The Journal of
the International Association of Physics Students

{ jiaps }

JIAPS 1/2005

...New year!

EC is working hard for you!

The winter has arrived and it is freezing cold and snowing. Well, especially for us Norwegians anyway. A new year has arrived, with a lot of cool things to look forward to, like ICPS, summer school and trips of different kinds. The ICPS registration has started, so get to it! The executive committee has had the first 2 get-togethers, one in Mulhouse, France and one in Oslo, Norway. I have to say it went well and we are all still friends, even if the pictures might suggest othervice...

During our meetings we got the time to get to know one another better, and of course discuss some serious matters, you know like peace on earth and stuff. No, just kidding. I think we got a lot done and set a good working morale for future meetings. If you are interested to look at the minutes or see some more photos, they are presented on our web page: **www.iaps.info**.

Also you can read all about our activities for this year on our web page. More details about each happening are being added all the time. If you have questions or comments, please send them to us: **iaps@iaps.info**.

Hope you had a nice Christmas and will have an even happier Physics Year.

Annett Thogersen
president

Challenges

You, dear reader perhaps don't know me personally, but I'm sure you know one of my biggest creations, because you are holding it in your hands (or reading it on the screen)!

The first time I fought for my opinion...

And most probably you don't know how JIAPS is made. I'd like to talk about this a little bit.

The most important ingredient is the writers! There is no newspaper without writers and articles! So I'd like to ask all of you to write interesting articles for me, for every National and Local Committee and JIAPS! If you are working on something interesting, or something happened around your assocition, or you just want to share something with the IAPS-members, write an article and send it to **jiaps@iaps.info**!

A good proofreader is needed also! Here I'd like to thank Jim Grozier for his work and suggestions! It would be much harder to create this newspaper without him.

Of course it's not my newspaper, I can't put anything inside it. It's like theatre, I have to find out what my audience wants to see (or in this case read)! But I don't do this alone! The Executive Committee is my greatest help. This is not easy, especially with JIAPS, because there are so many different people in the EC, different backgrouds and ways of thinking. Sometimes it's hard to find the common denominator. Sometimes I have to fight for my opinion, haven't I Annett…?

The other thing that is needed is a good computer, a good pagemaker, some nights without sleep, experience of how to create the layout of a newspaper, creative thinking and ideas. And here I come, this is my part.

You can ask why am I telling you such things? The answer is simple: as you can see this is a teamwork and by reading you are a member of this team also! So if you have an idea of how to make this newspaper better don't hesitate to write me!

Now you have a picture of how this is going and perhaps you see what a big challenge this is.

But as a wise person said once there are no insolvable problems, just small people. I hope I'm big enough for the challenges made by JIAPS and IAPS!

András Zsom
head-editor

Summary

JIAPS 1/2005

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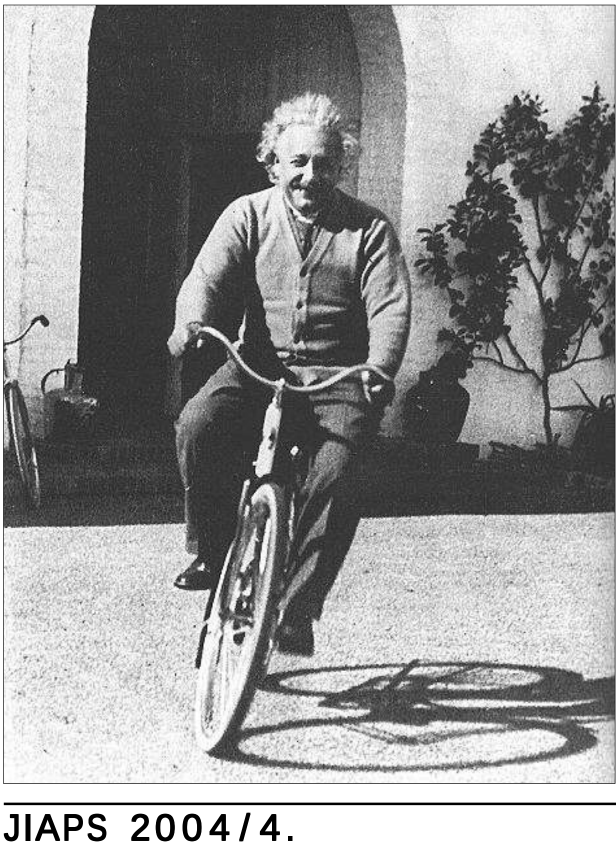
World Year of What...?

Physics of course. You see, a hundred years ago in 1905 a man we all know very well had a pretty good and productive year. Einstein managed to write 3 fabulous papers for *Annalen der Physik* about Brownian motion, the photoelectric effect and the last one about special relativity. And these topics are not the easiest ones to derive out of "*thin air*", so for that reason the United Nations decided that 2005 is going to be the world year of physics. And since CERN had their 50 years anniversary last year, this will be like the perfect *after party* or should we say "*the top of the cake*". A whole year to celebrate Einstein and all of the wonderful physics we surround ourselves with every day.

This year will be packed with physics activities and celebrations in countries around the world. We are starting with the WYP launch in Paris at the beginning of January. Here, representatives from countries around the world, including some students, will discuss *Physics for Tomorrow* and listen to presentations. Also starting in Princeton on the 18th of April there will be a "*ray of light*" travelling through countries around the world, transgressing boundaries and leaping across the sea, marking the day Einstein died. There will also be a poster contest (**www.wyp2005.at/glob5stories.htm**), Pirellis Relativity Challenge (**www.pirelliaward.com/einstein.html**), Physics Talent Search (**www.wyp2005.at/**), Stories in Physics contest (**www.wyp2005.at/glob5-stories.htm**) and other projects enhancing the knowledge and reputation of physics. As you can see a lot will happen and as a physics association we intend to join these celebrations and of course have some of or own.

One of *"the crew's"* brilliant ideas is to have a big flash mob about physics on the day that Einstein published the first of his three most famous papers, the 9th June. Having a big gathering of people at a public place doing an experiment using people can get physics publicity and seem fun. Because one of our goals this year should definitely be to get the word out there that physics is fun and exciting! One experiment that can be used is the Rutherford experiment. I know, it is not an Einstein experiment, but this show can look very good and be easily explained. Just think about people running towards a big object like a statue and then being scattered to *detector*-like objects. To get Einstein *in the game* we can also use the Brownian motion experiment. This activity is under development and people from different committees will discuss this event further in Oslo around New Years.



We as physicists obviously know that physics is both entertaining and mysterious, but somehow non-physicists are a little more sceptical about the use of these words. As Einstein said:

"*The most beautiful experience we can have is the mysterious. It is the fundamental emotion that stands at the cradle of true art and true science. Whoever does not know it and can no longer wonder, no longer marvel, is as good as dead, and his eyes are dimmed*".

To try changing people's minds about physics and save them from being *"as good as dead*" we want to encourage physics associations and students to promote science to *normal* people like arranging science shows/circuses. To present physics in a fun and easy way can bring knowledge and excitement among non-physicists. For that reason we will in the coming year make a *how to do a science show/circus guide* that will be available on the web. Also during the ICPS we will have a science show/circus contest. More about these activities will be presented on our webpage, and be updated as we go.

