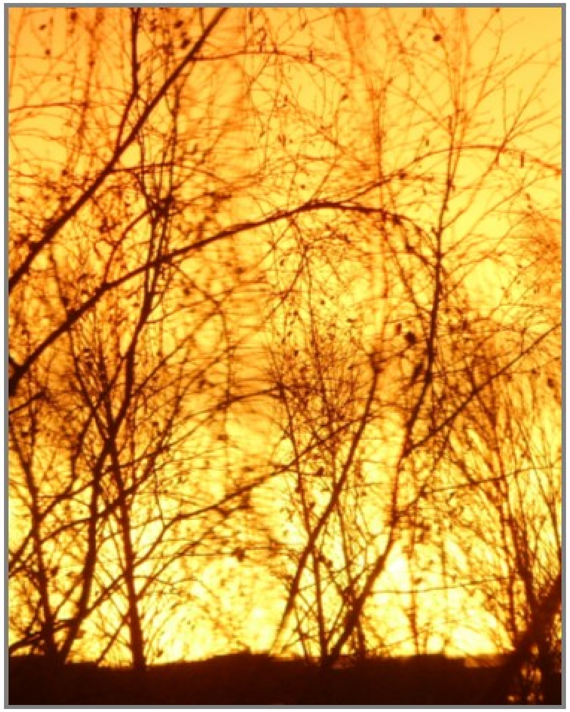
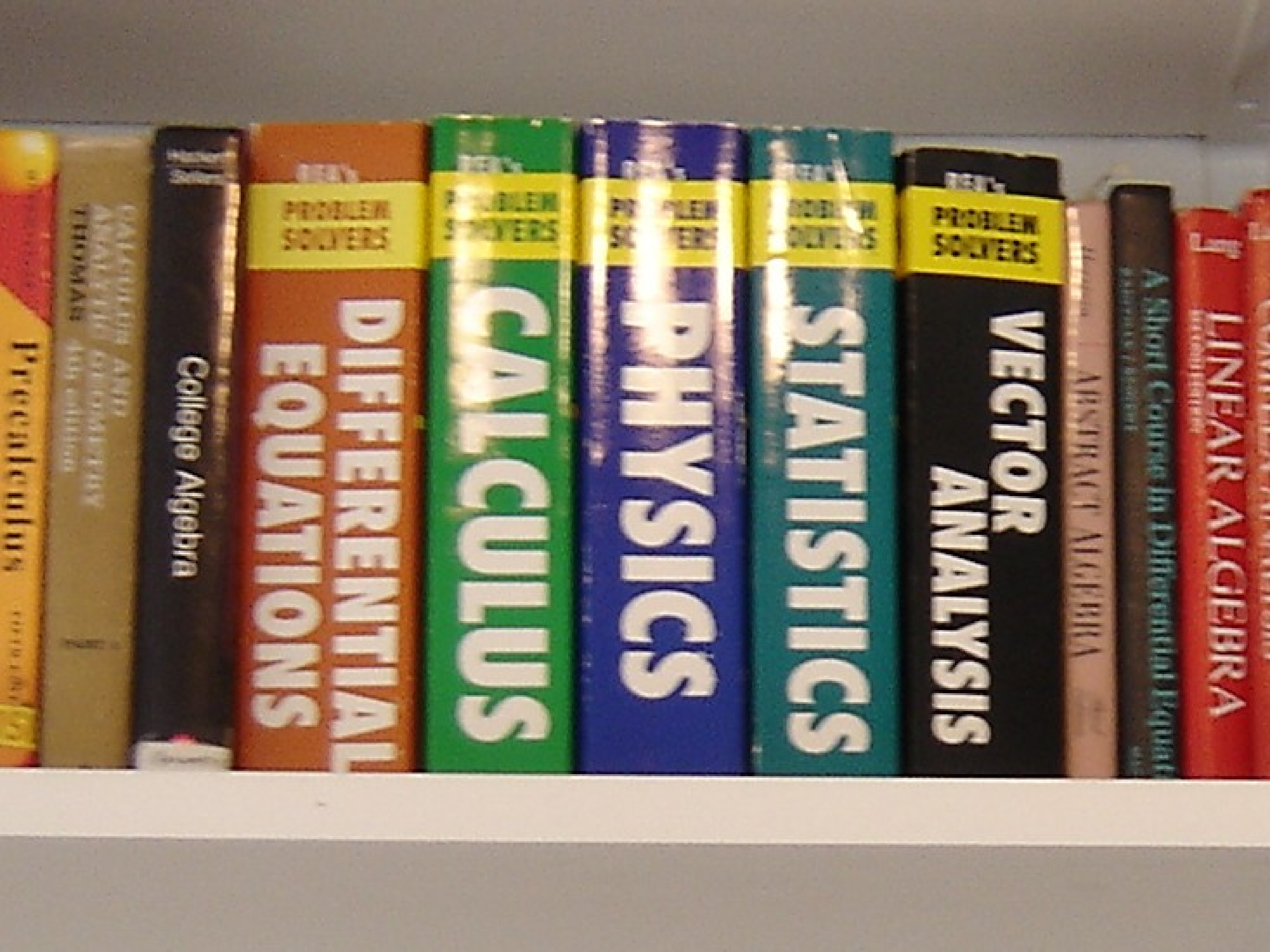


Preparation to the Young Physicists' Tournaments' 2008

Ilya Martchenko, POISK Centre


Precalculus
THOMAS
College Algebra
PROBLEM SOLVERS
DIFFERENTIAL EQUATIONS
PROBLEM SOLVERS
CALCULUS
PROBLEM SOLVERS
PHYSICS
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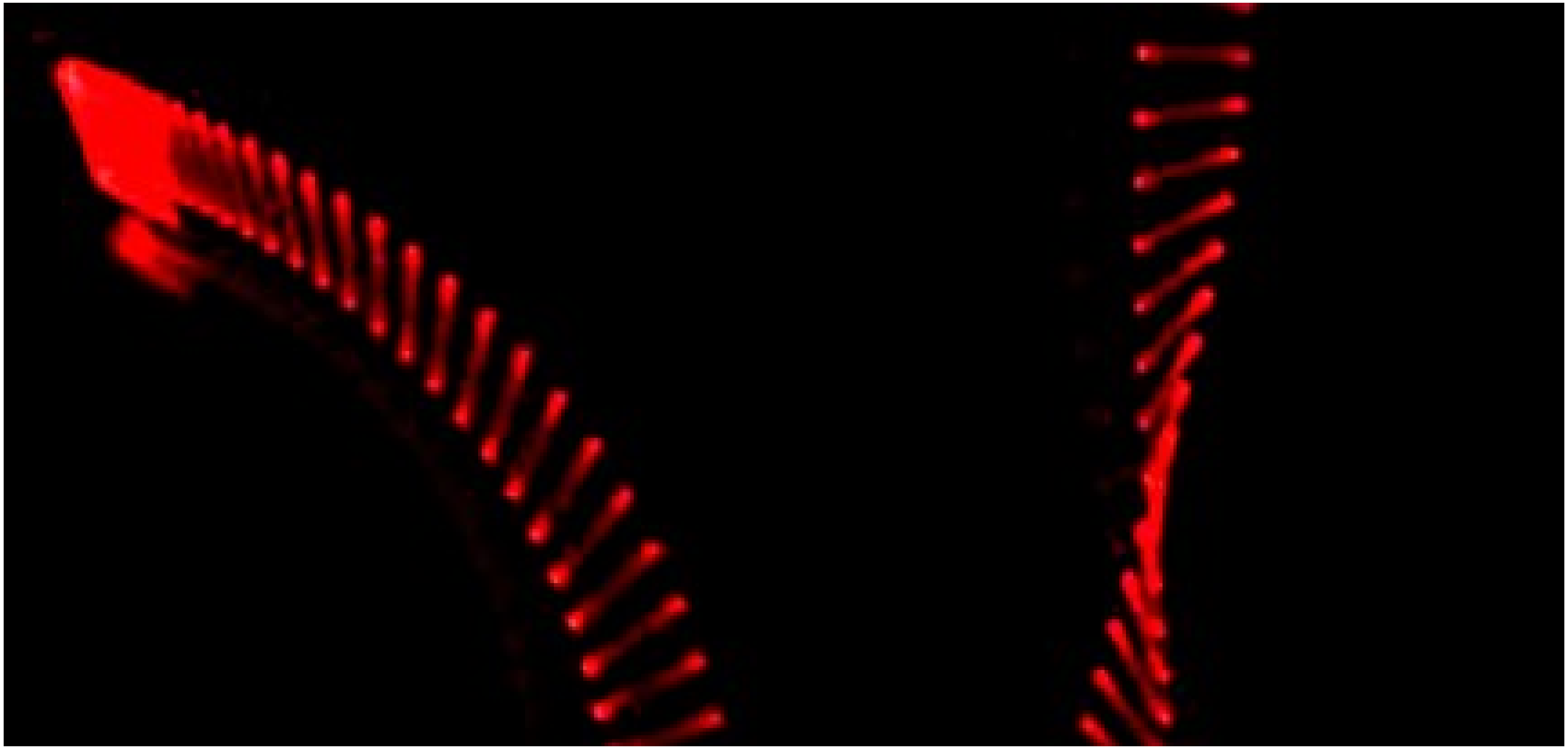
STATISTICS
PROBLEM SOLVERS
VECTOR ANALYSIS
ABSTRACT ALGEBRA
A Short Course in Differential Equat
LINEAR ALGEBRA



Problem No. 1 “Tip-cat”

Place a small wooden stick over the edge of a desk. Hit the end of the stick overhanging the table so that it flies away. How is the flight distance related to the relevant parameters? What is the condition for a maximum horizontal distance?

Additional reading

- Wikipedia: Tip-cat. http://en.wikipedia.org/wiki/Tip-cat
- D. Beard. Tip-cat. http://www.inquiry.net/OUTDOOR/games/beard/tipcat.htm
- Rod rotates when hit by point mass/ Conservation of angular momentum. Physics forums (2006). http://www.physicsforums.com/showthread.php?t=145602
- Problem Set 11: Angular Momentum, Rotation and Translation Solutions. Fall term 2005, MIT. http://web.mit.edu/americo/Public/8.01/ps11sol.pdf
- Wikipedia: List of moments of inertia. http://en.wikipedia.org/wiki/List_of_moments_of_inertia
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- H. Goldstein. Classical Mechanics (Addison-Wesley, 2nd. ed., 1980).
- Л.Д. Ландау, Е.М. Лифшиц. Механика. - М.: Физматгиз, 1958. - 208 с.
- J.B. Marion, S.T. Thornton. Classical Dynamics of Systems and Particles (Thomson, 4th. ed., 1995).
- K.R. Symon. Mechanics (Addison-Wesley, 3rd. ed., 1971).
- R.A. Tenenbaum. Fundamentals of Applied Dynamics (Springer, 2004).

Key questions

- The stick turns with respect to the edge of the desk when it is still in contact with it, but rotates about the center of masses when flies freely. How and when does the transition take place?
- Under what conditions the stick loses the reaction from the desk and starts free flight?
- The maximum horizontal displacement is achieved if a projectile is thrown under the angle of 45^0. Is that relevant to our problem?
- When the stick flies freely, what is its kinetic energy of rotation in comparison to its kinetic energy of translational motion?
- How does the stick hit the ground (vertically? horizontally? at a certain angle?) Can the stick re-bounce? Can it worsen or improve the results?
- Is there a method to hit the stick so that the displacement is negative (the stick lands under the desk)?
- What physical parameters of the interaction between our finger and the stick may influence on the results (duration of contact? speed or acceleration of the finger? trajectory of the finger?)
- What physical parameters of the stick may influence on the results? (length? density? shape? friction with the desk?)
- What initial conditions may influence on the results (position of the stick on the desk? length of the protruding end? if the desk is horizontal or titled?)
- Are any aerodynamic forces relevant to the problem? How significant is air resistance?
- Is it worth modeling the system numerically?

Problem No. 2 “Winged seed”

Investigate the motion of falling winged seeds such as those of the maple tree.


Nature prefers right-handed helices. Do both seeds of a certain pair twist in the same direction?

