# {jIAPS}

Journal of the International Association of Physics Students

Issue 1 2011

Cover photo: The experimental show ‘“Gernot Pottlacher will explode it” at ICPS 2010, Picture by the ICPS organisers, http://picasaweb.google.com/graz.icps2010/LastDay#5512038304052972338

# In This Issue




**Editors:** Jessica Stanley, Ragnhild Schrøder Hansen, Owen Jones, Joshua Fuchs, Anya Burkart, Norbert Bonnici

**Design:** Jessica Stanley

**Contact:** jiaps@iaps.info
www.iaps.info/jiaps

**Contributors:** Norbert Bonnici, Natalia Popa-Dăbuleanu, Konrad Schwenke, Ragnhild Schrøder Hansen, Jessica Stanley, Robert Thomen, Stephanie Walton, Julia Wiktor

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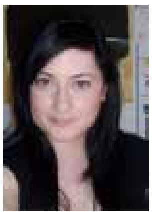
# A few words from the Editors...

This is the first issue of the journal of the International Association of Physics Students in 2011, and with it comes a change to the editing team. We bid farewell to Anne Pawsey, who is more than busy with her PhD, and welcome several new faces. We are also happy to announce the winner of the jIAPS writing contest, Stephanie Walton, for her article “The Physical State”, on the idea of a stereotypical physicist. Elsewhere in this issue, the new IAPS Executive Committee introduces itself, and the use of Youtube for physicists, the Golden Ratio, and quantum computing are explored. You can read about the EuroPhysics Fun network and a climate summer school at the University of Malta, and learn how to make an explosion with Diet Coke and Mentos, with a fun physics show experiment.

As always we are looking for contributions for future issues. If you would like to write for jIAPS, or if you have any comments or questions, don’t hesitate to get in touch with us at jiaps@iaps.info. For information about IAPS, see www.iaps.info.



**Jessica Stanley** is a master student of experimental physics (specialising in neurophysics of visual perception) at Utrecht University in the Netherlands. She previously studied theoretical physics at Trinity College in Dublin, where she is from. Jessica has been involved in Nexus, the student branch of the Institute of Physics, along with the Ireland branch of the Institute of Physics, and was IAPS secretary in 2008/2009. She has attended ICPS since 2006.

**Ragnhild Schrøder Hansen** is from Bergen, Norway, where she is a PhD student at the University of Bergen, studying Terrestrial Gamma-Ray Flashes. She is the former president of the Norwegian Association of Physics Students, and is an active member of Fysikkshow Bergen, doing demonstrations of experiments to teach kids about physics. She was a general member of the IAPS Executive Committee in 2008/2009, and has attended ICPS since 2007.

**Anya Burkart** researches biomechanical properties of cells using optical techniques at Creighton University in Omaha, Nebraska in the USA. Summer 2009 she worked on a soft matter physics research project at the Universität des Saarlandes in Germany. Anya developed student programs and outreach during her terms as president and vice-president in her local Society of Physics Students and represented the American Society of Physics Students at ICPS 2010.

**Joshua Fuchs** is finishing up his bachelor’s degree at Rhodes College in Memphis, Tennessee, USA this May. Interested in Astrophysics, he has conducted research at the Maria Mitchell Observatory in Massachusetts and the Institute for Astronomy at the University of Hawai’i. He has been heavily involved with the Society of Physics Students in the United States at the local and national level. He enjoys having fun and has attended ICPS since 2009.

**Owen Jones** is in his final year of study for the MPhys degree at the University of Warwick, England. His research interests lie in the field of laboratory and space plasma physics. Currently Secretary of the University of Warwick student Physics Society, he has been involved with the Society for three years, and organised trips to the Diamond Light Source and CERN, among others. He has attended the last two ICPS, in Split and Graz, and has only hazy memories of either.

**Norbert Bonnici** is in his first year of hard work for a degree in Physics and Computer Information Systems at the one and only University of Malta. Has a deep interest in weather patterns and likes to forecast the future, by using several climate models. He also likes to code in C, modify hardware to pleasure his needs and listening to music with high aptitudes. Lost his ICPS virginity in Graz.

# ...and the IAPS Executive Committee

You are reading the first issue of jIAPS in the academic year 2010/2011. A new executive committee has begun its work and will be introduced in the following pages. We met in Mulhouse at the end of November and while some of us are already serving their second term, others were able to use this meeting to learn a lot about IAPS and how an international student organisation works. It was noticeable that it helps a lot if people stay on the EC for more than one year, so that knowledge can be passed on. It is not too long since IAPS abolished the Central Office, where only the president was expected to serve on the EC for more than one year (first a year as president elect, then another year as president, and then a final one as past president). One of the biggest issues is always continuity. IAPS can only survive if you pass the torch to the next generation of students.

The current EC is already working on topics with which you may already be familiar. First of all, there are the trips. Two of them are planned for 2011. The IAPS trip to CERN existed already in the 80's, but was not a regular event. We had one last year, which was a huge success, and it will be repeated in April 2011.

And then there is still the trip to Portugal with the topic 'Renewable Energies' which is planned for July. By then it will be time for the next ICPS in Budapest. The webpage of ICPS 2011 is now online (http://icps2011.mafihe.hu) and registration will open in February. Besides these events, we are also working on re-establishing formal cooperation with IAESTE and are promoting the idea of international collaboration between physics students to potential members and organisations with similar target audiences.

If you are interested in the work of the EC, do not hesitate to contact us. Our meetings are public for all members.

Konrad Schwenke

*Contact the EC at ec@iaps.info*

*From left to right: Konrad Schwenke, Dragos Carabet, Bence Ferdinandy, Sahra Haji, Juha Korpi, Camelia-Florina Florica, Milan Vrućinić, Antonia Mijatović, Alexander van der Torren.*

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([{ICPS}Graz]2010)

ICPS 2010 was conducted in true Austrian style, with 1260 litres of beer and 50 litres of liquor consumed during the conference. Over 400 physics students attended, and there was a full programme of student talks, guest lectures, a poster session, a city tour, excursions, an experimental show, and parties, of course.

Pictures by Joshua Fuchs and the ICPS organisers, more at http://picasaweb.google.com/graz.icps2010

# News

a roundup of recent events in physics, compiled by Jessica Stanley

## Nobel prize awarded for graphene

In October it was announced that the 2010 Nobel Prize in physics goes to Andre Geim and Konstantin Novoselov "for groundbreaking experiments regarding the two dimensional material graphene. The material, a layer of carbon that is only one atom thick, has amazing strength, flexibility and conductivity, and has many applications in electronics and materials science. Geim and Novoselov first created it by using tape to pull very thin layers off a piece of graphite.

*More information: http://nobelprize.org/nobel_prizes/physics/laureates/2010/press.html*

## 42 Day

Celebrations took place on October 10th, or 42 day, because the date, when written as a binary number, 101010, is equal to 42 in base 10. The number 42 is the answer to the ultimate question, the meaning of life, the universe and everything, as calculated by supercomputer Deep Thought in Douglas Adams' 'The Hitchhiker's Guide to the Galaxy'. Some people took a ride on number 42 buses to mark the occasion, and one IAPS member chose to celebrate by ordering a number 42 pizza from a local pizzeria in Copenhagen.

## Construction progresses at ITER

A new phase of construction began at ITER, the world's largest fusion energy project, this past August. The foundations are now being laid for the tokamak, a huge toroidal chamber through which plasma (charged gases) will flow at temperatures high enough to cause colliding particles to fuse. ITER will become fully operational in 2025, at which point it will become the first reactor to produce net power from fusion.

*More information: http://www.iter.org*

## UK Scientists protest funding cuts

Thousands of UK scientists gathered outside government buildings in London on October 9th for the 'Science is Vital' rally, protesting funding cuts to scientific programmes. Wearing lab coats and bearing placards with slogans like 'Fair funding, it's not rocket science', protesters sang 'Hey Osbourne, leave our geeks alone' to the tune of Pink Floyd's 'Another Brick in the Wall', aimed at Chancellor of the Exchequer George Osbourne, the politician in charge of British financial affairs. Speakers including science writer Simon Singh stressed the importance of science and the negative effects on society that could be caused by funding cuts.

*More information: http://euroscientist.com/2010/10/podcast-science-is-vital-rally/*

## Unblocking arteries with lasers

Countless uses have been developed for the humble laser in the 50 years since the first one was constructed, including many medical applications. A new laser treatment for blocked arteries exploits the fact that ultraviolet light is well absorbed by biological matter. Light from an excimer laser is channelled through an optical fiber, which is directed through an artery to the problem area. The uv light absorbed by the material causing the blockage supplies enough energy to break molecular bonds, causing the blockage to be blasted into tiny particles which are then absorbed by the bloodstream. The procedure, which takes only a few minutes, is a considerably better alternative to previous treatments, which involved serious surgery and potential complications.

