Professional Guidelines for establishing an Open Nano Lab / a Nano Researcher Live area

nanotoTOUCH

Appendix:

List of Nano-Demonstrations

This handbook and its appendices present professional guidelines on how to establish an Open Nano Lab or a Nano Researcher Live area in a science museum / science centre in cooperation with a local partner university.

Of course the construction of such areas requires individual planning depending on the local circumstances, and thus this work can not be seen as a complete set of instructions, but far more as a guidance manual containing the experiences gathered in the 'Open Research Laboratory' of the Deutsches Museum in a condensed form.

SEVENTH FRAMEWORK PROGRAMME

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nanotoTOUCH
nanosciences live in science centres and museums

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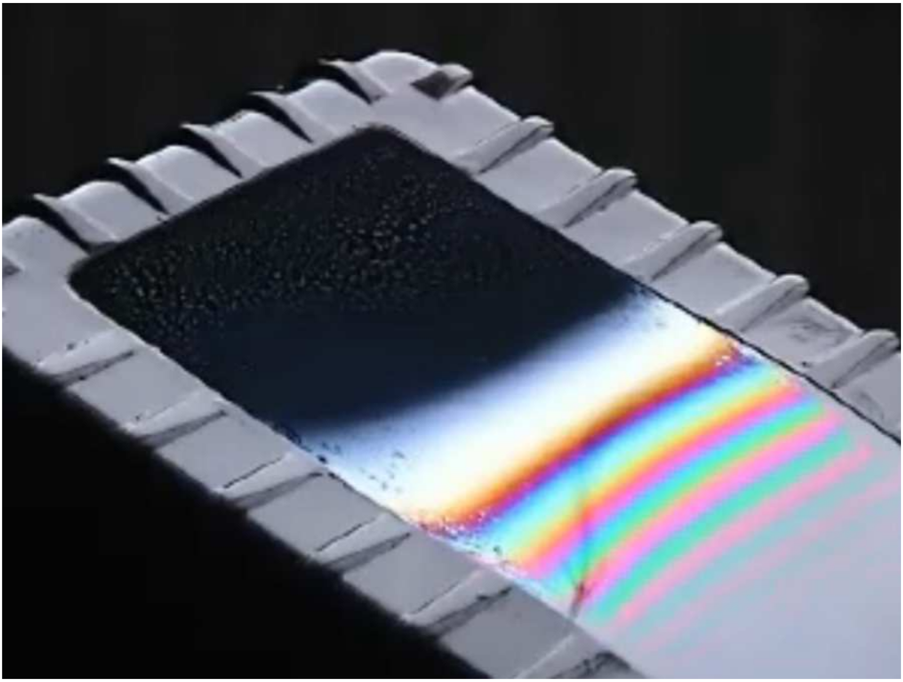
This Appendix

In this appendix are various nano-demonstrations which have been shown in the Open Research Laboratory of the Deutsches Museum.

This compilation is meant to assist you in creating texts for your Open Nano Lab or Researcher Live Area. Apart from translation into your local language, it will also be necessary to cooperate with the local university partner to create individual texts on the specific research conducted by the scientific group.

Please feel free to use these texts as they are, or to amend them to your requirements.



Soap bubble demonstration showing:

- at bottom right the colourful world of macroscopic structures (white area and interference stripes)

- at top left the colourless world of nanoscopic structures (black area of soap bubble)

Soap Bubble

General Description

A simple and easy-to-understand demonstration which is ideal as an introduction into the nano-world is by means of a soap bubble. When a soap bubble thins out, interference stripes emerge in different colours. The final stripe is bright white, after which the soap bubble appears completely black. In this black area, the soap bubble is below 100nm thick (explanation below), thus demonstrating that it is possible to 'see' nano-sized structures with the naked eye.