Background reading

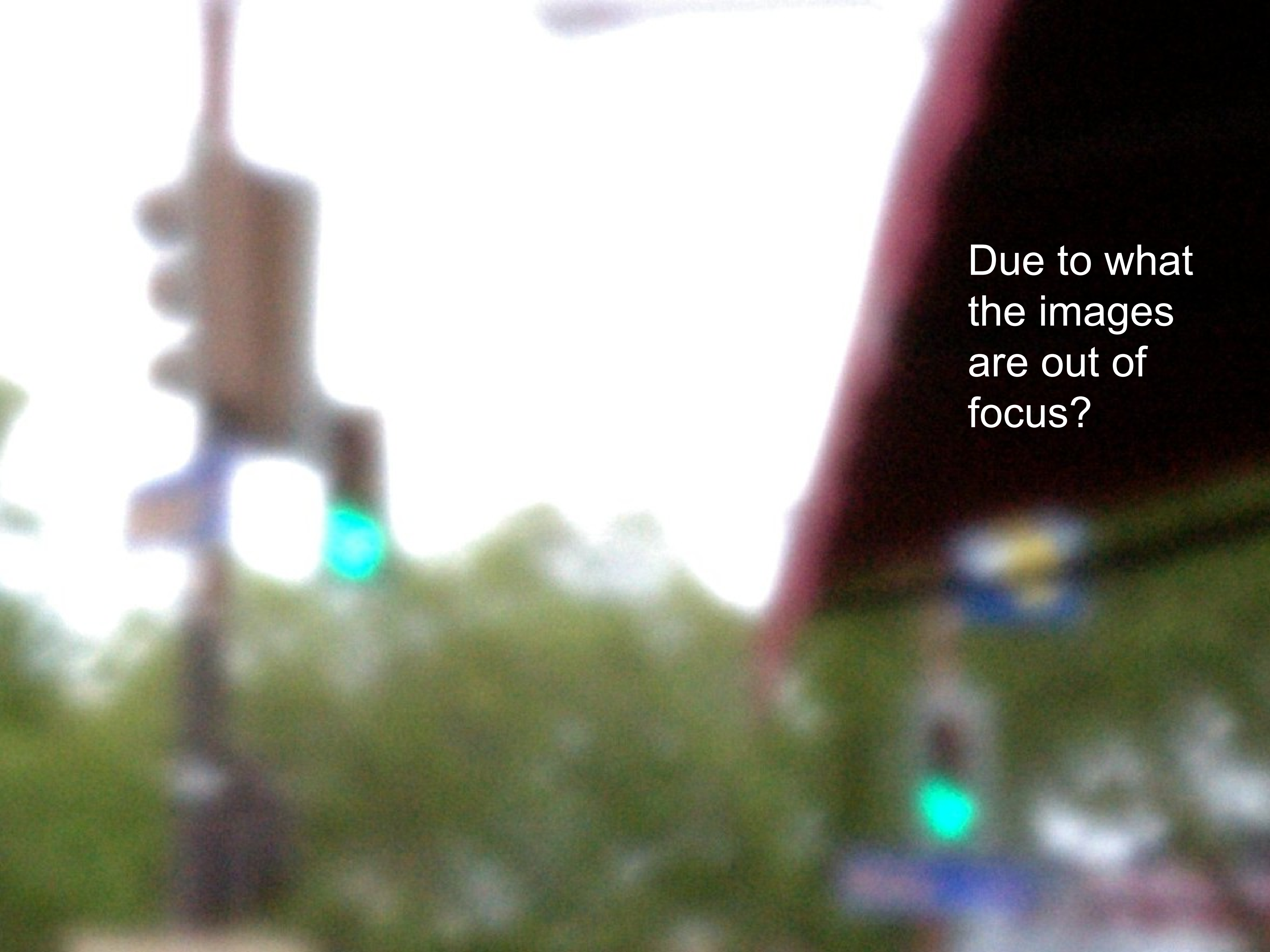
- Ф.В. Шмитц. Аэродинамика малых скоростей. – М.: ДОСААФ, 1963. http://www.jmk-project.narod.ru/books/Schmitz63_aerodinamika_malih_skorostey/cont.htm
- Principles of flight. National museum of the USAF. www.nationalmuseum.af.mil/shared/media/document/AFD-060512-004.pdf
- Paper maple seed on Earth and in space //Toys in space II. NASA. http://www.nasa.gov/pdf/151731main_Toys.In.Space.II.pdf
- Wikipedia: Maple. http://en.wikipedia.org/wiki/Maple
- Л. Прандтль - О. Титьенс. Гидро- и аэромеханика, т. первый. - М., Л.: ГТТИ, 1933.
- Г. Кирхгоф. Механика. Лекции по математической физике. - М.: Изд. АН СССР, 1962.
- Л.Г. Лойцянский. Механика жидкости и газа. - М., Л.: ГИТТЛ, 1950.
- Дж. Бэтчелор. Введение в динамику жидкости. - М.: Мир, 1973.

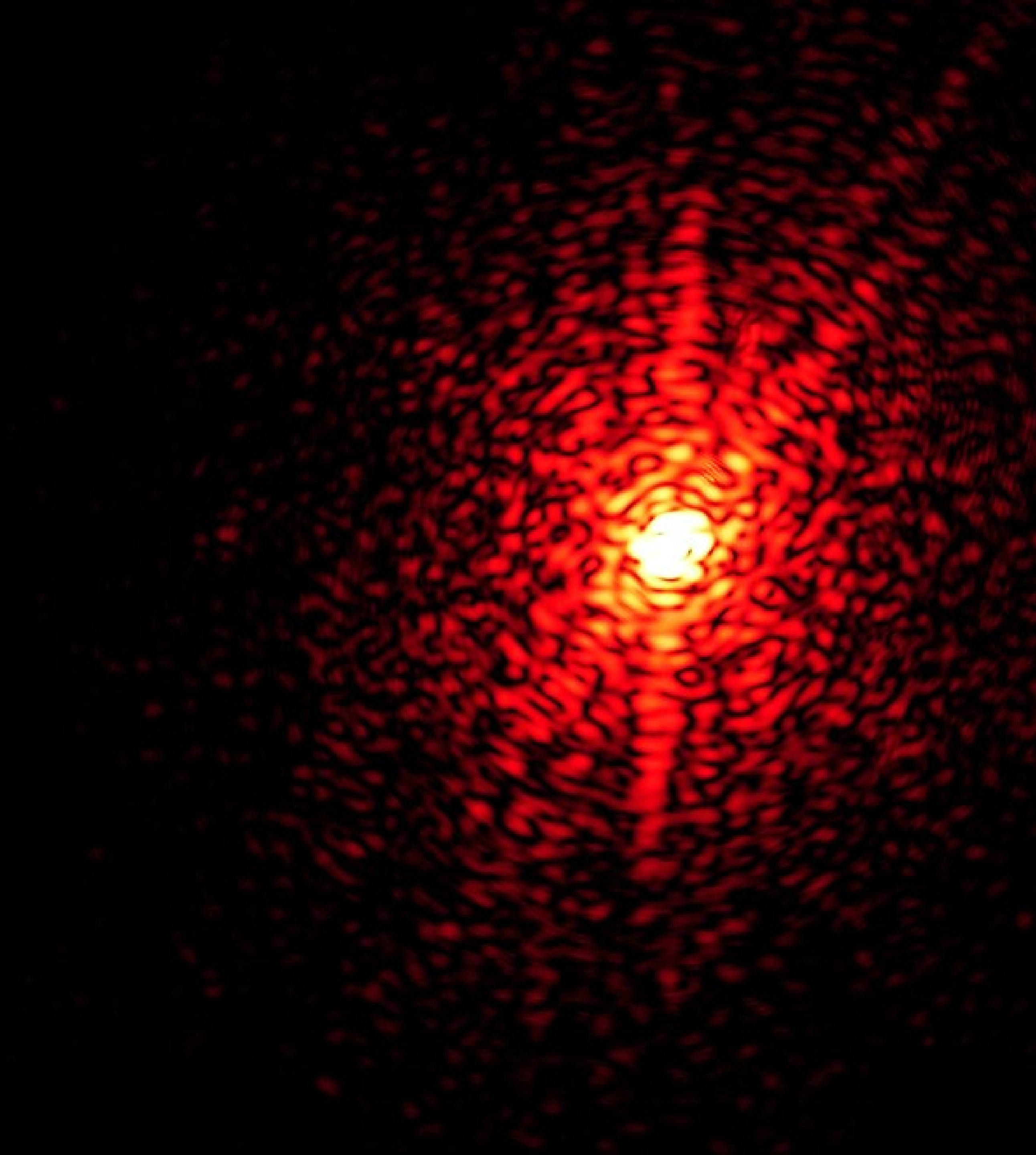
Key questions

- How and when does the transition between the initial free-fall-speed motion and the stable rotation take place?
- Where is the center of masses of a seed? How does the density distribution and the shape influence over the initial orientation of a seed and on its rotation?
- What other physical parameters determine the angle of attack and the spatial orientation of a seed when it is in a stable rotational motion?
- Maple seeds grow in pairs. If we drop both seeds of a certain pair, do they twist in the same direction, or in opposite directions?
- What determines the direction of rotation (clockwise/counter-clockwise)? Is the initial orientation of a seed relevant to that?
- What are the magnitudes of the Reynolds number for the flow around the maple seed? Is the flow laminar or turbulent? Does the Reynolds number change with time?
- What is the seed's kinetic energy of rotation in comparison to its kinetic energy of translational motion?
- Is it worth speaking of an analogy between the shape of a rotating maple seed and the shape of a single wing, or a blade, or a rotating aircraft with elevated ailerons?
- What maximum horizontal distance can reach a seed falling from a tree in a strong wind? How fast would it descend and fast would in move along a horizontal axis?

Problem No. 3 “Pinhole camera”

Study the characteristics of a pinhole camera and find the conditions for the camera to achieve optimum image quality.


Due to what
the images
are out of
focus?



Is diffraction possible? For what wavelengths?


Long exposures required
because of a small aperture?


Digital noises?
Sensitivity of CCDs or films?

Primary reading (science aspects)

- Wikipedia: Pinhole Camera. http://en.wikipedia.org/wiki/Pinhole_camera
- Wikipedia: Lochkamera. http://de.wikipedia.org/wiki/Lochkamera
- В. Майер. Отверстие-линза. - Квант, 1972, №8
- M. Young. Pinhole Imagery. Am. J. Phys., 40, 715 (1972).
- M. Young. Pinhole Optics. Appl. Optics, 10, 2763 (1971).
- R.E. Swing. D.P. Rooney. General Transfer Function for the Pinhole Camera, J. Opt. Soc. Amer., 58, 629 (1968).
- K. Sayanagi. Pinhole Imagery, J. Opt. Soc. Amer., 57, 1091 (1967).
- Г.Г. Слюсарев. О возможном и невозможном в оптике. - М.: ГТТИ, 1957, стр. 77-94.

Background reading (R&D + art aspects)

- Pinhole Visions Magazine. http://www.pinhole.com/
- The Pinhole Gallery. http://www.pinhole.org/
- The Pinhole Resource. http://www.pinholeresource.com/
- Pinhole Camera, parts 1, 2, 3. Thoughts about photography. http://www.foundphotography.com/PhotoThoughts/archives/2005/04/pinhole_camera.html
- S.L. Woodruff. Outmeal Box Pinhole Photography. http://users.rcn.com/stewoody/
- Jon Grepstad. Introduction to Pinhole Photography. http://photo.net/learn/pinhole/pinhole
- Bizzare Pinhole Camera. http://bizarrelabs.com/pin2.htm
- Weekend Projects - Make a Pinhole Camera. http://www.youtube.com/watch?v=KmJznKe4jpI
- Polaroid Super Shooter Pinhole Camera Conversion (part 1). http://fr.youtube.com/watch?v=9PrYuYp9ORY
- Jake's Attic - Pin Hole Camera. http://www.youtube.com/watch?v=eK9yVvFIRP4
- Juicebox pinhole camera. http://www.youtube.com/watch?v=gA1-K8qaQWA&NR=1
- Gallery of pinhole images. http://www.pinholeday.org/gallery/index.php

Key questions

- What is an 'optimum image quality'? For example, an image may be sharp but geometrically distorted, or may have nice natural colors but be poorly focused.
- Everyone knows the Rayleigh's formula for the pinhole camera. But how did Lord Rayleigh derive it?
- What physical parameters may quantitatively describe the sharpness, the level of distortions and all other features of pinhole images?
- Everyone can make a pinhole with a needle. But how to make a really small hole to approach wave effects such as color aberration and diffraction?
- Visible light may be registered with a lens camera as well. If there are any applications where a photograph cannot be obtained without a pinhole camera?
- Does a pinhole camera put limitations to maximum radiant intensity coming from photographed objects? What happens if you install a pinhole camera, open its aperture, take a common digital camera and shoot the pinhole with a flash?
- Is it difficult to compile a program to imitate a pinhole image on computer? Input data may include aperture's diameter and shape, all linear dimensions of the system (focal distance etc.) and a bitmap image (of 'the photographed object') to be processed.
- What parameters besides focal length, aperture and exposure may be altered in your pinhole camera?