*More information: http://www.dailymail.co.uk/health/article-1333443/Turbo-charged-How-new-laser-blasts-blocked-arteries.html; Bernardo et al. (2010). Lasers in Medical Science 24(6); Jessica's granny, who recently had this procedure and has since been telling everybody about her new interest in lasers.*

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# Introducing the Executive Committee:

Name: **Camelia-Florina Florica (President)**
Age: 23
Nationality: Romanian
Universities: University of Bucharest
Programme: Master of Physics
Field of studies: Nanotechnologies
Attended ICPS: 2008, 2009, 2010
Favorite Formula: $E_k = hf - \phi$
Other activities: NGO work, Zumba, roller skating

Name: **Konrad Schwenke (Secretary)**
Age: 26
Nationality: German
Universities: TU Dresden, Lunds Universitet, ETH Zürich
Programme: Doktorat
Field of studies: Computational soft matter physics
Attended ICPS: 2008, 2009, 2010
Favorite Formula: The one that fits best to my data
Other activities: Plenty

Name: **Juha Korpi (Treasurer)**
Age: 28
Nationality: Finnish
University: University of Helsinki
Programme: Master of Science
Field of studies: Physics teacher
Attended ICPS: 2004 - 2008, 2010
Favorite Formula: Newton’s third law
Other activities: Life

Name: **Sahra Haji (Vice-President)**
Age: 21
Nationality: British (Originally from Somalia)
Universities: University College London, University of London
Programme: Master of Science (MSci)
Field of Studies: Medical Physics
Attended ICPS: 2009, 2010
Favourite Formula: Any exponential function
Other activities: Driving, travelling, attempting to fly...

Name: **Milan Vrućinić (Membership Secretary)**
Age: 25
Nationality: Bosnian-Herzegovinian
Universities: Utrecht University (current), University of Banja Luka
Programme: Master of Science (Nanomaterials: Chemistry and Physics)
Field of studies: Nanomaterials
Attended ICPS: 2007, 2008, 2009, 2010
Favourite formula: All understandable
Other activities: NGO work, choir, travelling

Name: **Antonija Mijatović**
Age: 22
Nationality: Croatian
Universities: University of Split
Programme: Master of Science
Field of studies: Biophysics
Attended ICPS: 2009., 2010
Favorite Formula: $\Box F^{ab}=0$
Other activities: Singing in a choir, learning to drive

Name: **Bence Ferdinandy**
Age: 22
Nationality: Hungarian
Universities: Eötvös Loránd University
Programme: MSc. in Physics, BSc. in Biology
Field of studies: Theoretical physics, biological physics
Attended ICPS: 2010
Favorite Formula: $S=k_B ln\Omega$
Other activities: Reading, hanging out, relaxing, hiking, singing

Name: **Alexander van der Torren**
Age: 23
Nationality: Dutch
University: Leiden University
Programme: Master of Physics
Field of studies: Experimental Physics Research
Attended ICPS: 2008, 2009, 2010
Favorite Formula: Maxwell
Other activities: Plenty

Name: **Dragos Carabet**
Age: 22
Nationality: Romanian
Universities: University of Craiova
Programme: Master of Physics
Field of studies: Theoretical Physics
Attended ICPS: 2010
Favourite Formula: Mine is world known: $E=mc^2$
Other activities: Travel , reading , music , fun, and some extreme sports

# The Physical State

by Stephanie Walton

**Is there really such a thing as a stereotypical physicist, and do you conform to it? Are you only half stereotypical or even an atypical physicist? Join me as I try to create a truly typical physicist, X, a 50% typical physicist, Y, and an atypical physicist, Z, by studying 60 of the most famous physicists ever…**

## Name

Society is often eager to measure physicist-ness with superficial measures such as whether you wear glasses, how frequently you ask questions in classes or how close to the front of the lecture theatre you sit. These means of identification are all superfluous though, if you don't have a physicist's name. Indeed, a mother naming her child (with future physics glory in mind) should choose a name beginning with 'J' (15%), 'H' or at a stretch 'W', and should only consider marrying someone with a surname beginning with 'B' (17%) or 'H' (10%). At the other end of the spectrum, those with surnames beginning with 'A' or 'I' will face a battle against the odds to become famous physicists.

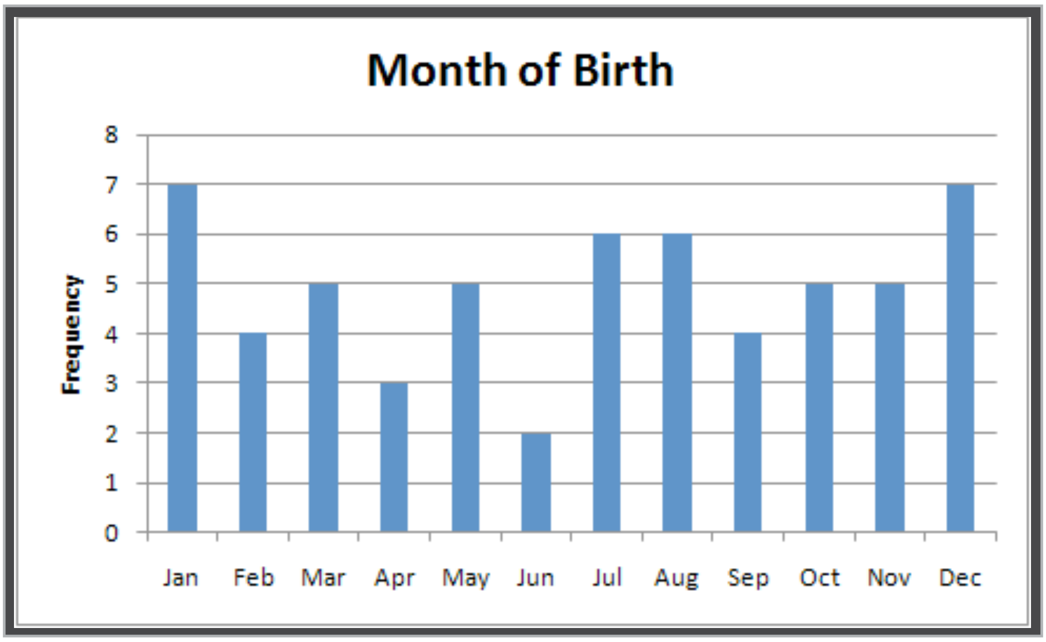
Of course, the ideal combination of initials is J.B., and indeed John Bardeen (1908-1991) is the only person ever to receive two Nobel Prizes in physics, shared in 1956 for research on semiconductors and the transistor effect, and shared in 1972 for the BCS theory of superconductivity.

X's initials should be J. B. (e.g. John Bardeen)
Y's initials should be H. H. (e.g. Heinrich Hertz)
Z's initials should be K. I.

## Date of birth

Sadly it is not as easy to influence one's birthday, but count yourself lucky if you were born on the 15th or the 23rd of a month, and failing that, have avoided the first six or so days of the month. Being born at the apex of seasons e.g. December or January, and July or August, also seems to be fortuitous. Indeed Becquerel and Yukawa both got it seriously right being born on the 15th December and 23rd January respectively.

Let X's birthday be the 23rd December.
Let Y' birthday be the 11th August.
Let Z's birthday be the 3rd June.




## Place of birth

To date, most famous physicists have spent their first few hours in Europe or America (with notable exceptions including Landau (Baku), W. L. Bragg (Adelaide) and Yukawa (Tokyo)), though only 27% of those were born in current capital cities. The capital city to have played host to the largest number of births is Vienna; Boltzmann, Meitner, Schrödinger and Pauli were all born there.

Let X be born in Germany.
Let Y be born in Vienna.
Let Z be born in Antarctica.

## Father's profession

Having a parent who is a scientist is likely to be a dual blessing; not only do you potentially have a genetic advantage, but you are also exposed to science first hand and have the opportunity to discuss science with someone from a young age. It therefore comes as no surprise that 27% of physicists surveyed had fathers who were some kind of scientist. Interestingly, the fathers of Einstein, Higgs and Landau were all engineers, and Kelvin's was a teacher of Mathematics and Engineering. Having a father who is physicist, though, is by no means common, indeed the only physicists whose fathers shared their profession were Becquerel and W. L. Bragg (his Nobel Prize of 1915 was even shared with his father when he was only 25, making him the youngest recipient ever). Having an ecclesiastical upbringing can also be conducive to future physics fame, with Zeeman, Tesla, Stokes and Hooke all having fathers in the church.