The coloured stripes are caused by light waves interfering with each other within the bubble. Some of the light entering from above is reflected by the surface of the bubble, as is some of the light entering from below. The minimum thickness for this to occur is half the wave-length of light (½ in + ½ out = 1 wavelength). However, these light waves interfere with each other at down to half of this distance (¼ the wavelength of light). For blue light (i.e. diffuse light) with a wavelength of 460 nm, this means that interference is visible down to 115 nm. When this figure is divided by the optical coefficient of soapy water (around 1,2), this means that the final interference limit is just below 100 nm.

Demonstration

For this it is necessary to create a planar soap bubble and place it at an angle so that it drains down, thus thinning out at the top. First create a soapy solution, e.g. of washing-up liquid in water. Then immerse a carrier object (in our case a rectangular black plastic container with the centre cut out; also possible is e.g. a wire frame or even a coffee mug) and remove from solution, creating a planar soap bubble. Place at an angle and let the bubble slowly drain downwards. The effect can best be observed in front of a black background.

Required Materials

washing-up liquid, water, carrier object (plastic container, wire frame, coffee mug,...)

YouTube film

Please see the demonstration filmed at the Deutsches Museum:

Name: Soap Bubble

User: manf1234

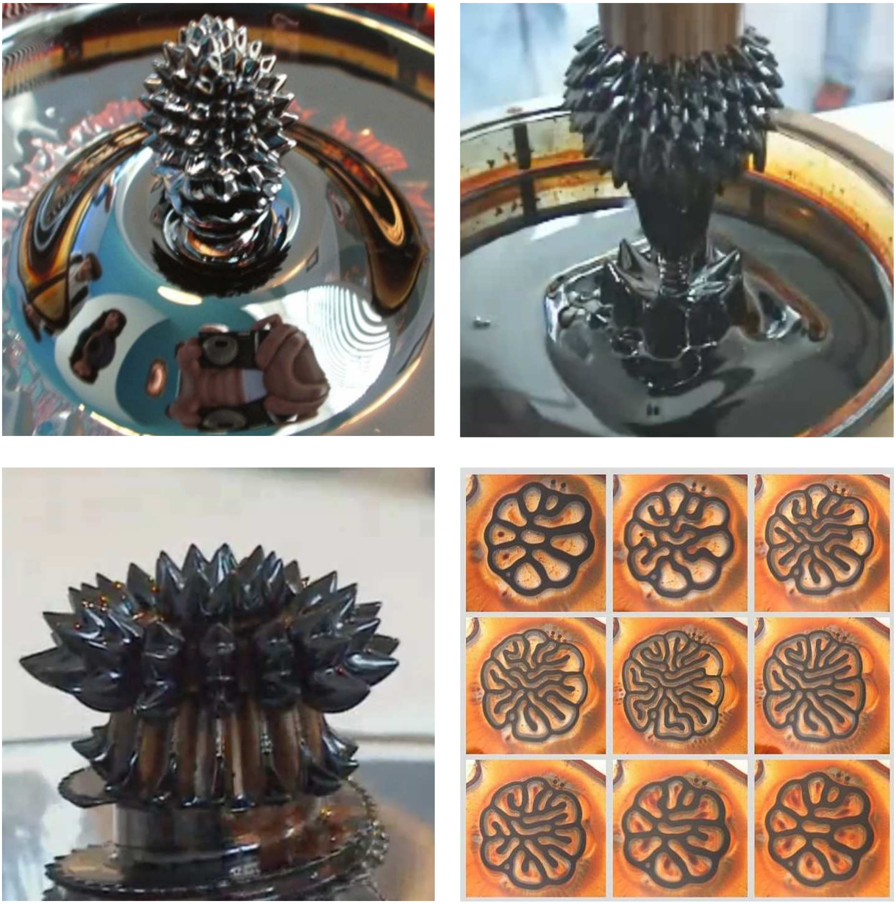
Link: http://www.youtube.com/watch?v=lRhUQTuEu3I

Ferrofluid

General Description

Ferrofluid is a liquid substance consisting of iron oxide nanocrystals (approx. 10 nm in size) suspended in a carrier liquid, usually oil or water. The crystals are covered by a so-called surfactant, which isolates the individual nanoparticles and prevents them from clumping together. This also ensures that each individual partner has a coating of the carrier liquid. Above a certain concentration of particles, all the liquid is bonded to the surface of a particle. Thus, by influencing the nanocrystals you can influence the whole liquid. As the nanocrystals react to a magnetic field, the result is that the liquid can be magnetically influenced. When an external magnetic field is applied to a ferrofluid it responds immediately, with the particles orienting themselves according to the field lines.