Problem No. 4 “Cymbal”

Discharging an electronic flash unit near a cymbal will produce a sound from the cymbal. Explain the phenomenon and investigate the relevant parameters.

The explanation?

- Acoustic or optical excitation?
- Separate a cymbal from a flash with a small black paper card. Most optical influence is then eliminated, while the sound of flash is still well heard.
- Separate a cymbal from a flash with a wide glass/plexiglass screen. That might help to verify the role of acoustical excitation.
- Focus the radiation of a flash with a lens. Is the sound different now?
- Discharge flashes at various distances from the cymbal. Are there any dependences?
- Discharge flashes at different positions with respect to the center of the cymbal. Are there any dependences?
- If a current surge is detected when a thermocouple joint is illuminated with a flash, it might support the rapid heating theory as the light pressure is irrelevant to heating.
- If there is no current surge on a thermocouple, the entire set may not be enough sensitive to detect a very rapid heating.
- Above all, does a black cymbal sounds the same as a white one?

Primary reading

- No. 2. Singing cymbal //Small Experiments at CERN, collected by I. Hamers, Ch. Barck and V. van Engelen, with the help of the people of HST2002. http://teachers.web.cern.ch/teachers/archiv/HST2002/smallexp/50smallexperimenets/Smallexperiments.htm
- N.H. Fletcher and T.D. Rossing. The Physics of Musical Instruments. (New York, Springer-Verlag, 1991), pp.65-94, 555-576.
- A Struck Cymbal: Slow Motion Video. http://www.acoustics.salford.ac.uk/feschools/waves/cymbalvideo.htm
- Vibrations of Circular Plates (Drums). http://wug.physics.uiuc.edu/courses/phys199pom/Lecture_Notes/P199POM_Lect4_Ch4_Part2.pdf

The explanation?

If we a find a conclusive evidence that the sound is explained by this or that phenomenon, then we identify its causes and answer the question.

Probable hypotheses:

- **Light pressure**
  - Rumors of such an explanation circulate on the Web
  - Provokes greatest concerns if the effect if strong enough to cause vibrations
  - Requires a theoretical estimation of what momentum a cymbal may gain after a flash
- **Sudden deformation of a cymbal caused by rapid heating**
  - Requires experimental and/or theoretical verification
  - If a joint of a thermocouple is illuminated with a flash, is there any current surge (registered with a PC)?
  - If existent, what is the cause? (absorption of radiation? Foucault currents caused by electromagnetic waves?)

Key questions

- Above all, what is the cause of the sound?
- If you propose an explanation, does it look as a subject to direct experimental proof or disproof?
- What qualitative/quantitative experiments may be held to validate or invalidate your explanation?
- What is a “confirmability” and a “falsifiability” or a physical theory?
- Many approaches and concepts may emerge at discussions (photons, electromagnetic waves, phonons,…) Can you re-formulate your explanation with different basic concepts?
- At what degree the sound is reproducible?
- Can a photoelectric multiplier help in measuring the parameters of the flash?
- What total acoustic energy is produced by the oscillating cymbal? How does it correspond to the energy radiated by flash and the energy stored in the flash’s capacitor?
- What is the spectrum of the produced sound? Does it change with time?
- After the initial excitation, how is the energy re-distributed among various oscillatory modes? Are any resonance effects relevant to this phenomenon?

камн и глиняным сосудомъ, наливаютъ насыщенный водный *растворъ мѣднаго купороса*, а въ глиняный сосудъ — *растворъ*

Рис. 302.

Рис. 303.

сѣрной кислоты; глиняный сосудъ обжигается весьма слабо, чтобы растворы мѣднаго купороса и сѣрной кислоты могли соприкасаться чрезъ его стѣнки. Рис. 303 изображаетъ элементъ

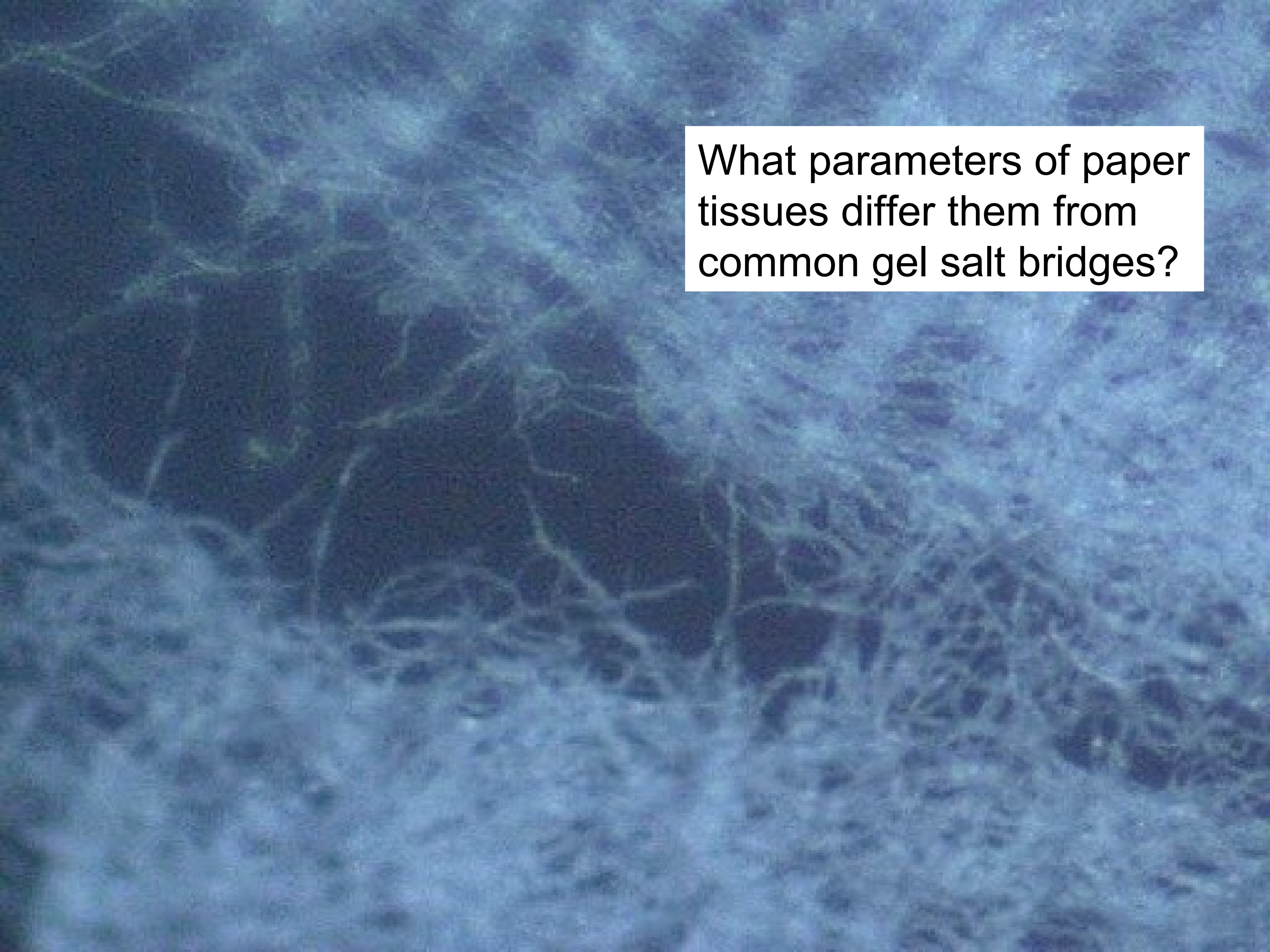
Problem No. 5 “Voltaic cell”

Make a voltaic cell using paper tissues as a salt bridge. Study and explain how the electromotive force of this battery depends on time.

К.Д. Краевичъ. Учебникъ физики. Спб.: 1912. Стр. 318 (Элементъ Данієля).

Basic reading in electrochemistry

- E.L. Sibert. Introduction to Electrochemistry. University of Wisconsin – Madison, 2001. http://www.chem.wisc.edu/~sibert/tci/329/powerpoints/Chem_329_Electrochemistry_1.ppt
- J.D. Bookstaver. Chapter 20. Electrochemistry (lecture notes). MichiganTech, 2006. http://www.chemistry.mtu.edu/pages/courses/files/ch1120-usalma/chapter_20au.ppt
- M.P. Heitz. Chapter 18. Electrochemistry (lecture notes). State University of New York at Brockport, 2005. http://www.chem.nthu.edu.tw/faculty/sdhuang/ch/ch_18.ppt
- S. Chandra. Lectures for Electrochemistry. The University of the South Pacific (Fiji), 2005. http://classshares.student.usp.ac.fj/CH105/Lectures%20for%20electrochemistry.ppt
- S. Perrier. Lecture notes on Electrochemistry. The University of Sydney (Australia), 2007. http://firstyear.chem.usyd.edu.au/Lectures/perrier%206_3.pdf
- Wikipedia: Electrochemistry. http://en.wikipedia.org/wiki/Electrochemistry
- Wikipedia: Primary cell terminology. http://en.wikipedia.org/wiki/Primary_cell_terminology
- Wikipedia: Galvanic cell. http://en.wikipedia.org/wiki/Galvanic_cell
- Wikipedia: Electrode potential. http://en.wikipedia.org/wiki/Electrode_potential
- Wikipedia: Table of standard electrode potentials. http://en.wikipedia.org/wiki/Standard_electrode_potential_%28data_page%29
- Wikipedia: Nernst equation. http://en.wikipedia.org/wiki/Nernst_equation
- Wikipedia: Daniel cell. http://en.wikipedia.org/wiki/Daniell_cell



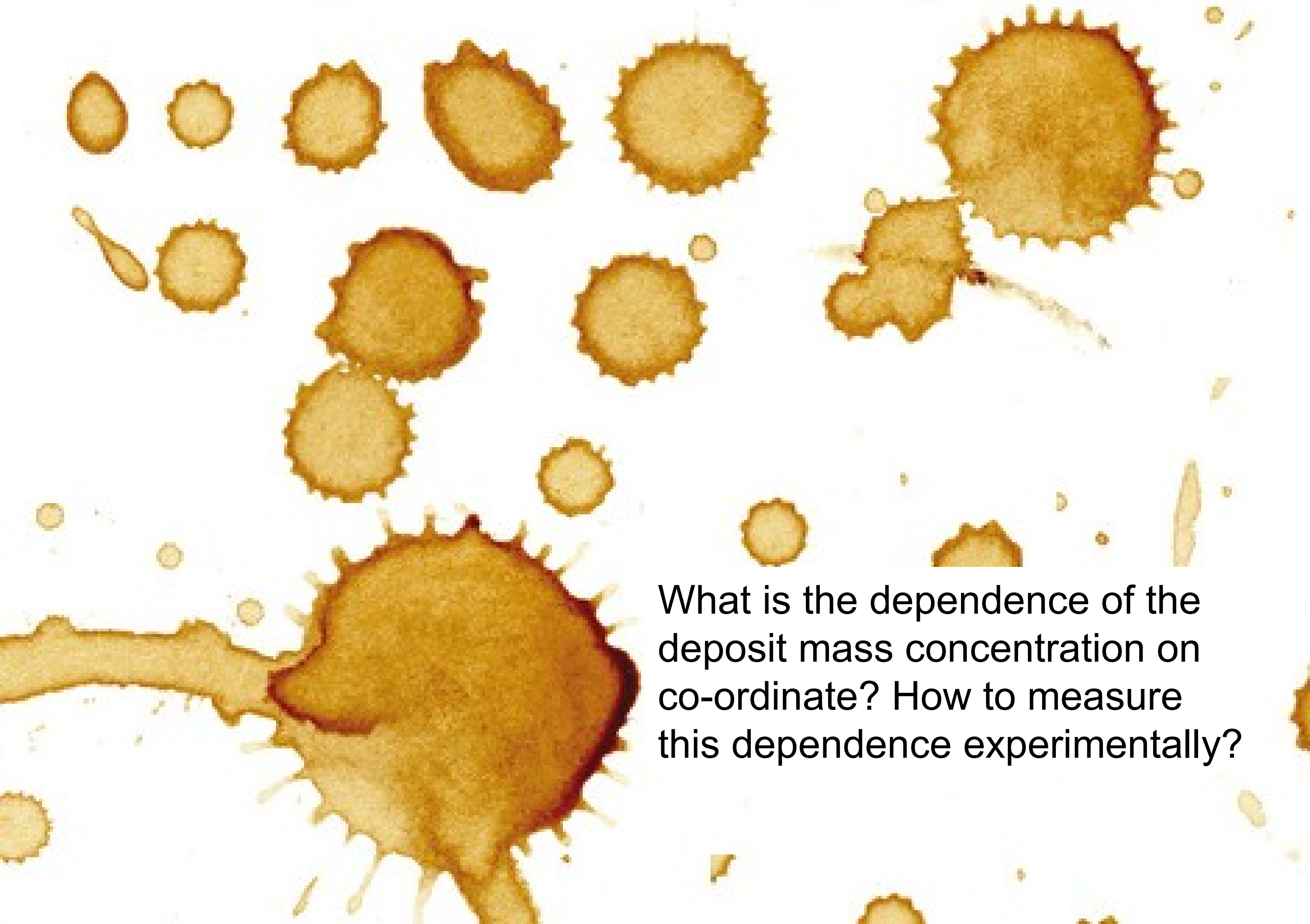
What parameters of paper tissues differ them from common gel salt bridges?