This year will be ours, and we should use this to our full advantage. I hope that you agree.

Annett Thogersen
University of Oslo

Table of contents

Coimbra

A Brief (and very personal) tour of the icps' 2005 host city.

Let's suppose you land in Lisbon and take the motorway to Coimbra. A few kilometres before the ICPS' 2005[1] host city, you will be greeted by a sign where you should be able to read something like "Coimbra: Cidade do Conhecimento", that is, "Coimbra: City of Knowledge" (this has been your first Portuguese lesson; don't worry, there will be many others next August).

One could say that knowledge, its pursuit and teaching, has been the distinctive mark of Coimbra since at least the XII century and the inception of the (then) kingdom of Portugal. The "Mosteiro de Santa Cruz" (Santa Cruz Monastery), founded in 1131, was the first major "university level" teaching institution in Coimbra; even today, its teaching days long gone and after many alterations, the "Igreja de Santa Cruz" (Church of Santa Cruz) is one of the most important monuments of Coimbra.

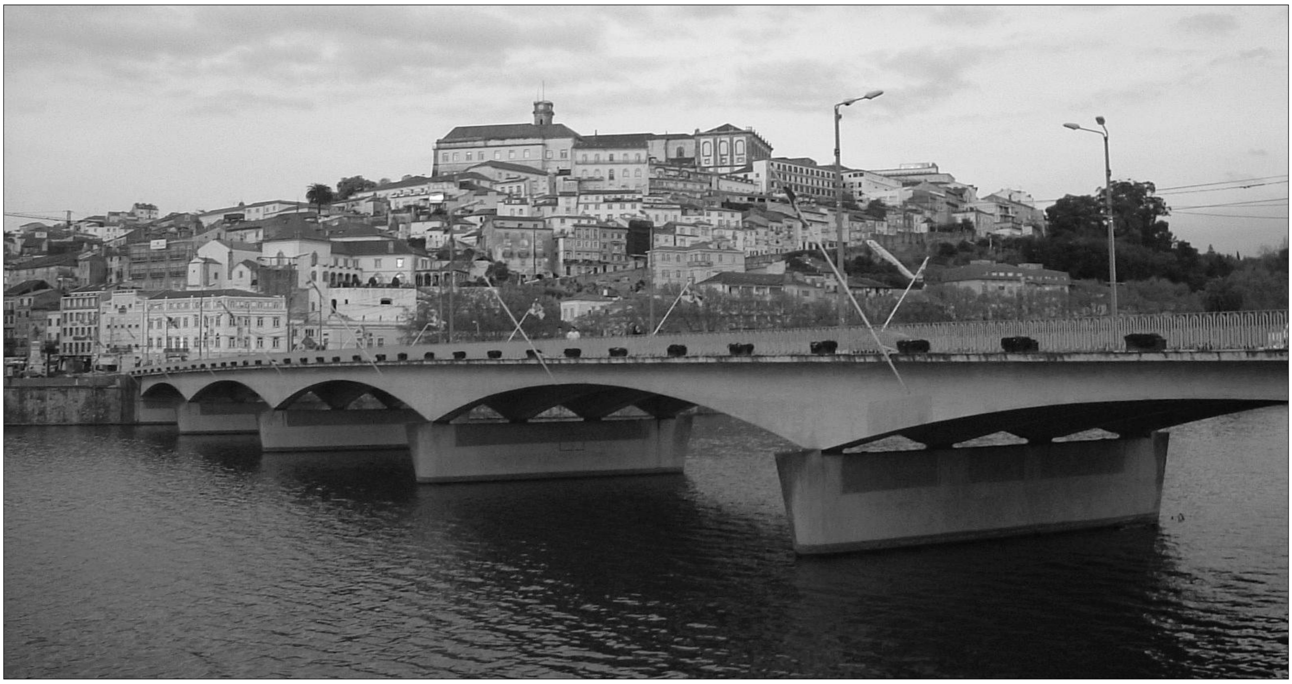
Only a century and a half later, in 1290, the University of Coimbra[2] was created, thus making it one of the most ancient universities in Europe. From that time little remains today, but one should not miss the opportunity to visit the university's XVI–XVIII century buildings in the Manuelline, Mannerist and Baroque styles: upon entering the "Pateo das Escolas" (the old university main yard) through the "Porta Férrea" (Iron Door), one can see the University Tower straight ahead, the "Via Latina" (an elegant colonnade) and the Rectory to your right and, to your left, the "Capela de S. Miguel" (St. Michael Chapel) and the fabulous "Biblioteca Joanina" (the old library). Also in the main university campus, it is important to mention the "Laboratório Chimico" (Chemistry Lab), the "Jardim Botânico" (Botanical Garden) and the "Colégio de Jesus" (Jesus College), not too far away from the "Pateo das Escolas" and in the neoclassical style. The latter is of special significance to us, physics students, because inside we can find the "Museu de Física" (Physics Museum), one of the two most important physics museums in the world, with a unique collection of XVIII and XIX century physics instruments. In anticipation of your forthcoming visit, please don't forget to check the museum's website[3].

Nowadays, the University of Coimbra has about 23 000 students (out of a total population of less than 140 000), distributed across three campuses and eight Faculties: Science and Technology, Arts, Law, Medicine, Psychology and Educational Science, Economics, Pharmacy and Sport. The Physics Department[4] hosts three undergraduate courses – Physics, Physics Engineering and Biomedical Engineering – and several research groups, working on topics such as theoretical, computational and solid state physics, radiation detectors, particle physics and electronics.

The old university was built at the top of one of Coimbra's many hills, overlooking the Mondego River and some of the city's finest monuments. Downhill from the "Pateo das Escolas", for example, our first task is to avoid getting lost in the medieval streets of the old city (be warned that this is not an easy task, even with a map) and then trying to find the "Sé Velha" (Old Cathedral), a remarkable Romanesque church dating from the XII century, the "Palácio de Sub-Ripas" (Sub-Ripas Palace) and the "Casa da Nau" (Ship house), to mention only a few of the most interesting buildings of old Coimbra.

Free from the maze of the old high town (where generations of students lived), we enter the ... maze of the old down town, Coimbra's first commercial area and home of

Cafe Santa Cruz



General view of old Coimbra

tradesmen, artisans and the like, who maintained a "healthy" rivalry with the students above, renewed every night in singing and drinking competitions, taking place in bars of disputable reputation, with the occasional fist fight outside.

In this lower part of the old city, one can find the already mentioned "Igreja de Santa Cruz", the "Igreja de S o Tiago" (St. James church), another Romanesque church, the Town Hall, the "Rua da Sofia" (Sofia Street) – "Sofia", of course, coming from the ancient Greek "Sophia", meaning wisdom, knowledge – and, across the river, the "Convento de Santa Clara-a-Velha" (old convent of Saint Claire).

I wouldn't like to finish this article without briefly mentioning the outskirts of Coimbra, because you will probably have the opportunity to visit some of them. To the east lies the important archaeological site of Roman "Conímbriga", which flourished in the epoch of the emperor Augustus and was destroyed by the Barbarians in 465, and the first slopes of the mountains of "Lous " and "Buçaco", with its ancient and well-preserved woods, stage of a famous battle in the Napoleonic wars.