Ferrofluid is an example of how materials at a nanoscopic scale show different behaviours and overall physical properties. Making a reactive ferrofluid is not a trivial process. To achieve the small size, the ferrofluid particles need to be precipitated out of a solution by means of a chemical reaction. They then immediately require coating with the surfactant to prevent aggregation into larger units. Finally, they have to be mixed into the carrier liquid.



Ferrofluid demonstrations (clockwise from top left)

Ferrofluid in static field on screw,
Ferrofluid with electromagnet above (film: 'Magnetic Fluid Screw')
Ferrofluid in dynamic field on screw (film: 'Ferrofluid Sculpture')
Ferrofluid in Hele-Shaw Cell

Ferrofluids were originally developed in the 1960s at the NASA Research Center, where scientists were studying different possible ways of managing liquids (especially fuel) in the microgravity environment of space. The synthesis of ferrofluids solved this problem, as they can be driven and controlled by a magnetic field.

Demonstration

There are various ways to demonstrate ferrofluids. Basically, all you need is the ferrofluid, a container for the fluid (e.g. petri dish) and a magnet. When the magnet is brought into the vicinity of the ferrofluid (e.g. positioned below the petri dish), the fluid aligns according to the field, creating the so-called Rosensweig peaks.

The demonstration is especially impressive if the fluid flows up the thread of a screw or 'jumps' up to a magnet positioned above. By using an electromagnet it is also possible to control the intensity of the magnetic field and thus influence the shape and flow velocity of the ferrofluid in a demonstration. A further idea is to seal the ferrofluid into a container so it can be handed to the visitors along with a magnet, enabling them to experiment hands-on with the liquid. Also, when placed between two glass plates (distance ~ 2mm), a Hele-Shaw cell is created where the ferrofluid is forced to propagate horizontally when a magnetic field is applied.

Required Materials

Ferrofluid, container (e.g. petri dish), magnet
alternative: ferrofluid demonstration kit

Supplier

There are a number of suppliers to be found in the internet. Simply search for 'ferrofluid'. Listed here are a selected few:
www.amazingmagnets.com;
www.magnet4less.com;
www.supermagnete.de

Alternatively, various ferrofluid display kits are available. One example is the so-called 'Ferrofluid Preform Display Cell', available from www.teachersource.com. In this case the ferrofluid is sealed in a tube and can thus be handed to visitors to experiment themselves without the danger of spillage.

Safety

Handle ferrofluids with care, as they can indelibly stain surfaces and textiles. In case of contact with skin wash with abundant water and soap. Ferrofluids with oil as a carrier liquid are to be disposed in the same way as motor oil. These ferrofluids are flammable.

YouTube films

There are a number of films on youtube demonstrating ferrofluids. Simply search for 'ferrofluid' of 'magnetic fluid'. Listed below are three demonstrations filmed at the Deutsches Museum

Name: Magnetic Fluid Screw
User: manf1234
Link: http://www.youtube.com/watch?v=z4iy0FWMuyY

Name: Ferrofluid Sculpture
User: manf1234
Link: http://www.youtube.com/watch?v=XUz1ZI-w6LQ&feature=channel_page

Name: Hele Shaw Cell
User: manf1234
Link: http://www.youtube.com/watch?v=yys3q_XBRI4

Hint

It is always good to compare the behaviour of ferrofluid to a known macroscopic substance. Some simple possiblities are iron nails in a bottle of oil, iron filings in a vial, or simply paper clips in a magnetic field.