Key questions

- Can we indirectly find the cell’s EMF is we know the standard reduction potentials for the solutions of chemical compounds?
- What changes, if in experiment we take an initially dry tissue, or a tissue imbued with water, or a tissue imbued with a conductive solution?
- What types of interactions may happen between the macromolecular chains of paper and molecules of acids/salts/bases used in the cell?
- What parameters of paper tissues are relevant (average diameter of pores? chemical properties of fibers? thickness of the paper tissues? using several paper tissues instead of one?)
- A typical AA battery has very small internal resistance which allows consuming almost all power on the external resistors. It that the case for our voltaic cell?
- Above all, the salt bridge is the path for what to move?
- What ambient physical conditions may directly influence on the physical processes in the salt bridge? (humidity of the air? temperature of the air?)
- How does the time dependence of EMF change for various external loads?
- What if we carry out a parallel experiment with more common salt bridges or without any salt bridge at all?

Problem No. 6 “Liquid stain”

When a drop of liquid such as coffee dries on a smooth surface, the stain usually remains at the edge of the drop. Investigate why the stain forms at the edge and what parameters affect the characteristics of the stain.



What is the dependence of the deposit mass concentration on co-ordinate? How to measure this dependence experimentally?

http://jfi.uchicago.edu/~tten/Coffee.drops/redner-popov/drop.jpg

Additional reading

- R.D. Deegan, O. Bakajin, T.F. Dupont, G. Huber, S.R. Nagel, T.A. Witten. Capillary flow as the cause of ring stains from dried liquid drops. Nature, 389, 327 (1997). http://jfi.uchicago.edu/~tten/Coffee.drops/Nagel.7.4.pdf
- J. Satterly. Casual Observations on Milk, Picjled Beet-Root, and Dried-Up Puddles, Am. J. Phys., 24, 529 (1956).
- R.D. Deegan. Contact Line Deposits in an Evaporating Drop. Phys. Rev. E, 62 (1), 756-765 (2000).
- R.D. Deegan. Deposition at Pinned and Depinned Contact Lines: Pattern Formation and Applications. PhD thesis at the University of Chicago (1998). http://jfi.uchicago.edu/~tten/Coffee.drops/Deegan.thesis.pdf
- H. Stone. Manipulating Thin-Film Flows: From Patterned Substrates to Evaporating Systems. Lecture on June 29, 2007. Diffusion des savoirs de l'École Normale Supériueure (France). http://www.diffusion.ens.fr/data/video-mp4/2007_06_29_stone.mp4
- R. Zheng, Y.O. Popov, and T.A. Witten. Deposit Growth in the Wetting of an Angular Region with Uniform Evaporation. arXiv:cond-mat/0410493 v3 1 Jun 2005
- R. Zheng. A Study of the Evaporative Deposition Process: Pipes and Truncated Transport Dynamics. arXiv:0712.0169v1 [cond-mat.soft] 2 Dec 2007
- V.A. Belyi, D. Kaya, and M. Muthukumar. Periodic Pattern Formation in Evaporating Drops. arXiv:cond-mat/0612574v1 21 Dec 2006

Additional reading

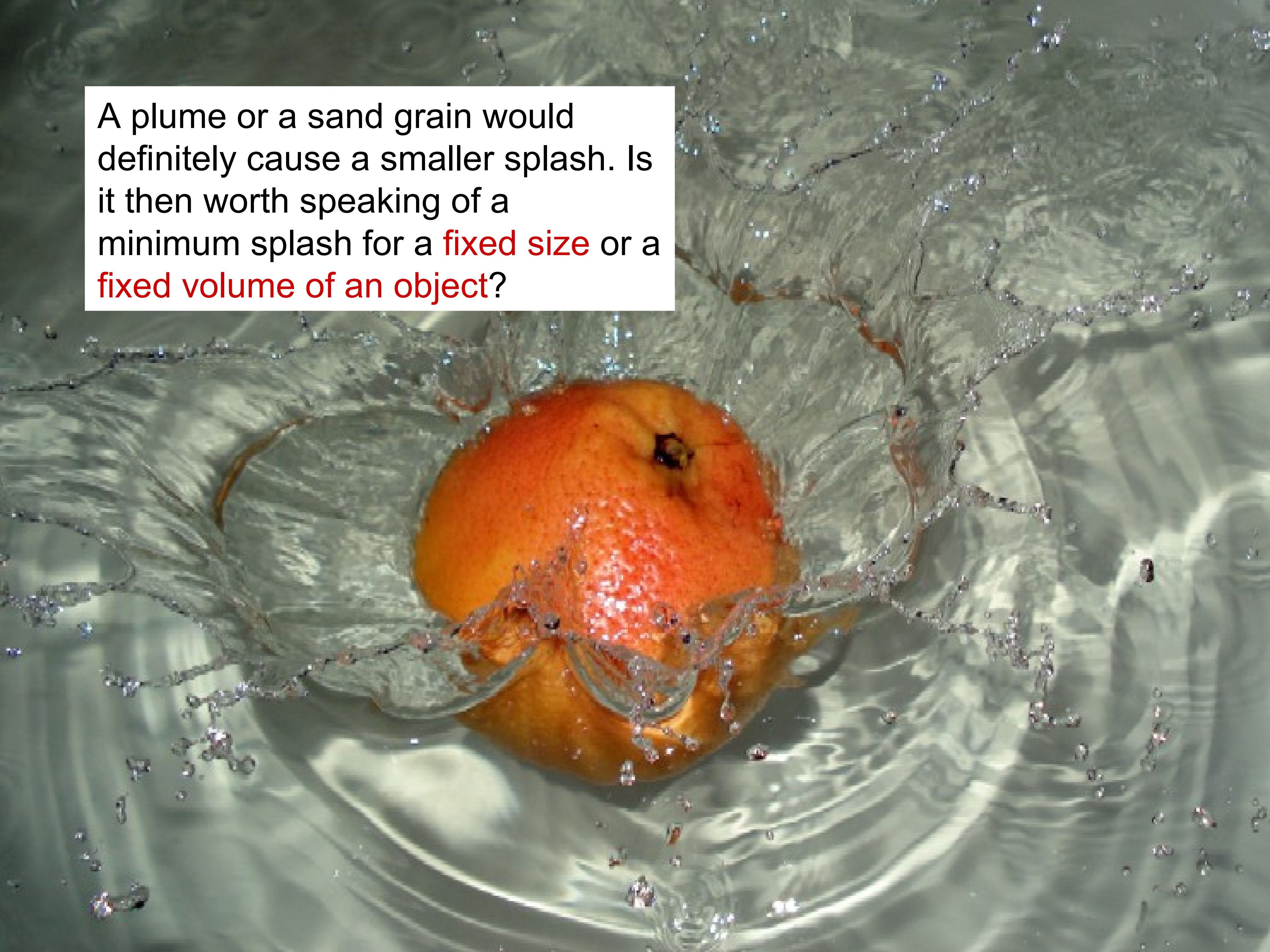
- E. Sultan, A. Boudaoud, M. Ben Amar. Evaporation of a thin film: Diffusion of the vapour and Marangoni instabilities. J. Fluid Mech. arXiv:cond-mat/0408609v2 [cond-mat.soft] 12 Nov 2004
- D. Barolo, C. Josserand, D. Bonn. Retraction Dynamics of Aqueous Drops Upon Impact on Non-Wetting Surfaces. J. Fluid Mech. arXiv:
- T. Haschke, D. Lautenschlager, W. Wiechert, E. Bonaccurso, H.-J. Butt. Simulation of Evaporating Droplets on AFM-Cantilevers
- Y.O. Popov. Evaporative Deposition Patterns Revisited: Spatial Dimensions of the Deposit. Phys. Rev. E, 71, 036313 (2005). arXiv:cond-mat/0408106 v2 7 Dec 2004
- Y.O. Popov, T.A. Witten. Characteristic Angles in the Wetting of an Angular Region: Surface Shape. arXiv:cond-mat/0006387 v4 13 Aug 2001
- Y.O. Popov. Singularities, Universality, and Scaling in Evaporative Deposition Patterns. PhD thesis at the University of Chicaho (2003). arXiv:cond-mat/0312196 v2 5 Aug 2004
- D.B. Van Dam. Layer Thickness Distribution of Thin-Film Ink-Jet Printed Structures. Proc. XXI ICTAM, August 15-21, 2004, Warsaw, Poland.
- L. Shmuylovich, A.Q. Shen and H.A. Stone. Surface Morphology of Drying Latex Films: Multiple Ring Formation. Langmuir, 18, pp. 3441-3445. (Apr. 6, 2002). http://www.me.wustl.edu/ME/faculty/aqshen/latex.pdf