Let X's father be a scientist. (e.g. Pauli: Chemist)
Let Y's father be a engineer. (e.g. Einstein)
Let Z's father be a shipwright. (e.g. Watt)

## Length of Life

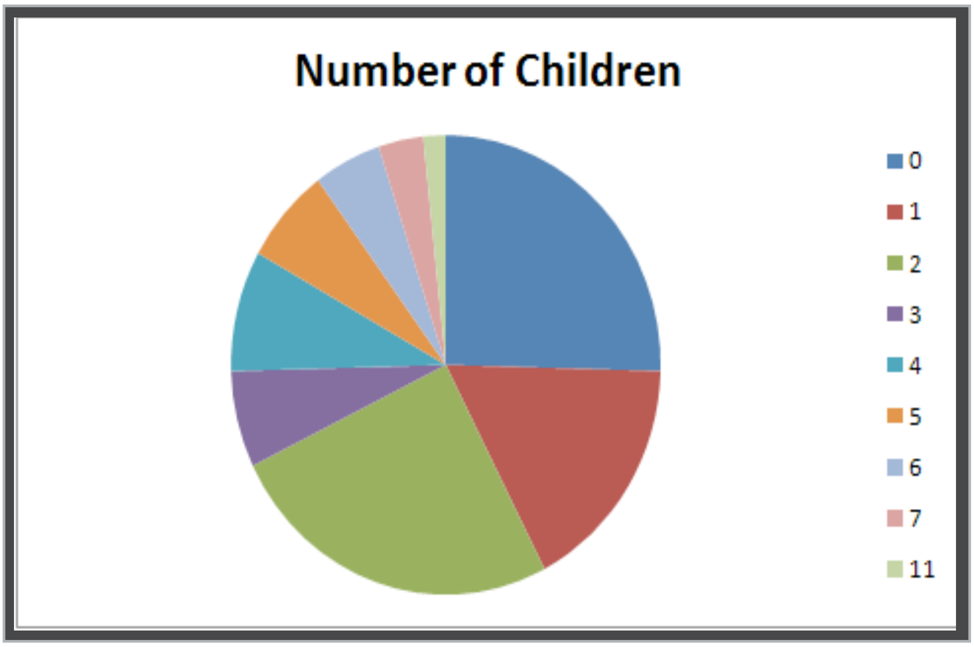
Famous physicists tend to live very long lives, on average for 73.6 years with modal life spans of 77 and 83. Bethe, de Broglie and Wigner all lived into their nineties (98, 94 and 92 respectively). Intriguingly, the average age for making a first important discovery in physics is 34.2 and remarkably, Chandrasekhar discovered his eponymous limit on a voyage from India to Cambridge to start his graduate degree at the precocious age of 20.

Let X live to 83. (e.g. Thomson)
Let Y live to 74. (e.g. Yukawa)
Let Z live to 92. (e.g. Wigner)

## Marriage and Children

Physicists tend to prefer the married state. On average a famous physicist has 1.086 spouses in the course of his life, with Feynman marrying thrice and some 17% remaining unmarried. Famous physicists on average have 2.28 children, though incredibly Kepler had 8 more children than he had Laws (i.e. 11)! Interestingly both Heisenberg and Planck had twins. On the birth of Maria and Wolfgang Heisenberg, Pauli amusingly congratulated Werner on his successful “pair creation”!

Let X have 1 spouse and 2 children (e.g. Dirac)
Let Y have 1 spouse and 1 child. (e.g. Landau)
Let Z have 2 spouses and no children.



## Miscellaneous

Did you know that Heisenberg was a pianist, Planck liked to sing, play the piano, organ and cello, and Feynman played the bongos?
Also, Tesla spoke 8 different languages and Hubble was known for his athleticism and boxing!

## Conclusion

| | X Typical | Y 50% Typical | Z Atypical |
|---|---|---|---|
| Initials | J.B. | H.H. | K.I. |
| Date of birth | 23rd December | 11th August | 3rd June |
| Place of birth | Germany | Vienna | Antarctica |
| Father's profession | Scientist | Engineer | Shipwright |
| Length of life | 83 | 74 | 92 |
| Spouses, children | 1,1 | 1,2 | 2,0 |

Physicists surveyed (forgive any obvious omissions…):
Bardeen, Becquerel, Bell Burnell, Bethe, Bloch, Bohr, Boltzmann, Born, Boyle, Bragg W.L., Chandrasekhar, Curie M., Curie P., de Broglie, Dirac, Edison, Einstein, Faraday, Fermi, Feynman, Gauss, Gell-Mann, Gibbs, Hawking, Heisenberg, Hertz, Higgs, Hooke, Hubble, Josephson, Joule, Kelvin. Kepler, Kirchoff, Landau, Lemaitre, Lorentz H., Maxwell, Meitner, Michelson, Newton, Ohm, Onnes, Pauli, Planck, Röntgen, Rutherford, Schrödinger, Stokes, Archimedes of Syracuse, Tesla, Thomson J.J., van der Waals, von Helmholtz, von Laue, Watt, Weber, Wigner, Yukawa, Zeeman

**References:**

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www.answers.com
www.wikipedia.org
www.bookrags.com/Biography
www.profiles.incredible-people.com
www.westminster-abbey.org
www.nndb.com
www-groups.dcs.st-and.ac.uk/~history/Biographies

*Stephanie Walton is the winner of the jIAPS writing contest. Last October she started her PhD at Imperial College London in the UK, studying nanomagnetism, in particular frustrated nanobars and nanodiscs. ICPS 2011 in Budapest will be her third time attending the conference.*


# Youtube: a physicist's best friend

by Julia Wiktor

Searching for a physics project? Go to Youtube! This year we tried to explain to our freshers what the Physics Students Scientific Association does. We described all the projects from recent years, one after another. They asked how they were started. And if we think it through, it goes like this: we watch a video, we find it amazing, we have to recreate the experiment. For the Physics Students Scientific Association of Gdansk University of Technology, popularising physics is one of the most important things. We always try to get as much fun out of science as possible. And of course we try to make other people join in.

It started before the Baltic Science Festival in 2008. It is an annual event, taking place in May, during which both scientists and students of different universities from north Poland put all their efforts into getting people interested in their fields of science. In other words, everyone tries to show something bigger than the others, something noisier, something funnier, and most of all something spectacular.

*Physics Students' Scientific Association of Gdansk UT's logo*

*Logo of the Baltic Science Festival*

The first project started with a video in which we first see a bowl of black, greasy liquid. Then lots of needles appear on its surface, they are changing their forms, rising and swirling. It's a ferrofluid. More precisely, a mixture of nanoscaled ferromagnetic particles suspended in a carrier fluid. We obviously fell in love with that magnetic hedgehog and had to make our own version. After a lot of mixing and finding a transformer, which creates really strong magnetic fields, we could present our ferrofluid in May 2008. The only drawback of this creature is that if you want to caress it, you get all dirty. But nobody cares about that, obviously.

The second type of videos are those presenting, let's say, electrical mushrooms. We can watch people who made their own Tesla Coils and now are proudly spreading sparks all over their gardens, basements or garages. The idea is simple: you send a current into a primary coil, it goes to a secondary coil with much more turns, then to the torus (air capacitor) and then, bzzzzt, in the air! Of course, it takes many, many calculations and a lot of planning before you can start building your Tesla Coil, but it is not that difficult, as there are lots of helpful websites. We decided to build a small version, because we didn't want to kill anybody. Our Tesla is approximately 25 cm tall and gives 2-3 cm sparks. And when you put your finger close to it, you can really feel the electricity without too much pain.

*Tesla coil presented at Baltic Science festival*

*Children watching our ferrofluid*

Then we got musical. How cool is making your own musical instrument? And if that instrument contains lots of resistors, capacitors, vacuum tubes and other geeky stuff? The theremin is the first electronic musical instrument, named after its Russian inventor. It's played without being touched, as the capacitors of volume and pitch circuits are formed between the antennas and the player’s hands. You move your hand, you change the capacitance, that changes the frequency, it plays. Easy. Sadly, building a theremin is more difficult. We spent a lot of time searching for a scheme, looking for all the parts needed, drilling and soldering. After all that we are still not happy with our result, but we don’t give up, and hope that one day it will sound nicely.