Pateo das Escolas, partial view

To the west, the forty kilometres to the sea are almost all flat. Before arriving at the coast, check the castle of "Montemor-o-Velho" and the "Dólmen das Carniçosas", a Palaeolithic archaeological site. And we finally are where we (or, more probably, you) want to be in the 38 or so degrees of the Portuguese summer: the "Figueira da Foz" beach, with its apparently endless kilometres of sand, sea and, believe me, sun!

Maria Jo o Benquerença
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University of Coimbra

ICPS' 2005 Team Coordinator

Pictures taken by Luis Almeida.

1 **http://physis.fis.uc.pt/icps2005**

2 **http://www.uc.pt**

3 **http://www1.fis.uc.pt/museu/index.htm**

4 **http://www.fis.uc.pt**

Germany to join IAPS

How to become the member of IAPS.

As I'm staying in Germany this term anyway as an exchange student, I was happy to be able to represent IAPS at ZaPF (Zusammenkunft der Physik Fachschaften, i.e. Meeting of the student bodies of the Physics faculties). The others present from IAPS were the President Annett Th gersen and the President Elect Davide Venturelli.

As the accommodation was organised to be in a gym hall about a mile from the Physics institute, we were able to see some of Hamburg already in the first evening. And of course the diversity of the pubs in Hamburg.

On Friday we started the day with an excursion of three hours to DESY, Deutsches Elektronen-Synkrotron which is in the city. The excursion was well led and interesting even for a biophysics student like me, as the applications and fields in which DESY is used are various.

ZaPF, the people

After the excursion the real work started in the work groups and the German physics students interested in organisational issues concentrated themselves on the rankings of the German physics departments, the internal evaluation of courses, and the tuition fees in Germany. In the evening there was a relaxing tour of the pubs and bars in Hamburg.

On the following morning, after a well/ not so well/ not at all slept night, we started to work right after breakfast. The issues for the day were greater than Germany, meaning IAPS and the Bachelor/Master curriculum, which is being adopted in Germany at the very moment.

Discussion about the advantages and disadvantages of joining IAPS was long and went through and through. As there were no real disbenefits found during the debate, the final conversation concentrated on opinions as to whether joining IAPS "just because there are no disadvantages" could be approved, and on the benefits of joining as well. Through IAPS, ZaPF could reach out internationally, and create contacts at the level of individuals as well as at the level of organisations. Thus also the German students outside of Hannover, where there is a Local Committee of IAPS at the moment, would be able to join, and their feeling of belonging to the international community of physics students could be improved. ZaPF would also become more organised, being at the moment a more or less informal meeting of associations. Of course this would take some time and effort, but that was found to be the only real drawback.

Being a rather informal organisation, Zapf should also reorganise its structures in order to be able to join IAPS as a National Committee (NC) since NCs are supposed to be registered organisations. For financial purposes there is also a registered organisation called ZaPF, but only with very few members compared to the informal ZaPF, to which all the German physics students belong. Thus also this organisation might be suitable as a future member of IAPS, but only after major modifications. Further organisational problems arose, on financing the membership and possibly the trips of the representatives to ICPS. For the purpose of solving these problems there was a commission founded. The results shall be seen in ZaPF in the Summer term 2005, where also the final decision of joining shall be made.

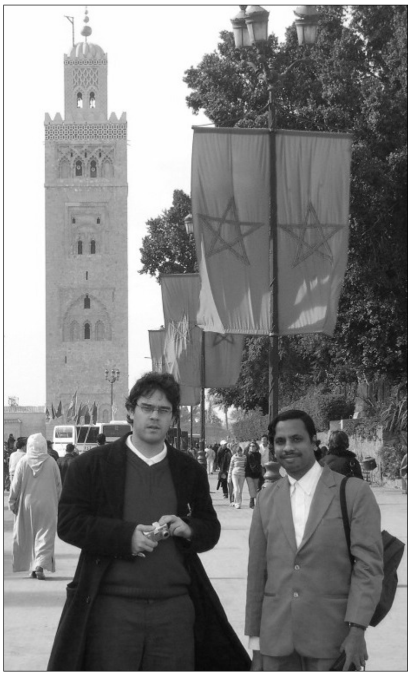
After a stressful afternoon the participants relaxed again with an "alternative excursion" through the campus of the University of Hamburg. Alternative meaning an excursion on the theme of the "history of National Socialism" in Hamburg. The excursion offered a very different and yet really interesting view of the city and its history.

But yet there was still a stressful evening to come, as all the workgroups presented shorter (or longer) abstracts of their work in the final session, reminding me of the General Meetings of IAPS both in its length and the passion of the conversation. And finally we were able to start the barbeque party with lots of German beer and meat.

Ending the weekend in the following morning I had to say goodbye to the nice and impressive city of Hamburg as well as the new friends I had made during the weekend. But there is still the next ZaPF to come only in six months, and I will hopefully be able to be there and see the result of discussion: "do German physics students want to make a difference in IAPS and be represented by IAPS?".

Paula Kuokkanen
Humboldt University, Berlin

What you always wanted to know about WAYS



Society is slowly understanding how important it is to encourage international relations among young people. In a world where terrorism, intolerance and drug use are rising, there is an increasing need to foster peaceful collaborations. Science has always represented a very efficient glue that usually succeeds in making people go beyond cultural, racial and religious barriers. This is why UNESCO (the United Nations' cultural body) started to support an active programme towards establishing an efficient, dynamic human network for young scientists of all countries.

In the middle of December 2004, in Marrakech (Morocco), the World Academy of Young Scientists (WAYS) was officially founded and organised. This is the idea: equal representation of youth of all countries should lead a world-wide no-profit organisation that aims to: coordinate and finance international projects, inform about local and international opportunities, promote excellence through competitions, build up a database of contacts and work towards the developing of science strategies focused on the third world.

In Morocco the first General Assembly was held. Selected delegates were called to discuss the constitution and the regulations of the newborn academy, as well as to elect the board and the steering committee of WAYS. IAPS, as recommended by the General Meeting in Novi Sad, was represented by delegates from Italy (me), India (Murugesan Udhayasankar) and Hungary (Laszlo Oroszlany) in order to find out how collaborations could be set up between our association and WAYS.

Let me give you a glimpse of the conclusion: WAYS, as it is now, is largely far from being efficient and organised. It will be a task of the elected board to make the body operative in two years' time. So, for now, there are not many "ways" IAPS could take a role in this new adventure. But let's proceed! The conference programme was serious, interesting and fun and quite well organised from the practical point of view. We had a formal opening ceremony, a round-table, two workshops and three plenary sessions with distinguished speakers. The topics developed ranged from Science in Developing Countries to Good Communication Policies for Science, passing through education and relationships among the youngest and the more mature researchers. We had very little time to visit the

wonderful city, but we were offered good accommodation and meals. All participants appeared to me as very interesting people, active in their country as young successful scientists or project organisers. I certainly made some very good friends. All seemed to be going well until we started to discuss the constitution of the academy.