Key questions

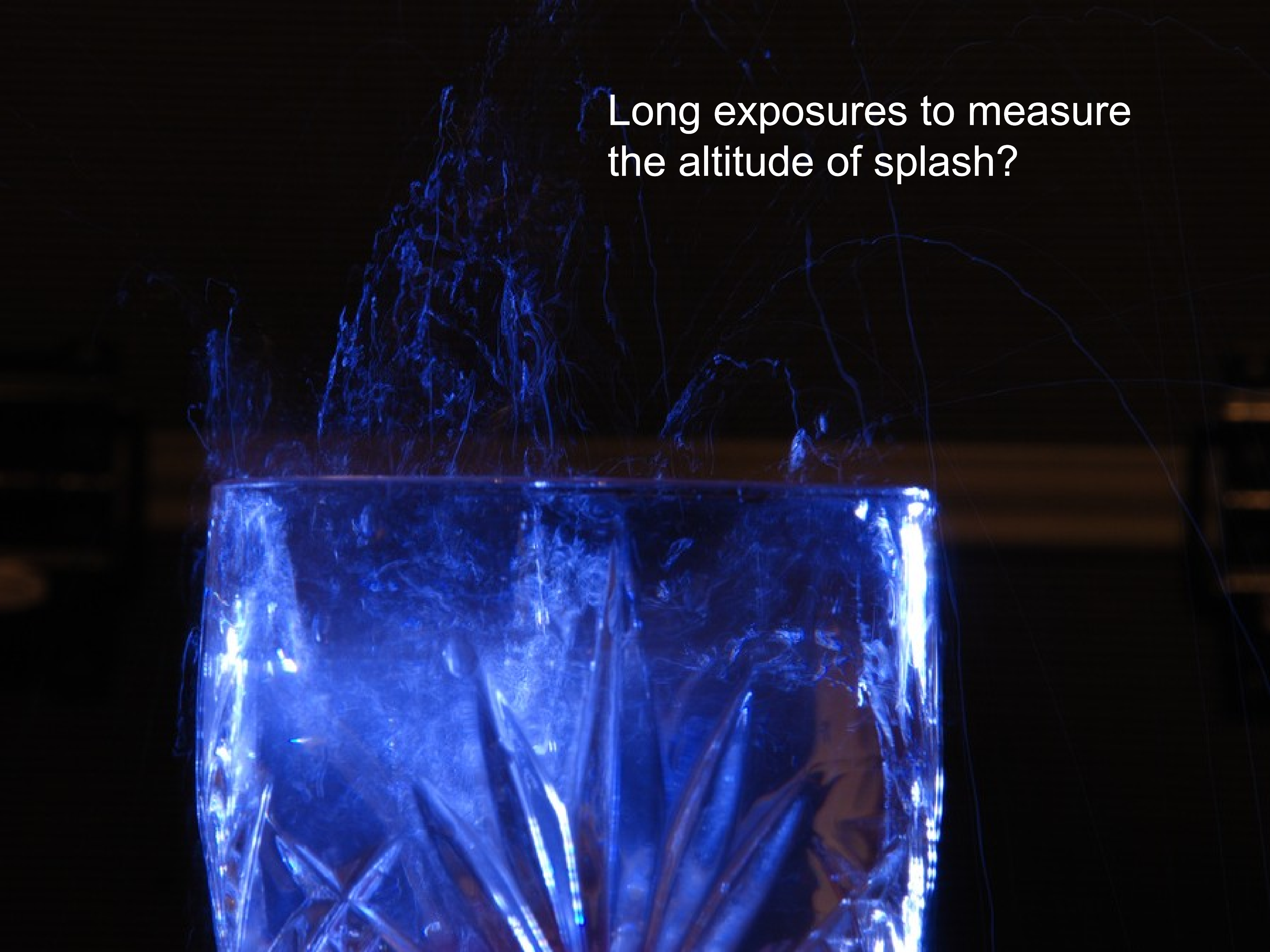
- Is such a phenomenon possible with the solutions of salts, which are not colloid suspensions like coffee?
- What is the initial shape of the evaporating coffee droplet? How does it change with time? How does the contact area between the droplet and the substrate change with time?
- Is there a way to measure experimentally the dependence of deposit density on co-ordinate? (color density measured with photoshop? number or particles per unit area counted under microscope? attenuation of a light beam measured with a proper sensor?)
- What physical parameters of the liquid may influence on the effect? (the viscosity? viscosity of the pure solvent? concentration? chemical nature of solvent? surface tension?)
- What initial parameters of the droplet may influence on the effect? (volume? height? shape?)
- What parameters of ambient atmosphere may influence on the effect? (air humidity? presence of air flows?)
- What is the role of the Brownian motion of coffee particles?
- Are the physical properties of the substrate relevant to the problem?
- Is it possible to observe not a single belt, but a series of belts?

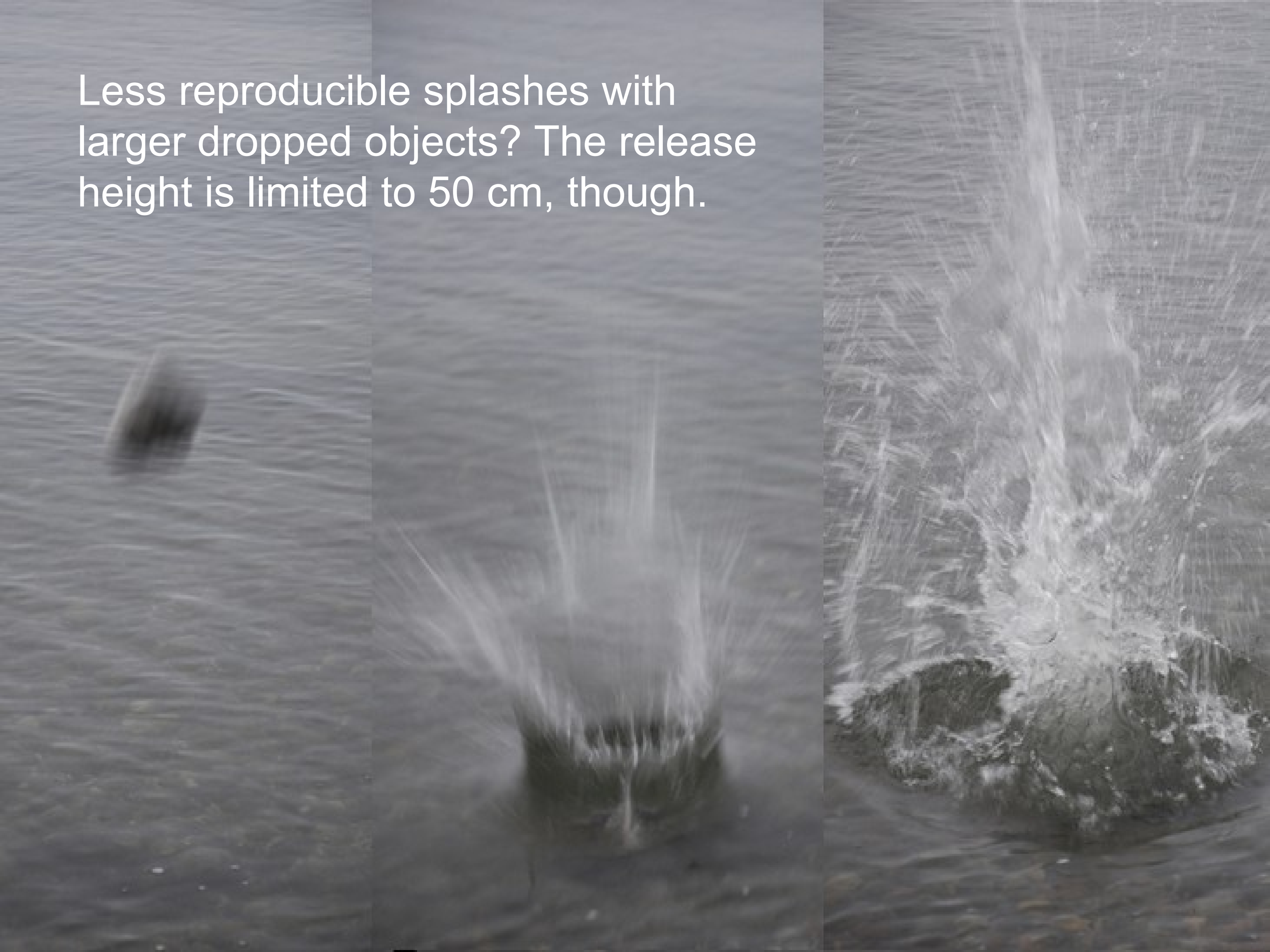
Problem No. 7 “Making a Splash”

A solid object is dropped into water from a height of 50 cm. Investigate the factors that would minimize the splash.



A plume or a sand grain would definitely cause a smaller splash. Is it then worth speaking of a minimum splash for a fixed size or a fixed volume of an object?


Long exposures to measure
the altitude of splash?


Less reproducible splashes with
larger dropped objects? The release
height is limited to 50 cm, though.

Background reading

- Wikipedia: Splash. http://en.wikipedia.org/wiki/Splash_%28fluid_mechanics%29
- C. Duez, C. Ybert, C. Clanet, L. Bocquet. Making a splash with water repellency. Nature, Vol. 3, p. 180-183. (March 2007). arXiv:cond-mat/0701093v1 5 Jan 2007
- J. Oliver. Water Entry and Related Problems. PhD thesis at Oxford University (2002). http://eprints.maths.ox.ac.uk/archive/00000132/01/oliver.pdf
- S.M. Laverty, Jr. Experimental Hydrodynamics of Spherical Projectiles Impacting On a Free Surface Using High Speed Imaging Techniques. Master's thesis at the MIT (August 2004). http://web.mit.edu/mhl/www/Impact%20Lab%20Page/Whole%20Thesis.pdf
- B. Akers, A. Belmonte. Impact dynamics of a solid sphere falling into a viscoelastic micellar fluid. J. Non-Newtonian Fluid Mech. 135, 97–108 (2006). http://www.math.psu.edu/belmonte/PaperFile/AkersImpact.pdf
- R. Bergmann, M. Stijnman, D. van der Meer, A. Prosperetti and D. Lohse. Void Collapse and Jet Formation: The impact of a disk on a water surface. (2004). http://fluid.ippt.gov.pl/ictam04/text/sessions/docs/FM10/11909/FM10_11909.pdf
- М.А. Лаврентьев, Б.В. Шабат. Проблемы гидродинамики и их математические модели. - М.: Наука, 1973. – стр. 291, 355

Key questions

- What physical parameters determine that the splash is indeed ‘minimum’? (maximum intensity or total acoustic energy of produced sound? altitude that sprinkles reach? mass of displaced water?)
- What physical properties of an object influence the splash? (volume of an object? shape of an object? initial angle of an inclined object? density of an object? mass of an object? properties of the object’s surface, such as if it is hydrophobic or hydrophilic?)
- What physical properties of a water basin influence the splash? (depth in a given point? proximity of walls? shape of a vessel?)
- Can we do something with the water surface? Wouldn’t we then violate the task? (pour some oil to make a thin film on the surface? dissolve a polymer analogous to polyox to make the solution non-Newtonian? increase viscosity? rotate liquid?)
- What is the role of cumulative jets? At what conditions the splash is determined by the cumulative jets, and at what conditions is not?
- What forces oppose the splash? (capillary? gravitational? viscous? inertial?)

Problem No. 8 “Astroblaster”

When a large ball is dropped, with a smaller one stacked on top of it, onto a hard surface, the smaller ball will often rise much higher than it would if dropped onto the same surface by itself while the larger ball hardly bounces at all. Investigate this phenomenon and design a multiple-ball system, using up to 4 balls, that will reach the greatest elevation of the top ball.

Background reading and watching

- Problem 26: Bouncing Superballs. OpenCourseWare at MIT (2005). http://ocw.mit.edu/NR/rdonlyres/Physics/8-01TFall-2004/634FEEA5-7439-4C3C-BBB9-E09B12027832/0/ic_sol_w08d1_1.pdf
- R. Kroeger. How the Astro Blaster works. http://www.phy.olemiss.edu/~kroeger/PHY211/AstroBlaster.pdf
- Vertikal Kollision i Astroblaster. FYSIKbasen.dk http://www.fysikbasen.dk/index.php?page=Vis&id=5
- Astro Blaster. Fascinations.com. http://www.fascinations.com/unique-toys-gifts/astro-blaster.htm; http://www.fysikbasen.dk/Referencemateriale/Film/astroBlaster.mov
- Tennis Ball and Basketball: A demonstration video from the University of Iowa. http://faraday.physics.uiowa.edu/Movies/MPEG/1n30.60.mpg
- W.R. Mellen. Superball Rebound Projectiles. Am. J. Phys., 26, 845 (1968).
- Class of W.G. Harter. Velocity Aplification in Collision Experiments Involving Superballs. Am. J. Phys., 39, 656 (1971).
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Key questions

- Simple theoretical considerations show that the upper ball may bounce as high as at $9h_0$ (for a 2-ball-system), $49h_0$ (for a 3-ball-system) and $225h_0$ (for a 4-ball-system). Is there a relation between these values and experimental observations?
- What is the dependence of the upper ball's bounce height on the release height?
- What physical parameters for each of the balls may improve the bounce height? (radius? density? elasticity of the material? properties of the balls' surface?)
- What is the dependence of restitution coefficients on these relevant parameters?
- What apparatus may help to release balls vertically and minimize further friction?
- The task asks to design a best system of balls. However, are there any external parameters that may improve or worsen the results? (properties of the substrate? precision in releasing system vertically? minor aerodynamic effects?)
- What if we replace free vertical bounces with a ballistic pendulum?
- Is it worth modeling the system numerically?
- What are the mechanical stresses at the collision points?

Problem No. 9 “Flute”

Drill a hole into the side of a tube that is open at one end and produce a sound by blowing the open end. Investigate the pitch and timbre of the sound of your flute and how they depend on the position and the diameter of the hole.