*Theremin on Youtube* [http://www.youtube.com/watch?v=X6lImGpk0wE]

Then we came to something a lot easier, but nice to show as well. If you take one portion of water and mix it with two portions of starch (potato flour in our case) you get a non-Newtonian fluid. Without application of any force it acts like a fluid, but when you push it, hit it, throw it, it will act rather like a solid. There is a video on Youtube, showing a whole pool of non-Newtonian fluid and people running on its surface. There are some who don’t believe that this video is real, so we thought we could prove it to people in Gdansk. 300 liters of that mixture can give you a crowd of maybe a little bit dirty, but really amused people.

*Students jumping on the non-Newtonian fluid’s surface*

As for the last project, we were inspired by the Mythbusters. In one of their videos, they wanted to check if it's possible to lift a child, using balloons only. They made it; with approximately 3000 balloons they lifted a small girl. But we are slightly bigger than children and we still wanted to fly, so we decided to increase that number. It took 5 hours, 50 people, 5000 balloons and 120 m3 of helium to lift an adult. That show was probably the most successful one. It was colorful, big, easy to understand and people loved it.

Those were only few of all our projects. And there are new videos and ideas on Youtube every day, so it's not finished yet. But we just wanted to let you know that lots of those cool things on the internet can be recreated successfully, even if it looks impossible at first sight. And it really brings a lot of fun and satisfaction when you see it working. Also, if you make it, you can show it to others and maybe there will be someone who will find physics less boring and useless thanks to you.

*Balloons in front of our university building*

**Videos to watch:**

Ferrofluid: http://www.youtube.com/watch?v=zpBxCnHU8Ao
Tesla Coil: http://www.youtube.com/watch?v=-jgqJr7gFIl
Theremin: http://www.youtube.com/watch?v=nJYho56INKU
Non-Newtonian fluid: http://www.youtube.com/watch?v=f2XQ97XHjVw
Balloons: http://dsc.discovery.com/videos/mythbusters-balloon-girl.html

*Julia Wiktor is in her fourth year of studying technical physics at the University of Gdansk in Poland, and she is mainly interested in practical uses of physics. If she had to choose a favourite field of physics, it would be lasers because, in her own words, everybody loves lasers, right?*

# The Golden Ratio

by Natalia Popa-Dăbuleanu

Although not naming it the Golden Ratio, around 300 BC Euclid of Alexandria defined the proportion: “A straight line is said to have been cut into extreme and mean ratio when, as the whole line is to the greater segment, so is the greater to the lesser.” The precise value of the Golden Ratio is an irrational number, phi=1.61803399... with an infinite decimal expansion.

In the year 1202 AD Leonardo of Pisa (1170 – 1250), better known as Fibonacci, uncovered a link amongst mathematics, nature and art. Fibonacci wanted to know how many rabbits would be produced in a year beginning with a single pair. As he worked towards the solution he noticed a pattern emerging. The number of rabbit couples increased in a certain sequence each month: 1, 2, 3, 5, 8, 13, 21 and so on. Each number in the series equals the sum of the two previous numbers. These numbers growing to infinity are known as the “Fibonacci series”, and they would become the key to unlocking more mysteries than a bunch of bunnies. For instance, in the field of botany, the structure of flowers is based on Fibonacci’s numbers. Lilies have a radial symmetry based on 3, violets have 5 petals, sunflowers have petals totaling 33, 55 or 89. This phenomenon, not explained until 1993, appears to go beyond genetics to the natural dynamics of growth. Whether it is the spiral of consecutive seeds in the sunflower, the spiraling growth of a Chambered Nautilus or the branching structure of bronchi in the lungs, organic growth is often guided by a mathematical ratio stemming from the Fibonacci series.

If you actually divide successive terms in the Fibonacci sequence, the quotients settle down to a specific value, as you can see in the table below.

| | | | |
|---|---|---|---|
| 1/1 | = 1 | 2/1 | = 2 |
| 3/2 | = 1.5 | 5/3 | = 1.666... |
| 8/5 | = 1.6 | 13/8 | = 1.625 |
| 21/13 | = 1.61538... | 34/21 | = 1.61904 |
| 55/34 | = 1.61764 | 89/55 | = 1.61818 |
| 144/89 | = 1.61798 | 233/144 | = 1.61805 |
| 377/233 | = 1.61802 | 610/377 | = 1/61803 |

The quotients approach a number called the Golden Ratio whose value can be calculated algebraically.

Now, the Golden Ratio is usually called *Φ*. We say *fn+1/fn*→ *Φ* as *n* → ∞. Noting that both *fn+1/fn* and *fn /fn-1* have the same limit, *Φ* as *n* → ∞, the calculation goes like this:

$$\frac{f_{n+1}}{f_n} = \frac{f_n+f_{n-1}}{f_n} = 1 + \frac{f_{n-1}}{f_n}$$

Now replace two terms: fn+1/fn with the variable x and fn-1/fn with 1/x.

$$x = 1 + \frac{1}{x}$$
$$x^2 = x + 1$$
$$x^2 - x - 1 = 0$$

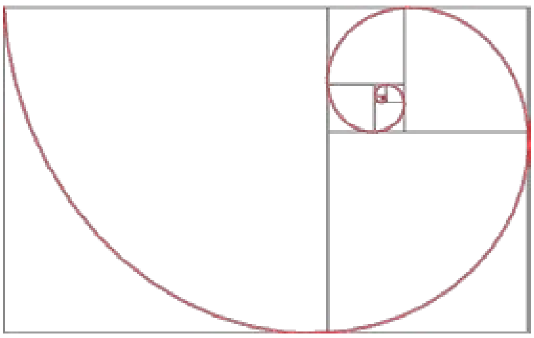
This quadratic equation has the two solutions:

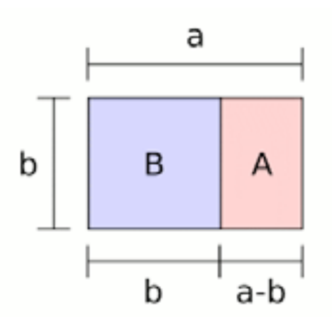
$$x = \frac{1 \pm \sqrt{5}}{2} \approx 1.61803, -0.61803$$

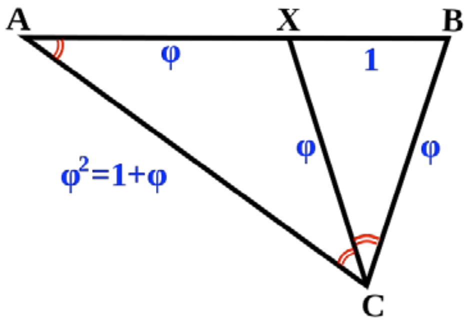
The first solution is the Golden Ratio *Φ*, and the second is just -1/Φ!

As Fibonacci numbers increase, the proportion of two successive numbers becomes more and more similar. This ratio was given the name “The Divine Proportion” and was later called “The Golden Mean” or “The Golden Number”. Eventually, it was given the abbreviation *Φ* after the initial of the Greek sculptor Phidias (Φειδίας) the creator of the artwork at the Parthenon.

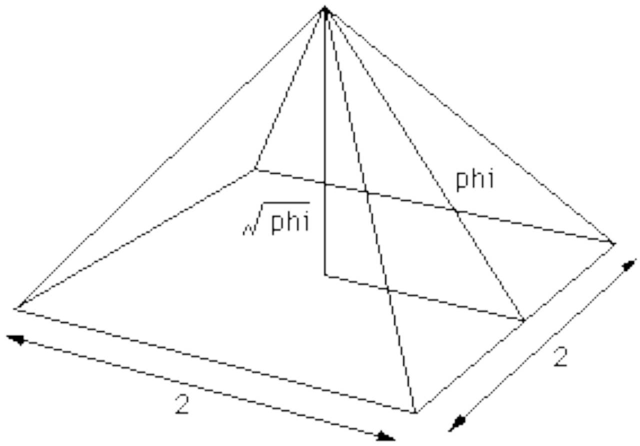
As early as the Pythagorean school (500 BC), the Greeks studied the ratio of *Φ* and developed a method of constructing a rectangle with sides measuring 1 and *Φ*. With the perfect square aligned from the mid-point and an arch, they created “The Golden Rectangle”. The Greeks also found that if they removed the original square, what was left was itself a “Golden Reclangle”. They believed that this rectangle held the mathematical key to beauty and they incorporated it in many designs.