They should have come to some of our General Meetings, since they naively thought that a couple of hours could have been sufficient for more than 100 delegates from different nations and cultures to agree on a common, detailed constitution suggested by the provisory board. After one hour of discussion, we finally agreed on maintaining the name of the association and to let it be registered in Hungary (First two lines of the constitution). Then we talked more important problems like defining the aims of the organisation; and this discussion (moreover focused on whether or not we should aim to create research centres) ended after half an hour with the decision to maintain the previous version. I'll let you imagine how long and tiring was the discussion about the representatives of the association and the votes per continent.

Basically, we had to continue in groups during and after dinner, and to fix an extraordinary assembly of 4 hours the last day, just before the expected elections of the officers. But we finally ended up with a "draft of an association", i.e. an official group that could start to work with some guidelines, even if the approved constitution has some evident inconsistencies, and some people were elected as representatives of some inner bodies whose aims and regulations had not been defined with precision, yet. The Steering Committee (15 people, equally representing the world geographical regions) will revise the constitution paper in two years' time.

So what has all this stuff to do with IAPS? As I was anticipating from the beginning, nothing really important for now. WAYS didn't define what relations it could have with institutional members (like NGOs) so it doesn't plan to have any in the near future. But the idea, the organisation, the guiding principles are in some areas very close to IAPS (although IAPS is concentrating on physics only) and thus it is important to maintain close contacts with this new body.

Nine of the representatives of the elected Board of WAYS are very interested in developing some sort of relation with IAPS, so maybe we will have some of them present in our future activities.

I have bored you enough, so I suggest interested people either contact me or have a look in at the link **http://www.waysnet.org/**. Anyone can join WAYS as a full member, it's free.

It is too early to understand if WAYS will be a successful idea, for now let's have faith in the skills and motivation of the President and the Board. I think we can expect something good from this new project in the next two years, if they manage to organise themselves despite all coming from different regions. To WAYS and to its future relation with IAPS, good luck !

Davide Venturelli
University of Modena and Reggio Emilia

25 questions, physics in the next 25 years

Summary of the Nobel laureate David Gross' lecture in Helsinki

One of the 2004 physics Nobel laureates, David Gross, accepted the invitation of the Finnish Physical Society and came to give a lecture in Helsinki. Instead of speaking of his work which gave him the Nobel prize, he gave a presentation of the most important questions that will make physics go forward in the next 25 years. The topics were gathered by questioning the participants of the Kavli Institute of Theoretical Physics' 25th anniversary. I will try to present these questions in brief.

Cosmological issues

The first questions were considering some of the most fundamental problems in cosmology. These are closely related to certain problems in other fields of physics, especially particle physics. The first question was to explore the beginning of the Universe. In the next 25 years there will be more experimental data available so that one can extrapolate closer to the Big Bang. One can also hope that unified field theories of particle physics could give some hints to solve the problem.

The next three questions are somewhat interrelated. The topics are dark matter, dark energy (or dark pressure) and astronomical structure formation. The first one has a clear connection to particle physics and needs (besides the study of massive neutrinos) some new form of stable matter. The most expected candidates for dark matter are supersymmetric particles. The proportions of dark matter and dark energy (which is like the cosmological constant) decide what our Universe will look in the far future. The proportions of different types of dark matter on the other hand have been responsible for the structure formation of galaxies. An interesting question concerning structure formation is the probability of forming a habitable planet and the search for extraterrestial life.

Issues concerning fundamental theories of physics

By saying fundamental theories of physics I mean such theories that are generally accepted to be "correct" by the scientific community. Although being very successful in describing physical phenomena, they don't fit together, so one might expect some failures and corrections on at least some scale.

General relativity is the best known theory for gravity. In the next 25 years it will be probed in a new way, when we get to measure gravitational waves. GR will be tested also by direct observations on very big and very small scales, and this may lead to a reformulation of the theory itself. Also the concept of space-time should be considered. It may be that the correct description of the big bang needs some other, more fundamental concept than time. Time would then be an emergent quantity like temperature is an average of kinetic energy.

Quantum mechanics is another fundamental theory, but gravity cannot be combined with it in a consistent way. The biggest problematic issues in QM itself are connected with complex systems, conscious systems and the quantum-mechanical description of the universe. One of these might reveal some new features of QM. The revolution in QM may also come from the study of the relations between the kinematical models (quantum field theory) and dynamical models (standard model) of particle physics.

There are strong clues that all physical phenomena may be presented (on a fundamental level) with one single theory. The question concerning this is naturally whether there is freedom in choosing the theory and if so, what kind of degrees of freedom exist and what kind of physical worlds one gets.

Issues in particle physics

There are several open questions in particle physics. Some of these will get experimental answers when the LHC begins to function. The apparent question is to be able to predict the values of the free parameters (masses, coupling constants) in the standard model. The unified theories should also give information on the cosmologically interesting questions of proton stability and baryon-antibaryon asymmetry. The possibility of supersymmetry at least in a reasonable energy region should be explored with the LHC. The mechanism breaking supersymmetry might also be a new one and have analogies in, for example, condensed matter physics.

Even though the Lagrangian of QCD was presented 30 years ago, there are still some unsolved questions. The mass pattern of light hadrons hasn't been solved analytically. Lattice simulations give reasonable results, but an analytical solution would open the way to a deeper study of hadron physics.

The last major questions in particle physics concern the role of fundamental constituents of matter. Are they strings, and what kind of string theory is the correct one? How many dimensions will there be in space-time? How are the extra dimensions compactified? How can we get experimental evidence of string theory? All of these questions will surely not be answered in 25 years, but progress in these questions will be useful.

Issues in biophysics

The field of physics that will grow most in the next 25 years will undoubtedly be biophysics. The main question will be whether physicists studying biology will be able to create a field of theoretical biology. The theoretical study of biological systems involves many scales and thus might need totally new kinds of mathematical methods. Some help might come from the study of complex systems (chaotic systems) and recognising important features in such systems. Their study with computers has become possible during the last decade and will go on.

There are two special themes that have interesting questions for physics.

The first is the genome and the second is consciousness. Will physics be able to solve the gap between the genome and organs? Will it be possible to make a genome and predict what kind of an organism it will be? Will we be able to give quantitative predictions on evolution? These are questions that seem quite odd now, but a lot can happen in 25 years. The problems in consciousness seem very challenging. Where is the limit between consciousness and non-consciousness? What is the mechanism of consciousness? Can we measure it? Could we make a machine that is conscious?

Applications of physics

The most important new applications in physics will most probably be the inventions of material physicists and nanoscientists. The questions that will mostly affect all physics will be the study to develop superconducting or ferromagnetic materials at high temperatures. Another possibility of new materials (though not as applicable) are possible new states of matter. Examples of these in the past are quantum-Hall states and Bose-Einstein condensation.

Two other challenges are in computation. The development of a reasonably functioning quantum computer is a hard task. Producing both hardware and software requires a lot of research in the next 25 years. It's not clear that quantum decoherence can be eliminated so perfectly that a computer with, say, 10000 qubits would be possible.

The development of computational physics has been very rapid. This will give rise to several questions in itself. How should the training of a physicist be changed when most of the cutting-edge research will be simulations on a computer? Will analytical methods be needed? Could we make a computer which could be a creative theoretical physicist? How could we train such a computer to become even better? There are a lot more questions on this field than answers.