Background reading

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Key questions

- When a tube is open at only one end, is it a flute or a clarinet? What are key differences between tubes open at one end and tubes open from both ends?
- When we play a tube and blow across an open end, we produce an air flow. How exactly does this air flow cause oscillations? Is this air flow laminar or turbulent? What are the flow lines and can they be visualized?
- What determines the positions of nodes and antinodes on the oscillating tube?
- What parameters describe the sound produced by the tube, such as by any other musical instrument? Which of them are "physical" and which are "subjective"? (timber? tone color? volume? pitch?) How do they correspond to the fundamental frequency and the upper harmonics?
- What is the role of the hole in a tube?
- What is an acoustic impedance and what is its influence on the produced sound?
- Besides its length, what other parameters of the tube are relevant? (diameter of the tube? thickness of walls? radiuses of curvature of the ends of the tube?)
- Does material of the tube influence the parameters of the sound?
- It seems to be reasonable to record the tube's sound. What should be the requirements for the sound-recording equipment?
- What new we can add to this profoundly researched problem?

Problem No. 10 “Kaye Effect”

When a thin stream of shampoo is poured onto a surface, a small stream of liquid occasionally leaps out.This effect lasts less than a second but occurs repeatedly. Investigate this phenomenon and give an explanation.

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3

72 cm² area;

[7] Wooten, L. A., and Brown, C., J. Amer. Chem. Soc., 65, 113 (1943).
[8] Podgurski, H. H., and Davis, F. N., *J. Phys. Chem.*, **65**, 1343 (1961).

A Bouncing Liquid Stream

I WISH to report an unexpected effect observed when a thin stream of a solution of polyisobutylene in 'Decalin' is poured into solution in an open dish.

The solution was poured from a height of about 25 cm in a stream approximately 1 mm diameter into solution contained in an evaporating dish of diameter 10 cm. The ciné still photographs in Fig. 1 consist of every fifth frame from a 16-mm film shot at 64 frames/sec. The whole sequence shown therefore occurred in slightly less than 1 sec.

In Fig. 2 a key to the various features in the photographs is given.

As the stream enters the liquid the condition in the first frame of Fig. 1 is quickly established. A small 'heap' of liquid is formed at the point of entry. As pouring proceeds a small stream of liquid appears to emerge from the heap with a trajectory approximately parallel to the liquid surface (frame 2). The trajectory of this secondary stream gradually steepens and usually changes in azimuth (frames 3, 4, 5, 6 and 7) and at the same time the heap disappears. The secondary stream then begins to die away and disappears (frames 8, 9, 10 and 11). The heap of liquid grows again (frame 12) and the whole sequence is repeated. The secondary stream is approximately the

A. Kaye. A Bouncing Liquid Stream. Nature, 197, 1001 (1963).

Primary reading and watching

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Key questions

- At what conditions the effect is stable and reproducible, and at what conditions is not?
- Can the leap's distance, angle and duration be approached statistically?
- Can we observe the Kaye effect if there is no rigid surface under the liquid?
- What is the dependence of the shampoo's viscosity on the intensity of agitation (shear rate)?
- What is the dependence of the shampoo's viscosity on how long it was agitated?
- Can we classify shampoo as a non-Newtonian liquid of a certain type (thixotropic/shear-thinning, rheopectic/shear-thickening, dilatant…?)
- Nevertheless, can the effect be observed for Newtonian liquids, such as water?
- How exactly does the bouncing stream interact with the liquid heap? Is there a contact between them?
- What is the dependence of the leap height on the height from which the liquid is released?
- What new we can add to this profoundly researched problem?
- In 1963, Kaye wrote:

> I can offer no explanation for this behaviour, but it may be relevant to note that solutions of the type described are markedly non-Newtonian and visco-elastic, as shown by the work of Brodnyan, Gaskins and Philippoff[1].

  - Finally, how the effect is explained?

Problem No. 11 “Gutter”

When a thin layer of water flows along an inclined gutter different wave patterns are sometimes observed. Study this phenomenon.

Background reading

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Key questions

- At least, several types of “wave patterns” may be observed in a gutter. Which ones are relevant to the task, e.g.,
  - a thin stream of water that bends into a sinusoid-like periodical curve?
  - capillary surface waves on thin water film? (Kelvin waves?)
  - structures similar to hydraulic jump? (roll waves?)
- What conditions are necessary for observing this or that “wave pattern”?
- What physical properties of the gutter are relevant to the problem?
- What physical parameters may be controlled in a certain experiment:
  - angle of inclination of the gutter?
  - surface tension of water?
  - linear speed or discharge rate for water?
  - shape and radius of curvature of the gutter?
  - properties of the gutter’s surface?


Kelvin ship waves?


Capillary or gravitational?

Problem No. 12 “Geyser”

Support a long, vertical tube containing water. Heat the tube directly from the bottom and you will observe that the water erupts. Arrange for the water to drain back into the tube to allow repeated eruptions. Investigate the parameters that affect the time dependence of the process.

Background reading

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Key questions

- Due to increased pressure in a real geyser, water boils at significantly higher temperatures. Does that influence the eruptions?
- Is it possible to reproduce the increase of boiling temperature effect in a kitchen experiment?
- What physical parameters of your geyser influence the eruptions? (length of the tube? diameter of the tube?)
- Can we describe this system as an oscillator with feedback?
- What approaches to the problem may best describe the time dependences of eruptions? (thermodynamic? mechanical? statistical?)
- Are the observed processes reproducible?
- What constitutes a similarity between your model and a real geyser? What physical parameters of such systems may be considered similar?
- Geysers and geyser models are profoundly researched. What new we can add to this problem?

Problem No. 13 “Spinning Ice”

Pour very hot water into a cup and stir it so the water rotates slowly. Place a small ice cube at the centre of the rotating water. The ice cube will spin faster than the water around it. Investigate the parameters that influence the ice rotation.

Primary reading

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Key questions

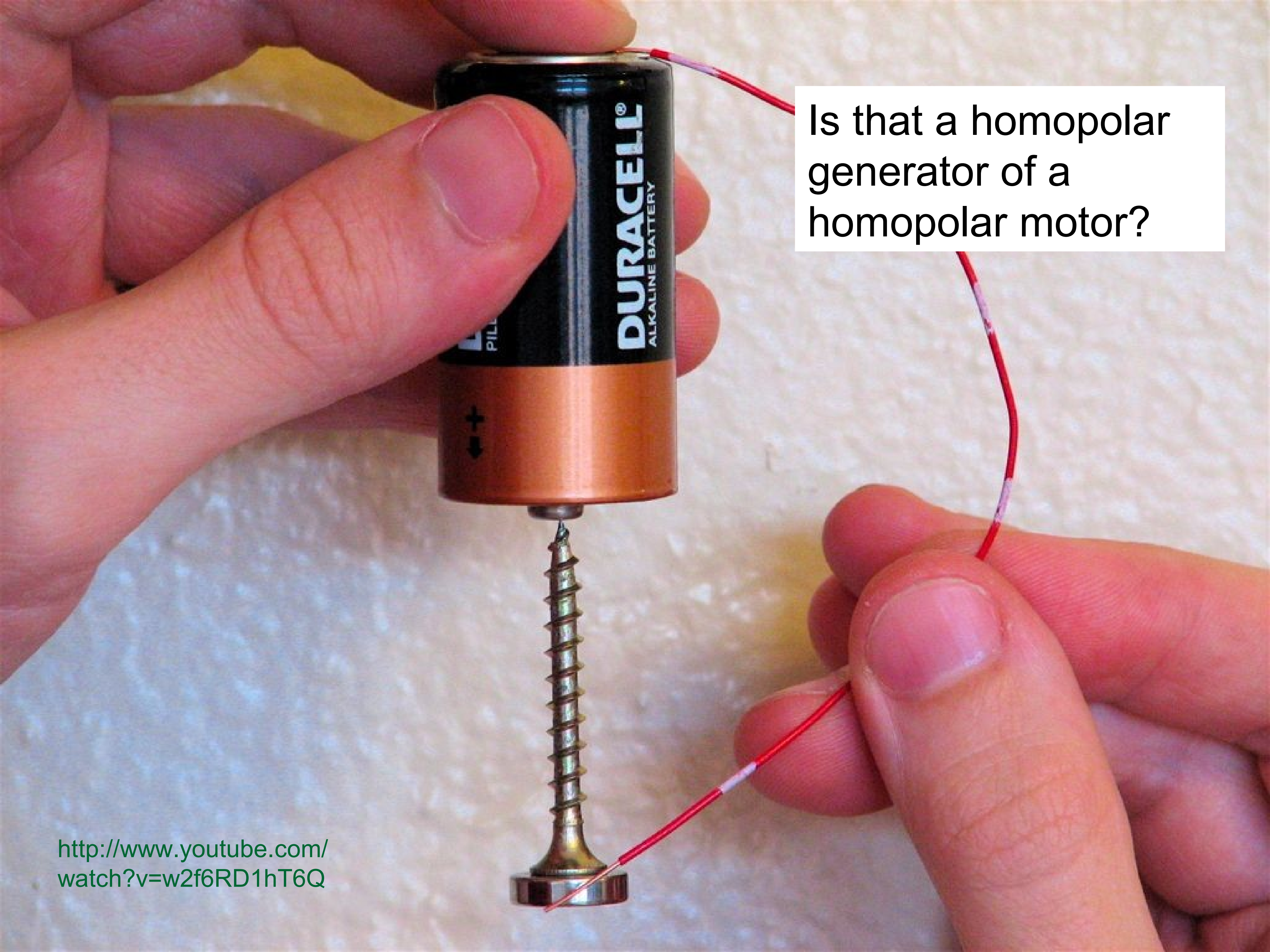
- Finally, why the ice cube spins faster?
- The cold water around the ice cube has a higher viscosity than the hot water in the rest of the vessel. Does that influence over the phenomenon?
- The cold water around the ice cube has a higher density than the hot water in the rest of the vessel. Does that influence the phenomenon?
- Dissolve some paint in the water before freezing it. Can that help in visualizing the flow patterns in the vessel as the ice cube melts?
- The ice cube loses its mass when melting. How does that affect its moment of inertia, its surface that experiences interface friction and other parameters that that are relevant to the angular speed?
- If you propose an explanation, does it look as a subject to direct experimental proof or disproof?
- What qualitative/quantitative experiments may be held to validate or invalidate your explanation?
- What is a “confirmability” and a “falsifiability” or a physical theory?

Problem No. 14 “Faraday Generator”

Construct a homopolar electric generator. Investigate the electrical properties of the device and find its efficiency.

http://www.earlytech.com/common/show_image.phtml?Id=1307954575&Item_Name=Faraday+Wheel+Dynamo+by+Griffin

Is that a homopolar generator of a homopolar motor?



http://www.youtube.com/watch?v=w2f6RD1hT6Q

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- G.N. Pellegrini and Arthur R. Swift, Maxwell's equations in a rotating medium: Is there a problem? Am. J. Phys. 63, 8, 694-705 (1995).

Key questions

- What physical parameters determine the generated voltage (angular speed of the disk? distance between contact electrodes? distance between the disk and the magnet?)
- Common electric motors have known efficiency. It you use rotate the Faraday disk with such a common motor and measure the consumed power along with the power generated by the Faraday disk, is that a method to find the Faraday disk's efficiency?
- What is the Faraday generator's efficiency in comparison to more widespread electric generators? What limits its efficiency? (much energy wastes to overcoming friction? counterflows in the parts of the disk that are less affected by the magnetic field? heating of the disk?)
- What parameters of the disk itself (not the entire apparatus) may influence the efficiency (material? roughness?)
- What is the role of the contact brushes?
- Can electric magnets help measuring the dependence of the Faraday disk's efficiency on the magnetic field?
- Why not to build a reverse Faraday's generator (a homopolar motor) that converges electricity into rotational motion, just for fun?

Problem No. 15 “Gelation”

Hot gelatine solution becomes a gel upon cooling. Investigate the electric conductivity as a function of temperature as it gels. Explain the results obtained.