Nano glass demonstration:

The nano-powder acts like a fluid when flowing from one plastic bottle to another (film: 'Nano Powder Flowing Between two Bottles')

Nano Glass Powder

General Description

Nano glass powder is commercially used in paints (increased scratch resistance) and plastics (reduced flammability), and thus is mass-produced. It is created by dispersing silicic acid in an oxyhydrogen flame, with the nano glass powder precipitating from the flame. It is available in various specifications, with the 'Aerosil 200' used in the Open Research Lab having an average particle size of ~12 nm and a specific surface area of $200m^2$ / per gram.

Due to the small particle size nano glass powder has various physical properties which differ from macroscopic powders. These can be demonstrated as described below.

Demonstration

Nano glass powder is suitable for a number of different demonstrations. One approach is to seal a small amount in a plastic bottle. When at rest, the nano glass behaves like a normal powder. However, when the bottle is shaken, the nano glass takes on liquid properties. It then takes a few minutes to revert to its rest state. This demonstrates how nanoparticles are easily affected by Brownian motion and thus behave differently to other powders (e.g. sugar).

This demonstration can be expanded upon, for example by attaching two bottles neck-to-neck with a small aperture between them (e.g. a straw) similar to an hourglass. In flowing from one bottle to the other, the nano glass demonstrates both solid and liquid properties. It is also possible to subject the bottle to a vibration such as a sinus tone from a loudspeaker. At the correct frequency the vibration causes a feedback coupling within the nano glass powder, causing it to form waves and apparently 'dance'.

Nano glass also enables the demonstration of a lotus-effect. When some nano glass is applied to a glass surface (e.g. petri dish), some of the particles bond to the glass, creating a lotus-effect surface. When water is applied to the treated surface (i.e. by pipette), it is repelled by the lotus structure, forming droplets which roll over the surface without friction. Small water droplets are even able to pick up excess nano glass on their surfaces, thus rendering the droplets themselves hydrophilic. When carefully transferred to a larger bowl containing water, it is possible to demonstrate water droplets floating on a water surface.

Required Materials

Nano glass powder, plastic bottle, petri dish, pipette

Supplier

The nano glass powder is produced by the company Evonik (formerly Degussa) under the product name 'Aerosil 200'. It can be ordered through the website www.aerosil.com. Also available are various derivates with different grain sizes and different properties (hydrophobic, hydrophilic). Feel free to experiment...

Safety

Although nanoparticles have not yet been specifically proven to pose a health risk, preliminary studies have indicated a possible danger. Thus, despite the normally inert properties of glass, it is advised to handle the nano glass with care and store in sealed, airtight containers. If handling is necessary, ensure sufficient ventilation and avoid inhaling particles. In case of spillage, wipe up with a damp cloth. Do not use a brush or a vacuum cleaner, as these will encourage distribution of the particles.

YouTube films

There are a number of films on youtube demonstrating ferrofluids. Simply search for 'ferrofluid' of 'magnetic fluid'. Listed below are three demonstrations filmed at the Deutsches Museum

Name: Cloud in a Glass
User: manf1234
Link: http://www.youtube.com/watch?v=cL_NSAV9CRA

Name: Nano Powder Flowing Between two Bottles
User: manf1234
Link: http://www.youtube.com/watch?v=Ou0vg2pkuC0

Name: Lotus Water Drops on Water
User: manf1234
Link: http://www.youtube.com/watch?v=Kjl6ojNAX84

Useful Objects

Various objects are useful for helping explain and illustrate the nano world, and thus are good to have in an Open Nano Lab or a Nano Researcher Live area.

Buckyball Model

Buckyballs could almost be described as the Swiss Army Knife of nanotechnology. From basic research to medical visions, from nano-car wheels to sports products, it seems that wherever one encounters nano, one encounters buckyballs. Sometimes even people who have never heard of nano will recognise a buckyball. Various models are available from do-it-yourself paper or cardboard folding kits to posh ball and rod models. Simply search the internet for 'buckyball model'.