The most striking example is maybe the Parthenon, with most of its proportions based on Golden Rectangles. The Greeks were not the first to use the visual balance of *Φ* in their architecture. 5000 years ago, the Egyptians based the design of the Great Pyramid of Kheops on golden proportions. These measurements may not have been intentional, but it reinforces the belief that *Φ* holds some universal aesthetic appeal.




For centuries artists have studied the psychology of beauty while biologists have tried to explain the complexity of nature. Yet it was Fibonacci, an Italian mathematician, who found the common mathematical thread that connect these two disciplines and many others, like physics, which derive from these and provide a deeper understanding. No wonder that the ancient Greeks had no division between disciplines like mathematics (geometry, arithmetic, astronomy) or art (music, poetry).

“The most irrational of all irrational numbers, the Golden Ratio”, as Mario Livio says, was used by Euclid more than two thousand years ago. Because of its crucial role in the construction of the pentagram, magical properties had been attributed. Since then it has frequently appeared in the most astonishing variety of places, from mollusc shells to sunflower florets, rose petals to the shape of galaxies.

Speaking of galaxies, we have to mention that *Φ* appears in the Solar System and the Universe. From the distances between the planets, to the structure of Saturn’s rings, to the shape of the Universe itself, *Φ* is found again and again in different manifestations. New findings reveal that the Universe itself is in the shape of a dodecahedron, a twelve-sided geometric solid with pentagon faces, all based on *Φ*. Saturn’s magnificent rings show a division at a golden section of the width of the rings. Curiously, even the relative distances of the eight planets and the largest asteroid average to *Φ*.

It is found that the Golden Ratio also plays a quantitative role in atomic physics. The interesting results are that it arises in atomic dimensions due to the electrostatic forces between negative and positive charges. The energy of atomic hydrogen is actually equivalent to the energy of the simplest atomic condenser with the Golden Mean capacity. The origin of two terms in the Rydberg equation for absorption and emission is in fact in the ground state term. All atoms can be assigned definite values of cationic and anionic radii based on the Golden Ratio and covalent radii.

Concluding, the Golden Number, Phi, appears in the proportions of the human body and many other animals and plants, in the structure of DNA, in the Solar System, art, architecture, music, population growth, the stock market, the Bible, in theology, and not least in mathematics and physics.

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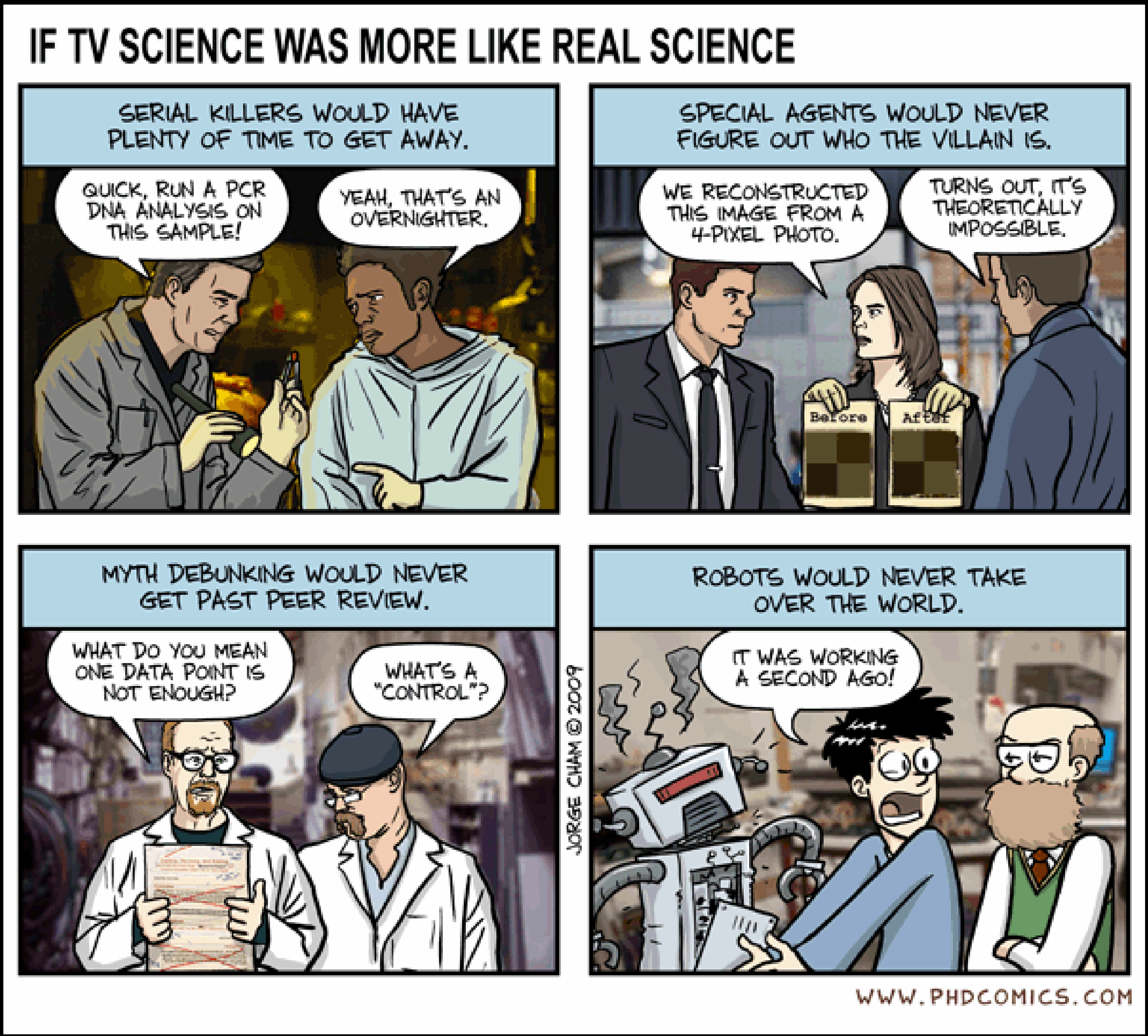
*Natalia Popa-Dăbuleanu is a second year physics student at Craiova University in Romania, specialising in medical physics. She is particularly interested in optics, and is a member of both the IAPS Local Committee at Craiova and the Romanian Federation of Physics Students. She also studies sociology, with a focus on community development and European integration.*

**"Piled Higher and Deeper" by Jorge Cham** **www.phdcomics.com**

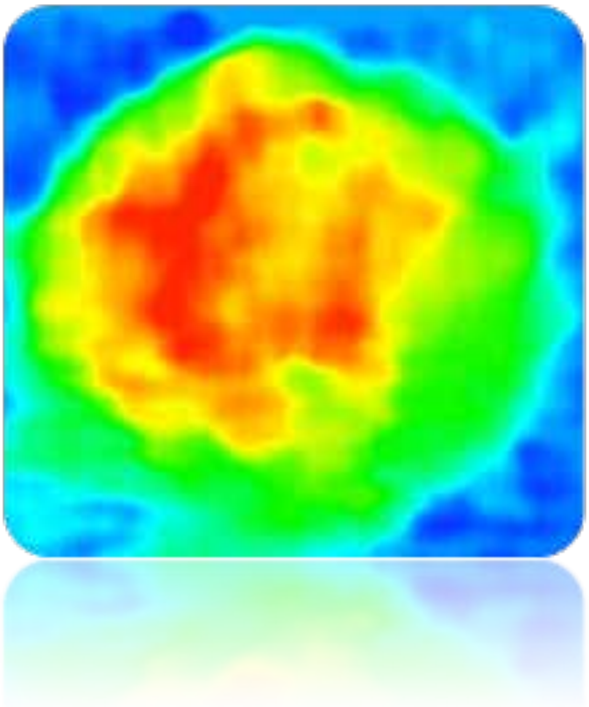


# Adventures in Holographic Microscopy

A holographic microscope digitally records the light wave front information (intensity and phase) from an object as a hologram. A computer program then converts this data into a 3D image. Essentially, a computer algorithm replaces the role of the lens in this kind of microscopy.

Digital holographic microscopy experiments to determine the height and refractive index of bone cells (osteoblasts) inspired this poem below. To the right is a 3D cell image, with red areas approximately 18μm in height and blue areas at the surface level.

- Anya Burkart



Affluent in photons though lord over few
The light-masters watch through holography's eyes
The children of Maxwell seek out what is true
And are sent through the demons for sake of the wise

Through dense living matter they struggle and strain
Arriving delayed causing phase to contrast.
My Boson, what fraction of speed was retained
As you passed through the reprobate Osteoblast?