Philosophical issues

These questions are not physical in the traditional sense, but should be thought by the community of physicists. The first one is "Balkanisation": How can one recognize a physicist in the future? Will there be new subfields in physics that differ so that they cannot be considered as physics? Also the role of theoretical physics can change a lot. During the last 20 years theoretical physicists have been ahead of their experimental colleagues in a few fields. How independent will theoretical physics be in the future? Shall it become a field of mathematics or something similar? The question of reductionism is somewhat similar: Can (theoretical particle) physics be an explanation for all phenomena in nature? The questions concerning consciousness and physics are related to this.

The last two questions are not so philosophical nor physical. They face the realities of the world. First of all: What happens when the costs of cutting-edge experiments approach infinity? Or the experimental apparatus becomes for example too big to construct? How to satisfy our natural curiosity towards fundamental questions? The last question was the only one, that Gross answered himself. The question was, whether physics will continue to be important. The answer should be obvious to you, too. Naturally: Yes, it will.

Harri Waltari
University of Helsinki

Minerva's Miscellanea

Letter of introduction

With this issue , I would like to introduce a knew concept in JIAPS. It is called *Minerva's Miscellanea* after the Roman goddess of knowledge, and is meant as a place fro all of you to be able to drop a line. It can be anything from a cool homepage or a nice piece of software to the greatest gadget ever created, the only requirement is that it is somewhat related to physics and could prove interesting (maybe even useful) to other physics students. Besides from that, there are no rules. All additions should be sent to me at **communication@iaps.info**.

Since I have hatched this idea, it would only be fair if I wrote the first lines.

Philip R. Jarnhus
Director of Communication

Free is not always bad – Being a Linux-user, I have come to realize that it does not have to cost a lot of money, to do great computational physics. The program I use is Octave. It is similar to MatLab from MathWorks (it has in fact the exact same commands). It is free and comes in a Linux-version, which can be downloaded from **http://www.octave.org**. (If you are new to MatLab/Octave, a short introduction can be downloaded at **http://www.fys.sdu.dk/fysik88/matlabintro.pdf**)

What we never knew about Britney – I must say I quite surprised when I came across this website. The introduction said: "It is a little known fact, that Ms Spears is an expert in semiconductor physics". This is the beginning of a fun introduction to semiconductor physics, that is a laugh to read for the expert as well as the rookie. It can be found at **http://britneyspears.ac/lasers.htm**. She also does one on Transfer Matrices (**http://britneyspears.ac/physics/transmtx/transfermtx.htm**). The pages are made by a group of graduates from the University of Essex. Enjoy!

The creature comes to life – This is more of a request. Please help us keep this idea alive and submit your own notes to this. It can be silly or serious, but share your knowledge.

IAPS-intern

How about a summer job in France? This summer we are offering an IAPS student internship at the European Physical Society in Mulhouse, France. You can choose to work from 2 to 3 months and possible task will be updating IAPS website, working in EPS Publishing and help organizing the EPS-13 conference, depending on the candidate. A complete job advertisement will be available on our webpage www.iaps.info.
If you have questions send an email to **iaps@iaps.info**.

Excursion to Germany

Join the IAPS science tour through Germany! We're going to travel from Munich to Cologne, with lots of interesting stops on the way: see a fusion reactor at Max Planc Institut for Plasma Physics, learn how physicists can make a difference at the European Molecular Biology Laboratory, visit the European Space Association Astronaut Centre and much more. And of course, there will be parties and sight-seeing...
Most likely the dates will be from the 21st to 29th of May. For more information and program visit our webpage:
http://www.iaps.info/activities/germany.php

ICPS

The preregistrat
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http://www.ia

Regional meeting in Budapest

Dear Physicists,

The Hungarian Association of Physics Students (MAFIHE) organises a Regional Meeting in Budapest, 21th-25th April 2005. All physics students of the seven neighbouring countries (Austria, Slovakia, Ukraine, Romania, Serbia and Montenegro, Croatia and Slovenia) and Poland, the Czech Republic and Italy are invited!
We don't intend to organise a “mini-ICPS”, we would like to deal with a certain field of physics, optics, and organise lectures held by great Hungarian physicists, like Gábor Szabó . We will also make a wonderful excursion to Visegrád and Esztergom, to the Danube Bend. A great atmosphere and of course big parties are guaranteed... This is a great chance to get to know Hungarian culture, Budapest and to see each other again, or making new friends!
Don't hesitate to apply, we will accept ~ 50 applications! Detailed program and costs to come up soon on our webpage at **www.mafihe.hu/eltehb** (we will ask for a fee of approx. 20-30 euros, depending on our sponsors...) Applications should contain all necessary information about you and a motivation letter why you would like to participate. Deadline 20. March 23:00.
Please send questions to **csere@mafihe.hu** and your application to your local committee or to the mentioned e-mail address.

Anikó Udvarhelyi,
exchange-organiser of MAFIHE

WYP celebrations by the Physics Association of Nigeria

This is the World Year of Physics and our committees are planning events all over the world. Here is the program for Nigeria:

1.Young Physicist Olympiad planned for secondary school pupils to 11--18 years.The event is a three day event sheduled from March 1st to 3rd,2005 in Ibadan,Nigeria.The participants will be drawn from 35 Secondary schools.The event is to motivate and arouse Young children to study Physics.

2.Einstern Year Conference.June 7th to 9th,2005,Ilorin Nigeria.

3.A public lecture aimed to sensitize the public on importance of Physics to the development of the soceity.Scheduled for March 5th,2005.

4.Exhibitions and shows.A three day event planned to hold in six major cities in the six geo-political zones of the Nigeria.The date will be determined later

5.Leadership training for Physics Students. A three day seminer sheduled to hold Oct 2nd to 4th,2005 Kano,Nigeria to celebrate Nigeria independence in the World Year of Physics.

2005

ion has opened!
nfo at
aps.info/icps/

Summerschool 2005, Hungary

The Hungarian Association of Physics Students is organising the next summershcool between 11st July and 21st of July! The summerschool will be about **quantum information**! The estimated cost will be 110EUR, which covers the accomodation, food and every program! The accomodation and the place of the lectures will be at a very nice, small village near Nagykanizsa. It's a good oppurtinity to learn and discover the untouched nature of Hungary!
The deadline of the registration is 1st May!
For more information contact with Dávid Visontai at **david@mafihe.hu**

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The Bologna process

and its implications for higher education in the UK and elsewhere

Under current EU higher education proposals, the UK faces the abolition of the integrated 4-year Masters courses (MSci, MPhys, MEng). They will be replaced by two-year Masters degrees that will become a compulsory qualification for anyone wishing to do a PhD. In effect, UK students will spend an extra year in education before qualifying for a Masters under the Bologna Process.

What is the Bologna Process?

In 1999 the higher education ministers of 29 European countries, including the UK, signed the Bologna Declaration, which seeks to harmonise higher education across the continent by creating a new European Higher Education Area (EHEA). Its purpose is to improve the quality of teaching and employability of graduates, encourage the mobility of both graduate and undergraduate students across Europe and to increase the number of overseas students in European universities.

The main change is the abolition of the current UK Masters degree system, which is not felt to be as rigorous as its European counterparts. A Masters will take two years to complete and become a mandatory requirement for starting a PhD. These changes will effectively bring to an end four year first degrees with an integrated Masters, such as the MSci, MPhys and MEng.