Atomic Surface Model

When explaining how an SPM works, it helps to have a stylised atomic surface model. The simplest way to create this is by gluing a number of table tennis balls together to form a hexagonal planar 'atomic landscape'. If so desired, it is possible to paint the structure; in grey for example it is a good representation of a graphite surface as imaged by a scanning tunneling microscope.

Optical Microscope

Although explicitly not 'nano', an optical microscope is a useful thing to have in an Open Nano Lab or a Nano Researcher Live area. On the one hand, when explaining why modern microscopes such as SPMs are required to image the nano world, it is often necessary to illustrate how an optical microscope works in comparison. On the other hand, an optical microscope is a handy tool to have in any research setting.

Nanoproducts

Obviously, it will be difficult to demonstrate the properties of nanoproducts which are on permanent display in an exhibition. However, visitors are often interested in seeing the effects for example of a self-cleaning surface. Thus, it is a good idea to have a few specific 'demonstration products' to show to visitors. Alternatively, it is possible to show films of the product properties - here an example on youtube:

Name: Mixology meets Nano-Tex Nanotechnology
User: gotnano
Link: http://www.youtube.com/watch?v=R51e0olmbb0

Further Nano-Demonstrations

Obviously, this compilation of nano-demonstrations is not exhaustive. Many more demonstrations exist, contained for example in nano-boxes, nano-kits and similar. Below is both an overview of such kits, as well as an overview of some of the contained demonstrations.

Nano-Kits & Nano-Boxes

NanoBoX

A small kit with five simple demonstrations, extensive written materials in kit and downloadable.
(available from: fonds.vci.de; producer: Fonds der Chemischen Industrie; cost: € 0,- + postage; language: German)

NanoSchoolBox

An extensive kit packed with
(available from: www.nanobionet.de; producer: NanoBioNet e.v.; cost: € 235,- + tax and postage; languages: English, German, French)

TIMEforNano NanoKit

(available from project partners (limited production); producer: CUEN srl; languages: English, others subject to translation)

NanoDays NanoKit

An easy-to-use kit with eight hands-on experimental stations and a large number of online resources. In return for ordering NISE network requires feedback on events.

(available from: www.nisenet.org; producer: NISE Network; cost: free, yet limited numbers - see website; language: English)

Demonstrations

Exploring Forces - Gravity (NISE Network)

This is a hands-on activity in which visitors discover that it's easy to pour water out of a regular-sized cup, but not out of a miniature cup. They learn that size can affect the way materials like water behave.

Exploring Measurement - Ruler (NISE Network)

This is a hands-on activity investigating just how small a billionth of a meter is. Visitors attempt to cut a paper ruler down to a nanometer-sized sliver. They learn that nano is too small to see, and certainly too small to cut with a pair of scissors!

Exploring Materials - Liquid Crystals (NISE Network)

This is a hands-on activity demonstrating that the way a material behaves on the macro scale is affected by its structure on the nano scale. Visitors investigate the properties of a heat sensitive liquid crystal and make their own liquid crystal sensor to take home.

Exploring Properties - Surface Area (NISE Network)

This demo about how nanoparticles behave differently, in part because they have a high surface area:volume ratio. Visitors learn that smaller particles have a much higher proportion of their atoms on the surface. Visitors unfold paper cubes, drop alka-seltzer in water, turn potatoes black with iodine, and see fireballs to understand how surface area changes as you get small.

Magnetic Probe Model

By pulling a magnetic probe over a magnetic sheet it is possible to 'feel' the magnetic bands the sheet consists of. This helps in explaining how SPM can generate an image of a surface by 'feeling' various forces.

Lotus effect textiles / surfaces

Of course it is also possible to demonstrate the self-cleaning and dirt-repellent properties of commercially available textiles and surfaces by dripping water, ketchup or oil onto them.

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