Through proliferation of pixels unwrapped
Assuage them, O Filters of Fourier and Mean!
Reveal the index from whence it lay trapped
At last when dimension of life can be seen!

- Robert P. Thomen

Robert Thomen is currently writing his master's dissertation on this research in the Biophysical Optics Research Group at Creighton University in the USA.

# The Climate Summer School

by Norbert Bonnici

What do you do if life gives you lemons? You make lemonade. The problem arises when you have a new computer cluster. The solution is 'clustade'. In very simple English, we run a few climate and weather models over a school of fish....erm...nodes, through MPI (Message Passing Interface).

Some people might wonder what scientists do; why do they waste their time playing with computers to model climate? Well first of all, personally, because it's fun using one of the most expensive devices on the island. The real reason is that, to understand how stuff works, you need to know how the atmosphere works, rather than replicate it, and be able to predict what it will do and what its most likely disastrous impacts would be. Since the Earth and its atmosphere are way too big to fit in a petri dish, we use computers to perform our experiments.

To reach young science students a summer school was organized by Dr. Noel Aquilina, a local lecturer in the University of Malta Department of Physics, with the help of Mr James Ciarlo` and yours truly, both students of his. It consisted of two parts: a series of introductory lectures on meteorology, data mining, how climate models work and post processing; and a hands-on experience with data mining and post processing of modeled data.

While the theoretical part was fun to learn, the hands-on was the best experience I had. My duty was to install two new models on the computer cluster, test them and provide an "easy how-to-use" guide. In addition, I had to learn and teach how to use NCL (National Center for Atmospheric Research Command Language) which is a command line post processing tool.

Learning a subject and trying to teach it in a very short time helps to instantly burn the information into your mind. If you have a short memory, you can always rely on the computer cluster's NAS (Network Attached Storage) box to store your priceless information. Doing such work during the summer holidays helped me get more organized through the use of the lab notebook (where every single piece of information must be written down), and get an inside look into the world of research, where I will spend the rest of my life. I really recommend that new students do something similar during their holidays instead of other meaningless and boring tasks such as visiting the historical place of Paceville.

The students, my colleagues and I are grateful to the extremely helpful and dedicated staff within the Department of Physics for helping us to set up the models and make them run smoothly. The Regional Climate Summer School 2011 is already recruiting physicists, computer geeks, mathematicians, chemists and climate enthusiasts to expand our experiments and activities. Feel free to come to speak to us about it and get a feel for what this climate stuff is all about.

Contact Dr. Noel Aquilina via email on noel.aquilina@um.edu.mt

# Quantum Computing

by Jessica Stanley

In Douglas Adams' legendary trilogy in five parts, 'The Hitchhiker's Guide to the Galaxy', a pan-dimensional, hyper-intelligent species builds a giant supercomputer, named 'Deep Thought', in order to finally find the answer to 'the ultimate question', 'the meaning of life, the universe, and everything'. When the computer is finally built, and is asked the question, the beings rejoice, but their happiness soon turns to angry frustration as the computer tells them that it will take 7.5 million years for the calculation to be completed. This kind of problem, namely that there are classes of problems that can theoretically be solved but take an eternity to do so in practice, is well known to human computer scientists, and has been exploited for applications such as cryptography. But what if there was another way of doing things, another method of computing that would drastically cut down the time needed to do these calculations?

Back here on earth, mankind's ever-increasing consumption of power and dependence on technology drives the device electronics industry like a slave master, demanding not 'bigger and better' but 'smaller and faster'. The huge advances in electronics since the 1970s are reflected in Moore's Law, which states that the number of transistors in an integrated circuit increases twofold every two years (and indeed, this is true of the last half-century). But can this go on indefinitely? The continuing miniaturisation of electronic devices inspires headlines such as 'Moore's Law reaches its limit' (Blankenhorn, 2010), and indeed as device size decreases, so does the number of electrons per device, both of these facts meaning that quantum effects become increasingly important. This is a problem for 'classical' computing, because although the supporting theory acknowledges quantum behaviour, the operation of a bit, the building block of any classical electronic device, relies on currents caused by the flow of upwards of 106 electrons, and the behaviour of such an ensemble of particles is characteristically different to that of one lonely electron. Nanoscale electronic devices also encounter the problem of tunnelling, the quantum effect whereby a particle in a quantum well, which in the classical case would be confined by the higher potential energy barrier, can escape by 'tunnelling' through the walls of the well. This problem shows the limited applicability of miniaturising classical device structures.

This is where quantum computing comes in, to use these problematic quantum effects to our advantage. There has been much publicity about this field of research, many news videos interviewing quantum computing experts with eerie music in the background or dizzying special effects, in an attempt to play on the public's concept of anything with 'quantum' in its name as being mysterious and strange, along the lines of mythical devices such as time machines. The reality is that quantum computing makes use of fundamental features of quantum mechanics, such as electronic structure, entanglement, superposition, and tunnelling, to create a new approach to computing.

No practical quantum computer exists yet, but much progress has been made in fabricating devices which could, in the future, lead to functional quantum computers. There are numerous methods being explored, and two of these will be mentioned later.

## History

The story of quantum computing begins in the early seventies, with the development of quantum information theory. Then in 1982, Richard Feynman proposed the first idea for a quantum computer (Feynman, 1982). Quantum computing remained in the realm of the abstract for the next few years, however, until 1994, when Peter Shor of Bell Laboratories produced an algorithm showing how a quantum computer could be utilised for factorisation of large numbers (Shor, 1994), a problem which is classically intractable. As this fact (the difficulty in factorising large numbers) forms the basis of most modern cryptographic systems, quantum computing began to rise in popularity, and that same year the first experimental implementation of a quantum logic gate was achieved, using trapped ions, by Cirac and Zoller at the National Institute of Standards and Technology (NIST) in the USA (Cirac, & Zoller, 1995). Since then there has been an explosion of both theoretical and experimental research on this subject, although the holy grail of a practical quantum computer is still out of reach.

## Basics of Quantum Computing

In classical computing, a bit, the computational building block, may be in one of two states, 1 or 0. The fundamental principle behind quantum computing exploits the fact that a quantum system, until a measurement is made on it, simultaneously exists in all possible states. This is called superposition. If a measurement is made on the system, it 'collapses' into one of the possible states. Thus a quantum bit, or qubit, may be in states 0, 1, or a superposition of both, as long as it is kept isolated from its environment. The advantage of this is that an operation on a superposition of states acts on two values in one 'clock cycle', because it is only one physical state. Add another qubit, and we can do four calculations in one go; three qubits enables 8 calculations at once. Continuing in this fashion would allow us to harness massive computing power.

One example of a situation in which quantum computing could have a huge advantage over classical computing was brought to light by Shor's algorithm, which finds the prime factorisation of a number N. In classical computing, the most efficient known algorithm is still intractable, as the time taken to do the calculation scales as O(e(log N)1/3 (log log N)2/3). Shor's algorithm run on a quantum computer, on the other hand, scales as O((log N)3), i.e. the run time doesn't blow up as N becomes large.

Shor's algorithm has been successfully run on several different types of quantum computers, but the typical calculation which has been done is factoring 15 into 3x5, which shows that those worried about quantum computers rendering internet security (which relies on the fact that large numbers are difficult to factorise) useless don't need to worry just yet.

## Ion Traps and Quantum Dots

In principle any two state physical system can be used to build a quantum computer. The options are limitless, and many approaches have already been tried, but all have experienced difficulties. At the moment there are many different methods being tried by different groups, a mixture of older, more developed methods, and newer ones which promise better alternatives and novel ideas. For example, the ion trap quantum computer is a more established, and relatively advanced method, but requires advanced fabrication technology. Another method using quantum dots provides a good contrast by being a newer method, but having the advantage of being attainable from existing semiconductor fabrication techniques.

The original, and possibly the most successful so far of the quantum computer architectures exploits atomic energy level structure. An ion, or group of ions in the case of multiple qubits, is confined in an electromagnetic trap, and the qubit consists of two chosen energy levels, one for state 1, one for state 0. Laser pulses at the resonant frequency induce an oscillation between the two states, driving transitions back and forth between the two states. The trap itself consists of electrodes which create an oscillating (radio frequency) electric field, with the atom 'trapped' in the middle, as shown in Figure 1. Scalability, meaning the ability to make devices with large numbers of bits, has been one of the biggest challenges for the ion trap method, but progress has been made in this area in recent years.