Why is it needed?

The Bologna Process is driven in part by a desire to forge a stronger sense of European identity by encouraging students to travel between universities or even consider a university in a different country for their first degree. This means standardising higher education across Europe so that a qualification gained in one country is recognised by the others. This has received a positive response from most universities.

Presently students across Europe experience a long first degree with course entry based on minimal selection criteria that leaves the rate of academic progress up to the individual student. As a result, many students take longer than the official time to complete their course. This is seen politically as a waste of resources. The Bologna Declaration proposes to shorten the first degree to three years so that students enter the labour market quicker. Universities, however, stress the importance of academic freedom and 'the right for students to choose their own path through the educational offerings presented to them'.

The Bologna Process also looks to increase the number of overseas students coming to European universities and challenge the US dominance of this market. The UK already attracts the second largest number of overseas students and is unique in Europe in charging them the full cost of tuition. The economic contribution made by foreign students is vital to the UK but countries such as Italy and Germany charge little or no fees out of principle. Many European universities regard overseas students as a symbol of international status. Postgraduate students are often valued for their contribution to research and because they may stay on to contribute directly to the local economy, especially in areas of skills shortages such as science and engineering.

The main objectives

i) Easily comparable degree structure across Europe to promote employability and international competitiveness.

ii) An education system based on two cycles, undergraduate and graduate, with the first undergraduate cycle lasting a minimum of three years and resulting in a qualification of a suitable standard for the European labour market. Progress to the second cycle will depend on successful completion of the first.

iii) Establishing a credit system as a means of encouraging student mobility – the European Credit Transfer System (ECTS). It may be possible to collect credits through lifelong learning provided that the university concerned recognised them.

iv) Tackling obstacles to the free movement of students across Europe.

v) European co-operation in developing comparable criteria and methodologies in education.

vi) Promoting a stronger sense of European identity.

Credit System

The European Credit Transfer System (ECTS) is designed to be a measure of the student workload rather than time spent in education. One year spent at university is worth 60 credits, so the 3+2+3 cycle of Bachelors-Masters-Doctorate would total 480 credits.

The Bologna Process specifies a limit of 180 to 240 credits, or three to four years, for a Bachelors degree, but assigning credits to Masters degrees remains more controversial. A minimum of 60 credits has been suggested (because a Masters is considered intellectually more demanding than a Bachelors), with the average number of credits varying between 90-120 ECTS units to take into account course differences in different countries. The current UK one-year Masters falls just within these limits since it entails roughly 50% more work than a normal undergraduate year; the integrated Masters course does not. There have been repeated calls for the preservation of this course in engineering subjects because it bridges the gap between Bachelors and postgraduate degrees very smoothly, but no decision has yet been made.

Consequences for the UK

The main point of concern for the UK is the position of the four-year integrated Masters degree and the recognition that a one-year Masters course will receive from the rest of Europe. There are few options for existing courses. If all first degrees are made into three-year courses there may well be a fall in the number of entrants into Masters programmes due to a lack of funding and the disincentive of paying extra tuition fees. As a Masters will be compulsory for starting a PhD, there may also be a corresponding decrease in the number of doctoral students. Re-designating four-year courses as Bachelors would be of little use as it is unlikely many students would want to undertake an extra year for no additional qualification. Therefore it is probable that UK students will spend an extra year in education before qualifying for a Masters.

The BSc course should see little or no change due to the Bologna Process since it develops physics competences (problem-solving and practical skills) better than most of the rest of Europe. The only weakness is that it does not provide as good a theoretical foundation for advanced Masters courses as some other European courses. A three-year first degree will, however, pose a significant change for most other European countries where the first degree is usually about five years long. These degrees - such as the German Diplom, Italian Laurea and the French Diplome - are widely acknowledged to provide a thorough education, especially for careers in academia and scientific research, but many students either do not complete their course or overrun their allotted time. Reducing the course time is a politically favoured move since it means graduates enter the job market quicker but concerns have been raised by academics in science and engineering disciplines about a resulting fall in academic standards.

It is risky to ignore the Bologna Process completely because all EU citizens have the right to live and work in any member country – so UK qualifications need to be recognised if domestic graduates want to remain competitive with their European counterparts. Currently, the UK's shorter Masters courses have the market advantage over other longer courses but there is a rapidly growing community of overseas students taking Masters courses in other European countries. If Britain is to persuade the rest of Europe to recognise the one-year Masters, we will need to prove that our one-year degree genuinely is as good as longer European courses and engender a proper public debate on the Bologna Process.

Malika Goonasekera

Malika is a postgraduate student at University College, London. This article was originally published in "Nexus News".

Safety in Bungee Jumping

... a physicist's perspective

Several years ago, I arrived at Oxford as an enthusiastic young undergraduate. One of the first events in freshers' week was the infamous Freshers' Fair: a chance for university clubs to recruit new blood. One club in particular caught my eye – the Oxford Stunt Factory. This group of "twisted stunt mongers" (to quote the highly respected *Loaded* magazine) offered a range of activities from abseiling to zorbing. However, the real gem in the club's crown is Bungee Jumping, a sport that many of its members pioneered.

I soon got to thinking about the physics involved in such sports and one jump in particular caught my eye, the Napalm Touchdown. This stunt involves the jumper leaping from 180ft, falling towards the ground at breakneck speed and finally touching down on the ground as the bungee rope's tension slows them to a halt. At this serene moment, a 5kg napalm simulation charge is detonated at their feet engulfing them in a huge ball of flame. How is it possible to engineer a bungee jump so accurately that this can be done without severely injuring the jumper?

The first ports of call in producing a model of the jump were Hooke's law and a classic conservation of energy calculation. It was immediately obvious that such a crude calculation could never replicate the behaviour of the system but it seemed as good a starting point as any. My first worry was that rubber (out of which most cords are made) doesn't actually obey Hooke's law but displays hysteresis. This results in a force-extension graph that looks distinctly non-linear (see top graph). A good approximation to this however is to consider the graph as two linear sections joining at a point corresponding to an extension of x_0. This change of behaviour relates to the reordering of the underlying polymeric structure during elongation. The energy stored by the cord is then easily found to be

$$\int_0^x F dx = \frac{1}{2}k_1 x_0^2 + k_1 x_0 (x - x_0) + \frac{1}{2}k_2 (x - x_0)^2$$

by calculating the area under the graph. I expected this to be only a small improvement on the original Hooke's law approach, but with a few extra corrections pertaining to the lost gravitional potential energy, I found that the model was already accurate to about 3%. This is clearly not enough to model a sucessful touchdown but it made me consider a far more fundamental question. If I can model to within 3% in a couple of hours, how do so many jumpers get it so wrong?

Every year new stories reach us of people dying during bungee jumping.

Is the sport as predictable as my model leads me to believe? The key difference between calculations for a touchdown and those for safety is not of course the model, but the data extracted from it. My model gave 97% accuracy in the mass of jumper needed to touch down safely, but this does not prove that they will make it through the jump without catastrophic equipment failure. What kind of forces are involved?