Background reading

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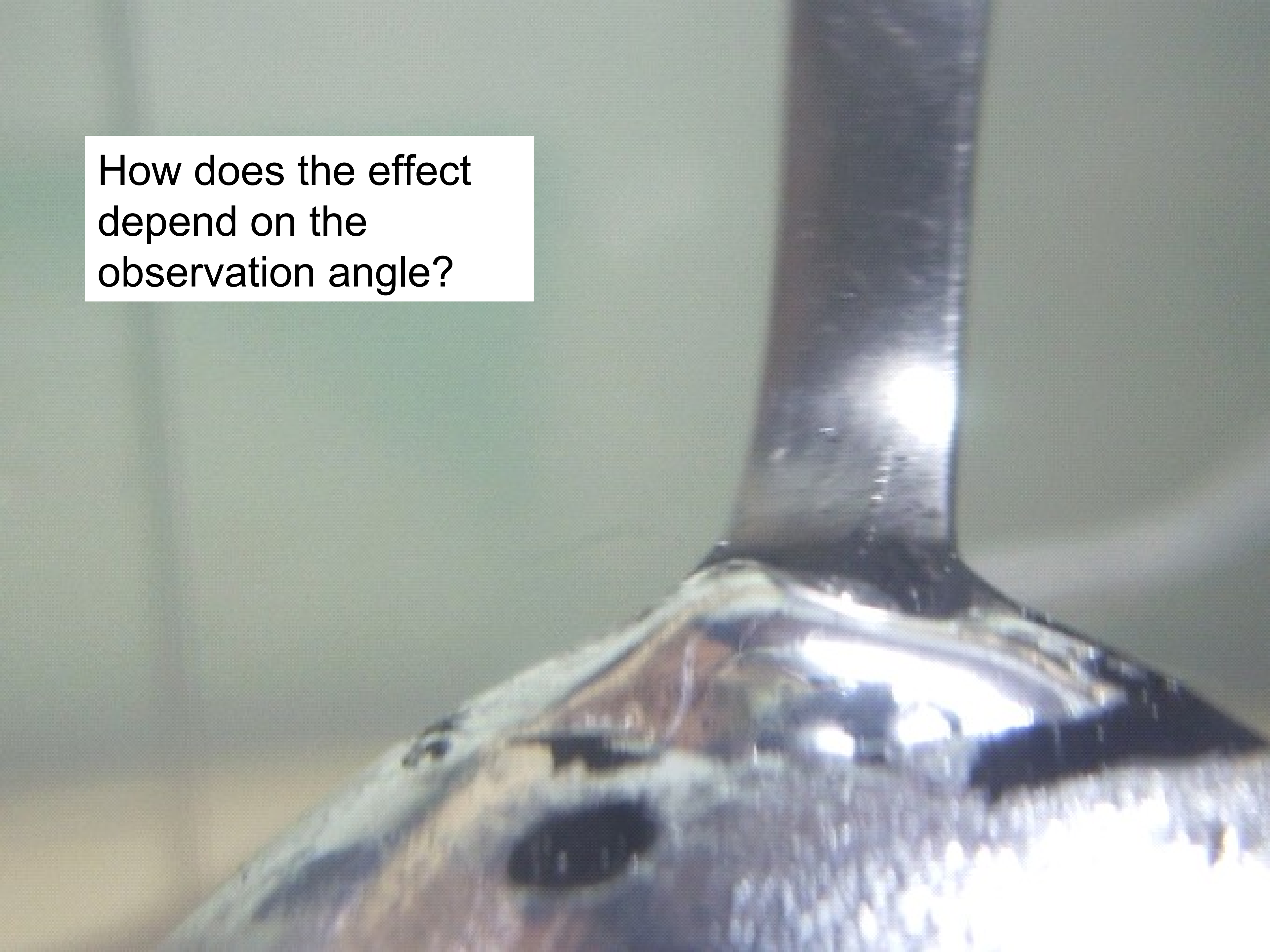
Key questions

- What is gelation, in fact? Is it always thermoreversible? Can it be regarded as a phase transition?
- What are charge carriers in gelatine? What happens to them during gelation? Is it worth speaking of a speed at which they can drift and of an ionic strength of the solution?
- Is there electrolysis when electric current passes through gelatine?
- What happens if we use not DC, but AC?
- Is there any abrupt change in electric conductivity of gelatine near the gelation point?
- What physical parameters influence on the magnitude of electric conductivity (initial concentration of gelatine solution? presence of salts in the solution? rate of temperature change, not only the actual temperature?)
- Does the frequency of AC influence the conductivity of gelatine?
- Many approaches and concepts may emerge at discussions (coil-helix transition, polymer networks, percolation, flocculation, coagulation, polycondensation of ions,…) Can you discuss their role and re-formulate your explanation with terminology familiar to opponents and jurors?
- Above all, what is your conclusion on the problem?

Problem No. 16 “Black spoon”

Blacken a spoon using a candle flame. If you immerse the spoon in water it appears glossy. Investigate the phenomenon and determine the optical properties of such a “mirror.”


How does the effect depend on the observation angle?

Primary reading

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Key questions

- Why the optical properties of a blackened spoon are different on the air and under water?
- Does the limit angle under which the effect is still observed correspond to the limit angle of total internal reflection for the air-water interface?
- A surface may behave as a mirror if the average size of its irregularities is smaller than the optical wavelength. Is it relevant in the problem?
- Is such a phenomenon possible with gel candles (that do not produce hydrophobic soot)?
- Is the blackened surface smooth or porous? What is the average size of its pores? If existent, how thick is the air layer between the blackened spoon and the water?
- What is the role of the spoon surface curvature? Can the mirror effect be observed on the internal surface of the spoon?
- What is the reflectivity of the black spoon in comparison to common mirrors?
- Above all, what optical properties are proposed to be determined and what methods might be used to measure them?

Problem No. 17 “Heat engine”

Build a heat engine powered only by the difference between the day and night air temperatures without using direct sunlight. Determine its efficiency.

Primary reading on heat engines

- Wikipedia: Heat engine. http://en.wikipedia.org/wiki/Heat_engine
- Wikipedia: Heat engine classifications. http://en.wikipedia.org/wiki/Heat_engine_classifications
- Wikipedia: Carnot cycle. http://en.wikipedia.org/wiki/Carnot_cycle
- Wikipedia: Carnot heat engine. http://en.wikipedia.org/wiki/Carnot_heat_engine
- Wikipedia: Thermal efficiency. http://en.wikipedia.org/wiki/Thermal_efficiency

Additional reading

- R.D. Lorenz, J.N. Spitale. The Yarkovsky effect as a heat engine. Icarus, 170, pp. 229–233 (2004). http://www.lpl.arizona.edu/~rlorenz/yarkovsky.pdf
- Wikipedia: Yarkovsky Effect. http://en.wikipedia.org/wiki/Yarkovsky_Effect
- Discussion on Heat-pumped storage of thermal energy. Halfbakery project. (2006). http://www.halfbakery.com/idea/Heat-pumped_20storage_20of_20thermal_20energy
- Discussion on conversion of heat gradient into energy at Physicsforums. (2008). http://www.physicsforums.com/archive/index.php/t-231382.html

Key questions

- Different processes may take place as the ambient temperature changes from the night one to the day one. Which of these processes may be used to make a heat engine?
- Everyone will focus on the thermodynamic gas processes and will discuss the Carnot heat engines. Some may even discuss the Yarkovsky effect as a key approach to the problem. However, what are other possible approaches?
  - bimetal plates?
  - a thermocouple that has one of its junctions deep underground?
  - an object that experiences a phase transition at these very temperatures and may repeatedly release or indirectly produce mechanic, electric or thermal energy?
  - finally, what if our heat engine may operate due to irreversible processes? a boiler powered by methyl ether?
- Which of these approaches are simplest to implement in practice? Is it difficult to assemble such devices?
- What parameter allows comparing different approaches and is a subject to optimization?
- What processes or phenomena lead to maximum possible efficiency? How to define the efficiency for a certain process?
- Does the built apparatus age with time? (gas leaks out? friction increases?)

what are its x, y, and z components in te

(b) Compute $(\hat{\mathbf{r}} \cdot \nabla)\hat{\mathbf{r}}$, where $\hat{\mathbf{r}}$ is the uni

(c) For the functions in Prob. 1.15, evalu

Problem 1.22 (For masochists only.) Pr the definition of $(\mathbf{A} \cdot \nabla)\mathbf{B}$.

Problem 1.23 Derive the three quotien

Problem 1.24

$T = \frac{1}{f}$ $\quad w = \frac{2\pi}{T} = 2\pi f$ $\quad F = -kx$ $\quad k = m w^2$ $\quad w = \sqrt{\frac{k}{m}}$ $\quad T = 2\pi\sqrt{\frac{m}{k}}$

$U(t) = \frac{1}{2}kx^2$ $\quad K(t) = \frac{1}{2}mv^2$ $\quad E_{Tot} = U + K$ $\quad PE = mgh$

$F_d = -bv$ $\quad x(t) = x_m e^{\frac{-bt}{2m}}\cos(w't + \phi)$ $\quad w' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$ $\quad E(t) \approx \frac{1}{2}kx_m^2 e^{\frac{-bt}{m}}$

critical damp $b^2 = 4km$

under damped $b^2 < 4km$

over damped $b^2 > 4km$

$T = 2\pi\sqrt{\frac{L}{g}}$ simple pend

$w_d = w$ resonance

$T = 2\pi\sqrt{\frac{I}{mgh}}$ physical pend

$y(x,t) = y_m \sin(kx - wt)$ wave in pos direction

$v(t) = -wx_m \sin(wt + \phi)$ $\quad a(t) = -w^2 x(t)$

$x(t) = x_m \cos(wt + \phi)$

$k = \frac{2\pi}{\lambda}$ $\quad v = \frac{w}{k} = \frac{\lambda}{T} = \lambda f$ $\quad v = \sqrt{\frac{\tau}{\mu}}$ $\quad \mu = \frac{mass}{length}$ $\quad P_{ave} = \frac{1}{2}\mu v w^2 y_m^2$

resonance $\lambda = \frac{2L}{n}$ $n = 1,2,3$ $\quad v = \sqrt{\frac{B}{\rho}}$ - Bulk modulus

$f = \frac{v}{\lambda} = \frac{nv}{2L}$ $n = 1,2,3$

$\Delta P_m = v\rho w S_m$ - displacement, pressure

$f = \frac{v}{\lambda} = \frac{nv}{2L}$ $n = 1,2,3$ Pipe 2 open ends displacement antinode pressure node

$P_m^2 = 2\rho v I$ $\quad P_m = v\rho w S_m$ $\quad f_{beat} = |f_1 - f_2|$

$f = \frac{nv}{4L}$ $(n = 1,3,5)$ Pipe 1 open end displacement antinode at open, node at closed

Interference $\quad I = \frac{Power}{Area} = \frac{P_s}{4\pi r^2}$ $\quad \sin\theta = \frac{v}{v_s}$ $\quad \frac{v_s}{v} =$ mach #

$\frac{\Delta L}{\lambda} = 0,1,2$ fully constructive $\quad \phi = \frac{\Delta L}{\lambda} 2\pi$ $\quad I = \frac{1}{2}\rho v w^2 S_m^2$ $\quad I_0 = 1\times10^{-12}$

$\frac{\Delta L}{\lambda} = 0.5, 1.5, 2.5$ fully destructive $\quad B = 3\alpha$ $\quad Q = C\Delta T$ heat capacity $\quad f' = f\frac{v \pm v_d}{v \pm v_s}$ $\quad B = (10)\log\frac{I}{I_0}$

$\Delta L = L\alpha\Delta T$ $\quad \Delta V = V\beta\Delta T$ $\quad T_F = \frac{9}{5}T_C + 32$ $\quad Q = cm\Delta T$ specific heat

$\Delta E_{int} = Q_{in} - W_{out}$ $\quad P_{cond} = \frac{Q}{t} = kA\frac{T_H - T_C}{L}$ $\quad Q = L_m$ Heat of transformation $\quad W = \int_{V_i}^{V_f} p\,dV$

$\log\frac{x}{y} = \log x - \log y$ $\quad \log_a x = y \Leftrightarrow a^y = x$

$n = \frac{molecules}{6.02\times10^{23}}$ $\quad R = \frac{L}{k}$ Multi Slab $P_{cond} = \frac{A(T_H - T_C)}{\Sigma L/k}$ $\quad P_{radiation} = \sigma\varepsilon AT^4$ emissivity $\quad P_{net} = P_{abs} - P_{rad}$

$5.67\times10^{-8}\frac{W}{m^2K^4}$ $\quad P_{abs} = \sigma\varepsilon AT_{env}^4$

Adiabatic $Q = 0$ $\Delta E = -W$ $\quad pV = nRT$ $\quad R = 8.31\frac{J}{mol\cdot k}$

Con Vol $W = 0$ $\Delta E = Q$

closed cyc $\Delta E = 0$ $Q = W$ $\quad W = nRT\ln\frac{V_f}{V_i}$ (isothermal) $\quad K_{avg} = \frac{3}{2}kT$ $\quad 1.38\times10^{-23}\frac{J}{K}$ $\quad M =$ molar mass $\quad V_{rms} = \sqrt{\frac{3RT}{M}}$