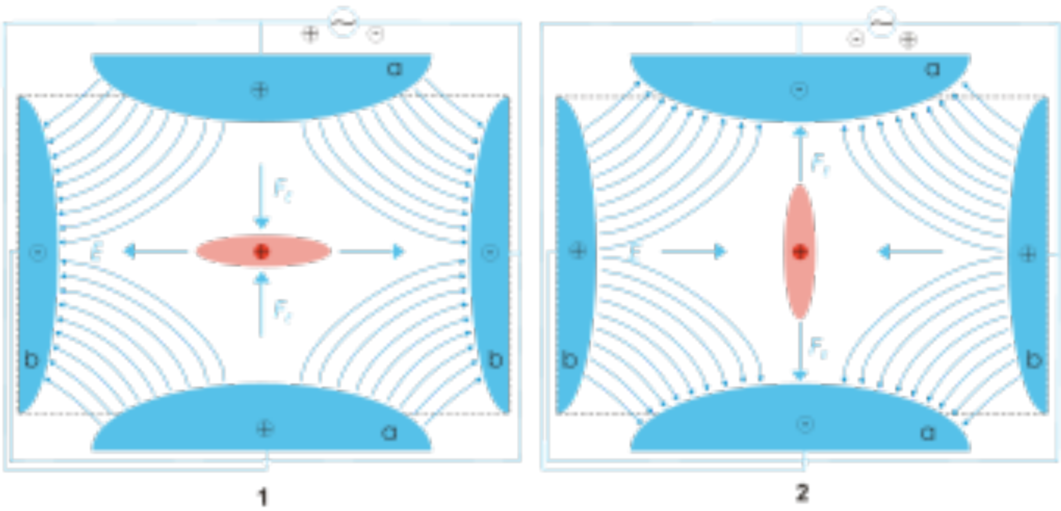



Fig 1: Diagram illustrating an ion trap. The atom (red) is confined by an oscillating electric field from hyperbolic electrodes (blue). Image from Wikimedia Commons.

Another method using quantum dots, proposed in 1997, looks promising. A quantum dot is basically a small cluster (typically spanning 10-100 nanometers) of semiconductor atoms, and its small size means it has fundamentally different electrical properties to that of a larger semiconductor. The charge carriers of the quantum dot are confined in three dimensions, and this confinement results in the discrete energy levels, as if the quantum dot were some sort of 'artificial atom'. Bulk semiconductors, on the other hand, have broad 'bands' of available energies. Quantum dots with a single excess electron are used, and the qubit in this case is the spin of that electron, or alternatively excitations of excitons (weakly bound electron-hole pairs) in the quantum dot can be used (like in the case of the ion trap).

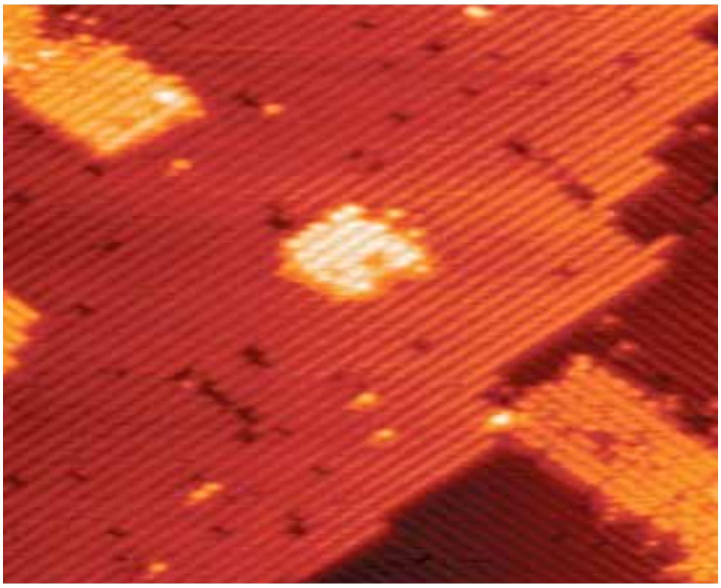


Fig 2: An image of the seven-atom quantum dot. The dot itself is visible in the middle, and the two bright rectangles are electrodes which enforce quantum confinement. Picture from nanowerk.com

A recent development in this field is a seven atom quantum dot (Fuechsle et al., 2010), ten times smaller than currently used transistors. The University of New South Wales team created this quantum dot transistor using Scanning Tunnelling Microscopy to dope Silicon with Phosphorous. One of the main advantages of this process is in overcoming previous problems with interface defects, which are a significant problem for quantum devices.

In the coming decades the field of quantum computing is sure to continue to grow, and at some point one method must emerge as the clear winner, before practical quantum computers can become a reality. Until then, though, many new methods may be tried, and may overtake those described here. Who knows, we may be on our way to checking Deep Thought's original calculation, namely that the meaning of life, the universe, and everything, is 42.

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by Ragnhild Schrøder Hansen

## Brief History and status of the EuroPhysics Fun network

In recent years, physics shows have come to the forefront of attention as a means of bridging the gap between scientists and the general public. Because of their small-scale nature they offer a possibility to establish valuable interactive communication between the scientific community and the general public. The performers of the shows try to gain the attention of the spectators by performing experiments, which demonstrate interesting physical phenomena explained through adventurous stories, humour and music. EuroPhysicsFun (EPF) was founded in 2004 to stimulate the exchange of ideas and the best practices between show groups.

The main goal of EuroPhysicsFun is to establish a European community of physics show groups. A physics show is often an ad-hoc activity done by people from very diverse backgrounds, such as students, university staff, actors, science centres and teachers. Such a diverse community represents a great untapped resource for high quality science communication.

EPF actively encourages the exchange of best practices between science shows by means of conferences and exchange programmes. In this manner, the knowledge that is present in each physics show is made available to the community and the quality of the physics shows can be improved.

Today, the EPF network consists of 40 physics shows from 20 countries. In total these groups reach about 400,000 people per year. Furthermore, EPF seeks to promote science shows as a method of science communication. It does this by encouraging projects that showcase science shows, by encouraging research into science shows and by establishing a central entry point for science event organizers

## Conference ShowPhysics

The main event on the EPF calendar is the annual conference ShowPhysics, at which groups from all over Europe gather to exchange best practices and share ideas. This conference is organized each year by one of the physics shows participating in the network. The most recent of these conferences was held in Bonn, Germany in April 2010. Around 20 shows from several European countries, as well as from further abroad, usually attend these conferences.

Earlier conferences have been held in Aarhus, Denmark in 2005, Leiden, the Netherlands in 2007, Tartu, Estonia in 2008 and Geneva, Switzerland in 2009. The next ShowPhysics conference will be held in Kharkiv, Ukraine on April 5-9 2011.

An important goal of ShowPhysics is to exchange information on demonstration experiments. This is done by means of experimental sessions. For these, the groups bring their equipment to the conference, so that they can demonstrate their experience to each other. At the end of the conference, the experimental sessions are rounded off with a demonstration in the centre of the host city.

The conferences are always a huge success. A comment which reflects the general atmosphere after the conferences is "…there is a lot we can learn from each other and great things can be done if we work together every once in a while. I've heard all of you speaking enthusiastically about this. I hope that this feeling remains…"

Besides organising a yearly conference, the network also functions as a repository for knowledge on show physics. Participants, who have experienced many shows first hand, form a community which is ideally suited to setting up new physics shows. Furthermore, the network also seeks to stimulate cooperation between shows on a national and international level.

## Evolution of the network

In 2010 EPF has also created a forum on their webpages to support the communication between physics shows. In this forum the show members can discuss everything from specific experiments and creation of shows to financial support. Alongside this there is also an experiment database to share experiments. The shows can easily expand this database with


*All pictures in this article are from the common shows at ShowPhysics 2009 and 2010*


their own experiments and find new experiments to add to their show.

To resolve the composition of show physics groups in Europe and establish what their respective goals are, we have performed a survey of the participants of the EPF network.

## Physics Shows in Europe

The primary goal of the physics shows is popularisation of physics. Another common goal is to demonstrate that physics can be a lot of fun. An important goal of the shows is to increase the interest of youngsters in studying physics and to choose natural sciences as a subject in secondary school.

Besides the usual aims, there are many groups which also have other goals, such as: increasing enthusiasm for physics and science in general, demonstrating and explaining everyday phenomena and demonstration of the importance of physics to modern technology. Other frequently indicated goals are: popularisation of science and research, demonstration and explanation of special physical phenomena such as superconductivity and levitation, reducing fear of physics as a difficult school subject, increasing young people's interest in studying physics at university. Surprisingly, only relatively small percentages (20%) of the groups aim to demonstrate the methods and principles of scientific research.