Maximum Working Loads:

Karabiners ~ 20KN
Harnesses ~ 20-30KN
Rope ~ 15KN
Chain ~ 15KN
Crane Cable ~ 400KN

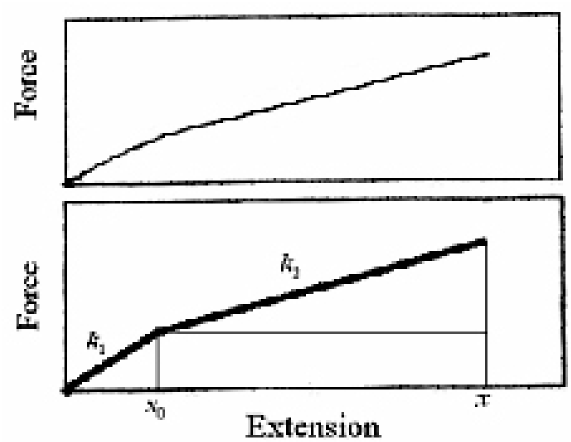
The model predicts a maximum dynamic force of around 3000N for a jumper of the maximum mass allowed on our rig. This is the amount our bungee cord itself must be capable of withstanding. Add to this the 7000N static weight of the rig itself, and a total force of 10kN must be supported by structural components of the rig.

A brief investigation of the maximum working loads of the common equipment used in the sport reveals that it is more than adequate to support the loads it experiences during a jump. So we return to our original problem, why do accidents happen when the physics is on our side?

There are two parts to the answer of this question, one of which is based in physics and the other of which is more an exercise in sociology. A small fraction of the accidents that occur are classed as unpredictable. They result from the chaotic nature of the system as a whole. The model above is restricted to one dimension for simplicity and although this captures the essence of the kinetics, it completely underestimates the dynamical side of the jump. The

jumper can swing, somersault and even tangle in the rope on the rebound, a phenomenon called wraparound. Wraparound accounts for a small number of incidents in the history of the sport and its results can be horrific (broken limbs, ripping out of hair and unconsciousness all occurring in one recent accident). However, physics again comes to our aid and helps to minimise the probability of serious wraparound injuries. The first contributing factor is the torsional stiffness of the cord. This means that it is very difficult to wrap the cord around yourself as it doesn't like to bend in such a tight loop. Other factors such as the pendulum motion of the jumper prevent the cord coming close to them on the rebound, further minimising the risk. Even when wraparound does occur it tends to unravel harmlessly on the way back down.

The real cause of injury in the sport is, more often than not, negligence on behalf of the site crew. Failure to fully check the equipment can lead to faulty components being used. This has led to a number of jumpers being injured due to catastrophic equipment failure during jumps. Another more sinister cause of injury is bungee companies using inferior methods and equipment in order to cut costs or increase turnaround time for jumpers. This drive to maximise profits led the first commercial operations to use ankle harnessing as opposed to the much safer full body harnesses, purely because they are cheaper and quicker to apply and remove from jumpers.



This lack of attention to safety was the driving force behind the formation of BERSA (the British Elastic Rope Sports Association), the regulatory body of bungee jumping in the UK. BERSA (many of whose members have been involved in the sport since its creation by Oxford's Dangerous Sports Club in 1979), were the first to set out a code of safe practice which, if followed, can help to minimise the risks of the sport by ensuring that safety is always put first. It should come as no surprise to find out that the Oxford Stunt Factory is a founder member of the association.

Hopefully you will feel a little more convinced of the safety of the sport after reading this. One unconfirmed statistic suggests that the risk of serious injury during a jump is the same as the risk during a 100 mile car journey, around one in 500,000 (and significantly lower than this if you jump with a BERSA registered club!) Even the medical profession are now admitting that the effects of bungee jumping on the body are not as severe as was once thought.[1]

So go out there and try it. I guarantee that the physics of the jump will be far from your mind as you fall for what seems like the longest and most thrilling few seconds of your life.

Andy Higginbotham

[1] *After the Fall: Symptoms in Bungee Jumpers* - **THE PHYSICIAN AND SPORTS MEDICINE** - VOL 26 - NO. 5 - MAY 98.

Andy Higginbotham is an undergraduate student at Oxford University. His talk on the Physics of Bungee Jumping won the Nexus Undergraduate Lecture Competition at the Young Physicists' Conference in 2003.

Wind turbines

Generating your own power and selling it to the national grid? The French are looking at energy sources close to home.

Wouldn't it be great if we lived in a world in which money was easier to earn than spend, physics degrees were handed out in xmas crackers and at the end of the month, when your electricity bill arrives, the power authority owed you money?

Well, if you live in France you now have an opportunity to make the latter come true. Some French citizens now receive two brown envelopes each month from the country's power generating authority, EDF (électricité de France). Whereas one details the power drawn from the national grid and consumed, the other records the energy that they have put back into the system. The latter credits the former and, in some cases, the electricity authority ends up owing you money.

The situation has arisen due to a recent change in French law that opens the power generation market to a much wider class of operators. It is now possible for a Frenchman to install solar panels, a wind turbine etc. on his property and, after having made a connection to the high tension grid, begin injecting amps into the energy network. Such a set up requires two electricity meters – one to measure the power you consume and the second that which you generate.

Even better, because the EU has set a target for member countries to receive 21% of their energy from renewable sources by 2010, EDF is obliged to buy its energy from renewable sources when they exist. So the Frenchman with the solar panel or wind turbine has a ready-made customer in the energy authority.

There is a good economic argument for turning your home into a mini power station too. A typical twenty square metre installation of solar panels costs about €8000 but a subsidy of 40% is available thanks to the same incentives to develop renewable energy resources. EDF is obliged to buy power from you at a fixed tariff and most installations are likely to recover their installation costs between 10 and 15 years.

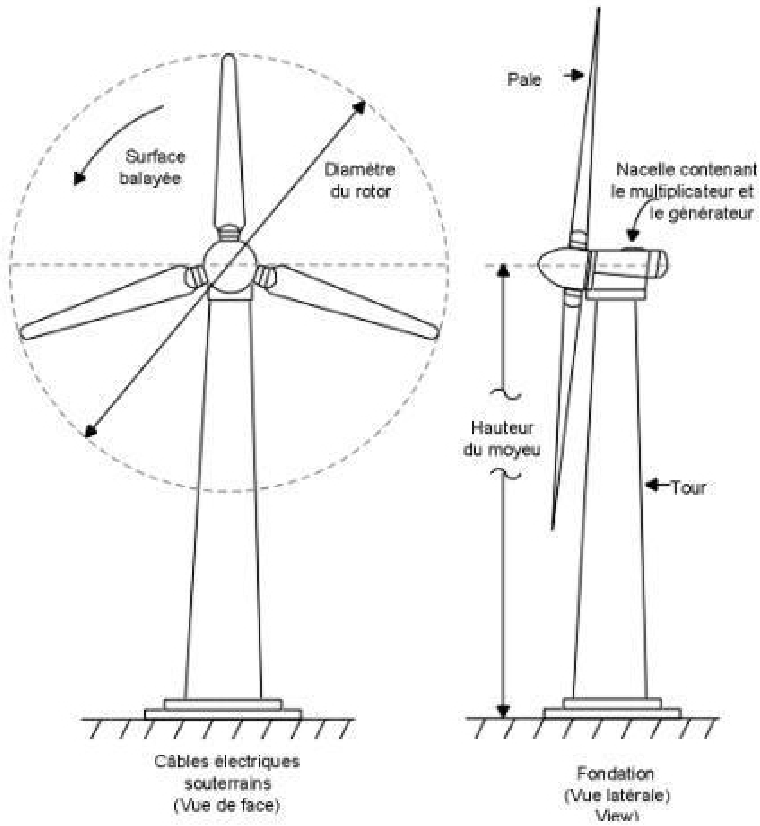
The incentive is particularly strong for owners of holiday homes. With no energy consumption when not in use, a holiday chalet can be earning money year round.