Free exp $Q = W = 0$ $\Delta E = 0$ $\Delta T = 0$

$E_{int} = \frac{3}{2}nRT$ changes $\quad Q = nC_V\Delta T$ (constant Volume) $\quad Q = nC_p\Delta T$ (con press) $\quad W = p\Delta V = nR\Delta T$ (con press) $\quad \gamma = \frac{C_p}{C_V}$ $\quad V_{avg} = \sqrt{\frac{8RT}{\pi M}}$

$C_V = \frac{3}{2}R$ changes $\quad C_V = C_p - R$ $\quad \Delta E = \frac{3}{2}nR\Delta T$ changes $\quad T_iV_i^{\gamma-1} = T_fV_f^{\gamma-1}$ $\quad P_iV_i^{\gamma} = P_fV_f^{\gamma}$ (adiabatic) $\quad V_{mp} = \sqrt{\frac{2RT}{M}}$

$\Delta E = nC_V\Delta T$ $\quad$ Free exp $P_iV_i = P_fV_f$ $\quad \Delta S = \frac{|Q_H|}{T_H} - \frac{|Q_L|}{T_L}$

Deg of freedom

	Translation	rotation	Tot	C_V	C_p
monatomic	3	0	3	$3/2 R$	$5/2 R$
Diatomic	3	2	5	$5/2 R$	$7/2 R$
Polyatomic	3	3	6	$3R$	$4R$

$\Delta S = \int_i^f \frac{dQ}{T}$ $\quad \Delta S = \frac{Q}{T}$ isothermal $\quad \Delta S = \frac{Q}{T_{ave}}$ small ΔT

$\Delta S = nR\ln\left(\frac{V_f}{V_i}\right) + nC_V\ln\frac{T_f}{T_i}$

engine $W = |Q_H| - |Q_L|$ $\quad \frac{|Q_H|}{T_H} = \frac{|Q_L|}{T_L}$ $\quad \varepsilon = \frac{|W|}{|Q_H|}$ energy we get / energy we pay for $\quad \varepsilon_C = \frac{|Q_H| - |Q_L|}{|Q_H|} = 1 - \frac{Q_L}{Q_H}$

Refrigerator $k = \frac{|Q_L|}{|W|}$ what we want / what we pay for $\quad K_C = \frac{|Q_L|}{|Q_H| - |Q_L|}$ $\quad K_C = \frac{T_L}{T_H - T_L}$ $\quad \varepsilon_C = 1 - \frac{T_L}{T_H}$ $\quad \Delta S = -\frac{|Q|}{T_L} + \frac{|Q|}{T_H}$

$Q_{in} = \Delta U + W_{out}$

Pos: Heat absorbed, Increase energy, work done by System

Neg: Heat released, Decrease energy, work done on System

Polarization $I = I_0\cos^2\theta$ $\quad n = \frac{c}{v}$ $\quad \lambda_n = \frac{\lambda}{n}$ $\quad N_1 = \frac{Ln_1}{\lambda}$ $\quad N_2 = \frac{Ln_2}{\lambda}$

refraction $n_1\sin\theta_1 = n_2\sin\theta_2$ $\quad \frac{\lambda_1}{\lambda_2} = \frac{V_1}{V_2}$

critical angle $\theta_c = \sin^{-1}\frac{n_2}{n_1}$

Double slit $\Delta L = d\sin\theta$ $\quad d\sin\theta = m\lambda$ $(0,1,2)$ max $\quad d\sin\theta = (m + \frac{1}{2})\lambda$ $(0,1,2)$ min

$I = 4I_0\cos^2\left(\frac{1}{2}\phi\right)$ $\quad \phi = \frac{2\pi d}{\lambda}\sin\theta$

Brewsters angle $\theta_B = \tan^{-1}\frac{n_2}{n_1}$

Thin film $2L = \left(m + \frac{1}{2}\right)\frac{\lambda}{n_2}$ $(m = 0,1,2)$ maxima $\quad 2L = m\frac{\lambda}{n_2}$ $(m = 0,1,2)$

Single slit diffraction

$a\sin\theta = m\lambda$ $(m = 1,2,3)$ minima $\quad I = I_m\left(\frac{\sin\alpha}{\alpha}\right)^2$ $\quad \alpha = \frac{1}{2}\phi = \frac{\pi a}{\lambda}\sin\theta$

Circular Diffraction $\sin\theta = 1.22\frac{\lambda}{d}$ first minimum, d aperture diameter $\quad \theta_r = 1.22\frac{\lambda}{d}$ rayleigh criterion, if $\theta > \theta_r$

Diffraction grating

$d\sin\theta = m\lambda$ $(m = 0,1,2)$ maxima lines $\quad \Delta\theta_{hw} = \frac{\lambda}{Nd\cos\theta}$ half width

lit separation $\quad R = Nm$ resolving power

$D = \frac{m}{d\cos\theta}$ dispersion

Plane mirror $i = -p$

Obj - S is pos in coming

Img - S' is pos outgoing light

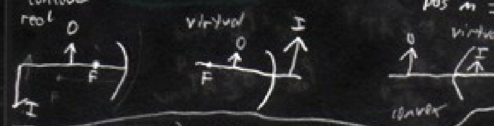
F - pos if on same light

$\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$ spherical mirror

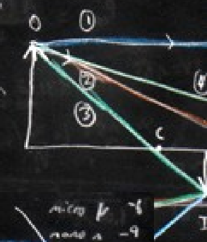
$f = \frac{\text{radius of curvature}}{2}$ $\quad |m| = \frac{h'}{h}$ $\quad m = -\frac{i}{p}$

pos m = same orientation

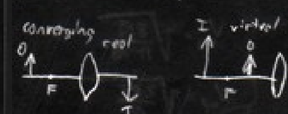
concave real, virtual, convex virtual

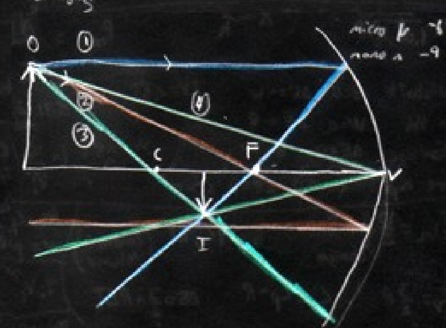


$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$ r_1 is near object $\quad M = m_1 \cdot m_2$

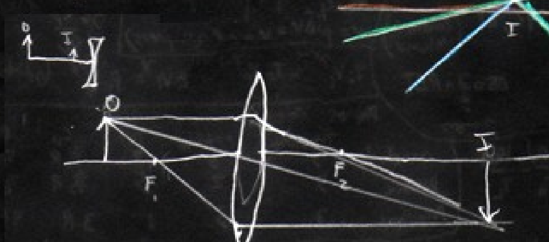


converging real, virtual, diverging





$m_\theta = \frac{25\text{ cm}}{f}$



These problems have no solution?

- "But, my dear fellows," said Feodor Simeonovich, having deciphered the handwriting. "This is Ben Beczalel's problem! Didn't Cagliostro prove that it had no solution?"
- "We know that it has no solution, too," said Junta. "But we wish to learn how to solve it"
- "How strangely you reason, Cristo… How can you look for a solution, where it does not exist? It's some sort of nonsense."
- "Excuse me, Feodor, but it's you who are reasoning strangely. It's nonsense to look for a solution if it already exists. We are talking about how to deal with a problem that has no solution. This is a question of profound principle…"

Arkady Strugatsky and Boris Strugatsky

Quote from: Arkady Strugatsky and Boris Strugatsky. Monday Begins on Saturday. Translated from the Russian. (The Young Guard Publishing House, Moscow, 1966).

To work towards results?

- Nobody needs an infinitely perfect report in an infinite time!

- If you can't solve the entire problem, decide what is really necessary and solve a partial problem.
- If you can solve the entire problem, nevertheless decide what partial case is sufficient, and your solution will be much better.
- Be brave in what you do, but always reserve a great degree of scientific skepticism!

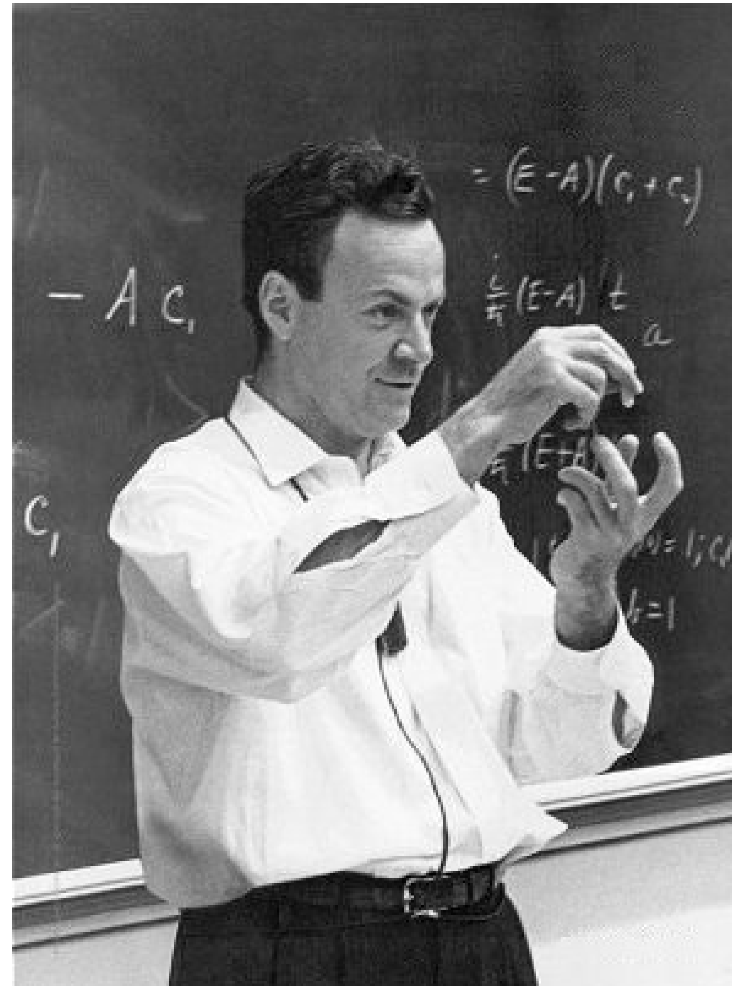
Requirements for a successful IYPT report

- A novel research, not a compilation of known facts or a survey
- A balance between experimental investigation and theoretical analysis
- A comprehensible, logical and interesting presentation, not a detailed description of everything-you-have-performed-and-thought-about
- A clear understanding of the validity of your experiments and how exactly you analyzed the obtained data
- A clear understanding of what your theory relies upon, and in what limits it may be applied
- Comparison of your theory with your experiments
- Clear conclusions and clear answers to voiced questions
- Solid knowledge of relevant physics
- Proofread nice-looking slides and all of your presentation skills
- An unexpected trick, such as a demonstration *in situ*, will always be a plus

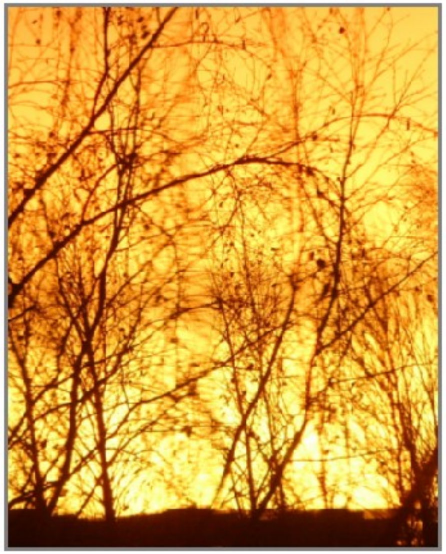
Feynman: being self-confident?

- I've very often made mistakes in my physics by thinking the theory isn't as good as it really is, thinking that there are lots of complications that are going to spoil it

- \- an attitude that anything can happen, in spite of what you're pretty sure should happen.



R.P. Feynman, Surely You’re Joking, Mr. Feynman, (Norton, New York, NY, 1985).



Preparation to the Young Physicists' Tournaments' 2008:

ideas, guidelines and advices

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