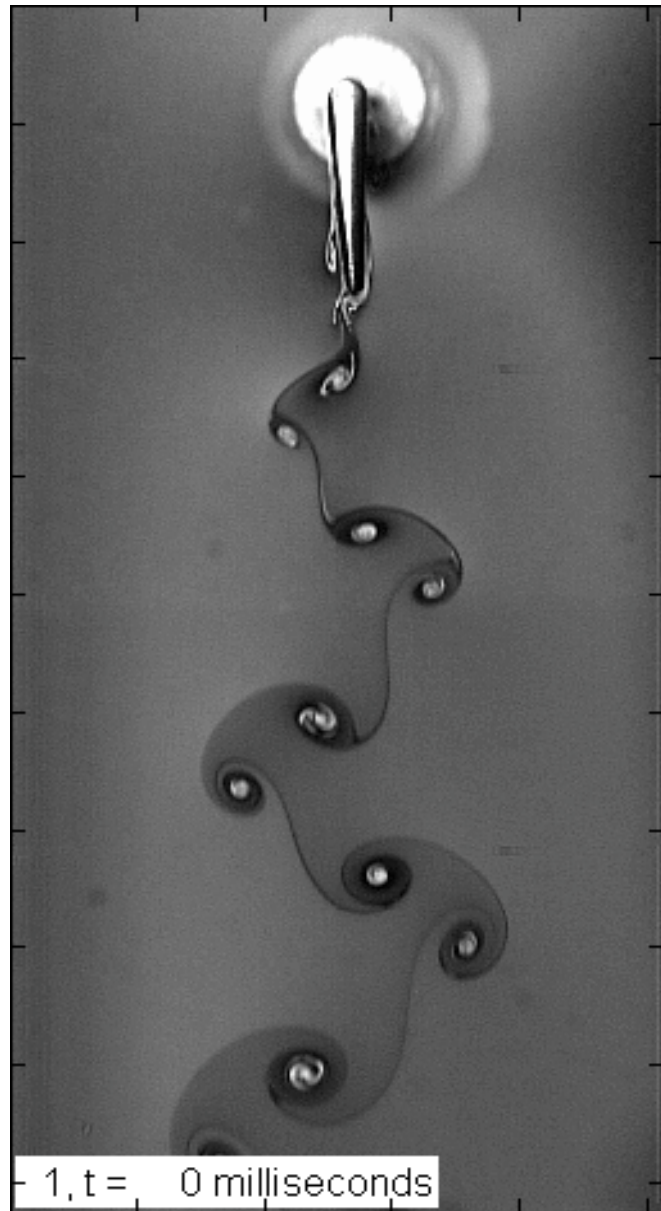
*Hvirvelafløsning -
svømning og flyvning*

Hvirvelallé



Svømning i en sæbefilm

Teis
Schnipper



Vandloppers jagtmetoder

(Vincent Langlois, Thomas Kiørboe)

Real time

SLO MO
(1/271 x Real time)

Jeg skulle vist være stoppet
forlængst
- god fornøjelse resten af dagen