From the survey, we have found that the shows are staffed by a very diverse group of people, who mostly have a background in physics (over 80%). This includes everyone from undergraduate students to university staff. Some groups also incorporate amateur physics enthusiasts and other groups consist of actors who perform comedy shows and historical tales (such as the German group Physicanten & Co).

In most cases performances are aimed at secondary (high) school students, but many groups also target both primary school children and students. People of all ages were indicated as a target audience by only 13% of the groups, while pre-school children were claimed to be the target audience by only one out of 15 respondent groups.

Almost all groups combine the experimental demonstration and explanation of basic physical phenomena with interactive experiments. About 50% of the shows include hands-on experiments. This way of learning is thought to be much more effective than just observing; it is of course also much more attractive, especially for young spectators.

The chain experiment group from Slovenia, for example, organises yearly events for which independent teams construct the experiments entirely by themselves. A large part of the groups demonstrate experiments with basic emphasis on show and entertainment. Besides this, many

groups provide also seminars and lectures.

The majority of the groups present their shows directly at the school buildings. Market stands are also quite common. To achieve the necessary interaction, about 50% of the groups organise workshops and similar events. Some of the groups also organise performances in museums and science centers.

## Conclusions

The positive response of society to physics shows confirms its importance as a method of communicating and presenting physics to the general population. The humour, excitement and interesting stories told between the experiments satisfy children as well as students and adults. The increasing visitor numbers also demonstrates the success of physics shows.

The participation in the shows provides physics students – the performers of the show – an important opportunity to express their ideas, to improve their knowledge and to acquire skills needed for public speaking. Therefore both sides, the performers and the spectators, gain a lot of new knowledge and also a lot of fun.

## Contacts

Ms Ragnhild Schroeder Hansen, Bergen, Norway
Mr Grzegorz Brzezinka, Cracow, Poland
Mr Sune Nielsen, Aarhus, Denmark
Dr Olivier Gaumer, Geneva, Switzerland

Email contact : mail@europhysicsfun.org
Homepage: http://wiki.europhysicsfun.org

# Experiment:

# Mentos and Diet Coke explosion

Ragnhild Schrøder Hansen shares a fun physics show experiment to try at home.

## Purpose

To demonstrate an almost explosive phase change from dissolved $CO_2$ to gaseous $CO_2$.

## Summary

A Mentos dropped into Diet Coke will cause the $CO_2$ in the soda to rapidly form gaseous bubbles resulting in an explosion.

## Description

If you put a Mentos into a soda, you will get a very sudden and powerful eruption. When $CO_2$ dissolved in soda forms bubbles, this does not happen in the middle of the liquid. The small $CO_2$ bubble has to counteract the strong surface tension of the water, and for this to be possible, the bubble will preferably form at small impurities in the liquid or on the surface of the container. Similarly, one will only see $CO_2$ bubbles from a glass of beer or a soft drink being formed at certain points on the inside of the glass, and if extraordinarily many bubbles form at the bottom of a glass of carbonated liquid, it is very possible that the glass is not completely clean.

There are many of these tiny crevices, in which the bubbles can be formed, on the surface of the rough Mentos, and this make them very efficient at releasing the carbon dioxide of the soda. In addition, the candy's content of gum arabic reduces the surface tension of water, making it even easier for the bubbles to form.

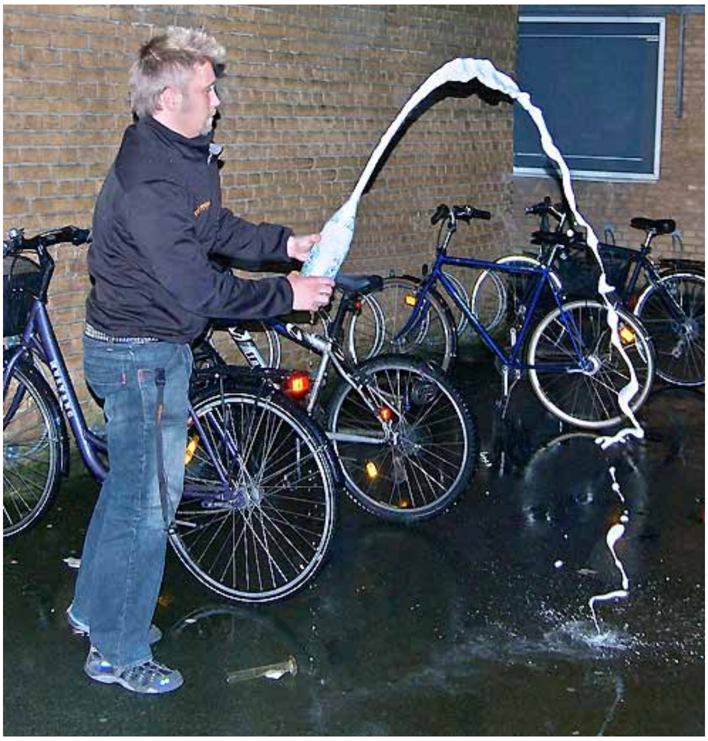
Diet Coke is better than ordinary Coke, which contains sugar. This is due to the surface tension of the aspartame-containing diet product, which is lower than that of the sugar-containing soda. Because of this, it is easier to form bubbles in diet soda. Another advantage of using diet soda is the fact that the liquid is less sticky, making it easier to clean up after the demonstration has been done!

The Mentos candy can be dropped directly into an open Coke bottle, but you can also make a device where the candy is placed on a string or similarly right below a hole in the lid. You then just have to pull the string to release the Mentos. The small hole in the lid will also increase the power of the jet.

The Mentos and Diet Coke experiment has, in a very short time, become very popular, and on the internet (for instance on Google Video) many videos of the demonstration can be found.

The reason for the popularity is "viral marketing", where entertaining videos containing commercial products are spread like a kind of virus on the internet. If the video is fun, people will automatically forward it to their friends, and the companies behind the products in the video will get plenty of free advertising. The Mentos demonstration was, however, not made as a viral campaign from either the producers of Diet Coke or Mentos, but the videos are so popular that the Mentos company estimates that they have a value of more than 10 million dollars!


*Coke and Mentos. Here, the Mentos are places in a graduated cylinder, but one can also use a tube folded from paper or cardboard.*



*A whole Mentos roll dropped into a soda.*

The demonstration has been known for some years, but it first became widely known in the public as a science experiment in American television in 2005. Steve Spangler performs entertaining physics and chemistry demonstration experiments on the morning show of 9NEWS. Steve describes the demonstration on his own webpage, and on the webpage of 9NEWS Steve's videos can be found (see the references).

Steve's Mentos videos were quickly spread on the net through blogs, and the demonstration has been featured on shows like Letterman, The Today Show and ABC's Good Morning America. Even the Wall Street Journal has written about it. The demonstration was finally believed to be explained in an article by Tonya Coffey from 2008 (see the references).

The current most popular Mentos video was made by EepyBird.com ("Extreme Diet Coke & Mentos Experiment"), who have performed a great experiment with 200 litres of Diet Coke and more than 500 Mentos. The demonstration was posted on their website on June 3rd 2006, and in only one week the video was watched about 800,000 times.

A variation of the demonstration is to put a whole roll of Mentos (still wrapped in the aluminum foil) into a Coke bottle, which is then immediately sealed. The bottle is shaken lightly and soon becomes very hard due to the pressure. You then loosen the lid a bit, so the gas is just beginning to escape. Throw the bottle hard down on the ground. The lid will fly off, the coke is pushed out in a powerful jetbeam, and the bottle will fly far away as a rocket.

Note that the bottle flies away with great force. Try to be far from something that may break, and never throw the bottle so that the lid is pointing away from you (the bottle will be flying towards you).

*The Chemistry Show of Aarhus, Denmark, performing a show with Mentos and soda in 2006.*

## Equipment and materials

- Large bottle of soda (Diet Coke or similar)
- Mentos

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The 3rd place picture in the Contrived Category from the American Association of Physics Teachers annual photo contest. Natalie Hummel, the photographer from Columbus School for Girls, describes the physics behind the image: “The smiley face depicted in the picture is created by a reflection of two sequins and a pencil in a martini shaker. The outer surface of the martini shaker forms a convex mirror. Thus, the shaker’s surface creates an image that is upright and smaller than the original object. This curvature and the angle of incidence distorts the straight pencil into an upward curve forming a smiley face.” Don’t martini shakers make everyone smile?

*Image from http://www.aapt.org/Programs/contests/winners.cfm?theyear=2010*

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