Wind turbines represent a more significant investment but the potential appearance of a new market of small-scale home producers has encouraged one company, Krug Wind, to specialise in small turbines for home energy production. Installation can be completed within a day and the timescales for recovering your investment become similar to those of solar panels.

There is a hitch however: 1,500 Frenchmen rushed their applications to EDF in June 2004 alone and this has created a backlog and delays of several months. Worse still, many customers complain that EDF has made the application process very bureaucratic with numerous visits from different agents required to validate and certify your home power station. It has been suggested that EDF are making the process deliberately difficult as it is much more costly and complicated for them to work with a greater number of small suppliers.

It may be a while before the lawns of France and the fields of Provence are scattered with windmills but maybe the new law might have the desirable side-effect of causing us to give a little more thought to our planet's scant resources and direct ways that we can get involved to actively use renewable energy sources.

Kevin Crampton



Wind Turbine Schematic in French

Bibliography

1) "Science & Vie", August 2004, P79-83: "Faites d'EDF votre débiteur"

2) **http://www.krugwind.com**: Website and discussion forum for home-based wind turbines

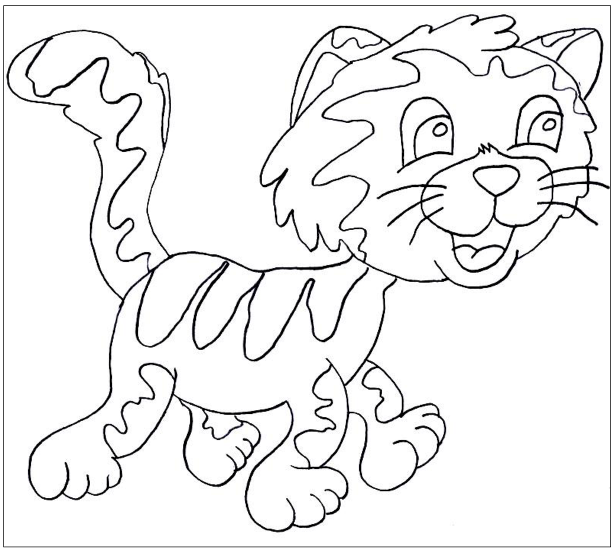
3) **http://www.edf.fr**: Official web site of EDF

Measuring up Schrödinger's cat

Investigating the question of "how big?"

Classical wisdom has it that a cat has nine lives. However, if you look at the number of cat lifespanssince Erwin Schrödinger proposed his particular specimen of the species in 1935 (in ref. [1]), and multiplythat by the number of times the infamous radioactive atom in the box must have decayed and killed the poor kitty since then, nine starts to look like a very modest number.

2005 is not only the centenary for Einstein's annus mirabilis, it is also the 70th anniversary of the mostfamous cat in science. Despite its age, the septuagenarian cat seems to be even more alive and purringtoday than ever before. Nowadays it is also increasingly making its presence felt in the lab and not just on the blackboard. To date some experiments demonstrating real Schrödinger cats, where at least semimacroscopic systems have been put into quantum superposition states, have been carried out, and more seem to be on the way, so that it might seem that the kitten is finally "growing up" into a real adult-sized macroscopic tomcat. But there are still lingering questions about how large these Schrödinger cats really are. In this article, I will review some of the questions the old cat poses to modern physicists, argue why it is interesting to try to produce real macroscopic cat states, and finally give some insights into the debate over whether such states really have been produced and why the question is not as easy to settle as you might think.



Bigger and Bigger ...

For microscopic systems, Schrödinger cat-states have already been realised in a large number of experiments with cold atoms, photons, electrons, neutrons, high-energy particles, you name it, going all the way back to the original double-slit experiments with single electrons, where electrons were made to be in a superposition state of going through one slit and another slit. Macroscopic systems, like Schrödinger's original cat itself, are of course much more difficult to put into quantum superposition states, but serious progress has been made in the last decade. In 1999 people in Anton Zeilinger's group at the University of Vienna managed to perform the double-slit experiment with C60 Bucky-ball molecules ([2]), which although hardly macroscopic are still several orders of magnitude bigger and heavier than the electrons or neutrons usually used in this kind of experiment. In 2001 people in Eugene Polzik's group at the University of Aarhus further managed to put a system consisting of two clouds of around 10^{12} caesium atoms in a superposition of different spin states ([3]). And in 2000 two groups at the State University of New York at Stony Brook ([4]) and at the Delft University of Technology ([5]) both performed perhaps the most convincing macroscopic cat-state experiments to date, by putting superconducting loops broken by Josephson junctions in a state which was essentially a superposition of a more or less macroscopic current going one way and the other way around the loop.

Although none of these experiments involve anything as huge as a live animal, they seem to demonstrate that more or less macroscopic systems can in fact exist in quantum superposition states akin to the infamous cat. Physics, both experimental and theoretical, is unfortunately still a field dominated by men, and maybe it should therefore come as no surprise that the question of "how big is yours?" was raised in connection with these experimental Schrödinger cats. However, to answer this question, you need to define some measure of size for Schrödinger cat-like superpositions, and it turns out that this is not quite as straight-forward as just measuring lengths, volumes or masses. But before explaining why, I will make a small detour (well, not so small actually) to review what the cat and its much-touted paradox is really about.

Schrödinger's original cat was in part an attempt to highlight the apparent ridiculousness of quantum mechanics when applied to macroscopic objects, but also pointed out that applying quantum mechanics to microscopic objects would inevitably have consequences for macroscopic objects as well, and this seemingly created a paradox that has perplexed both physicists and laypeople ever since (perhaps even more than it should have).

The Story So Far ...

The standard tale of Schrödinger's unfortunate feline goes as follows: A cat is trapped in a box together with a sadistical device consisting of a small amount of radioactive material (for simplicity let us say just a single radioactive nucleus), a sealed flask of highly toxic hydrocyanic acid and a Geiger counter connected to an apparatus which releases a hammer and breaks the flask if the Geiger counter registers a radioactive decay. So at any given moment, if the nucleus has not decayed the flask should be whole and the cat should be alive and well, but if it has the flask will have spilt its toxic contents and killed the cat. The problem now is that if no observer has looked at the contents of the box, quantum mechanics mandates that one cannot say that the radioactive nucleus really has or has not decayed. Instead the quantum state |_i of the nucleus must be described by a quantum superposition state. If we look at a time at which the nucleus will have decayed with exactly 1/2 probability, this superposition will have the form:

|_i =
1
p2 _|_1i + ei_ |_2i_ (1)

where |_1i denotes the state in which the nucleus definitely has not decayed and |_2i the state in which it definitely has (in fact this is somewhat simplified, since in general the state |_2i will need to include the state of _-, _- or -particles or other radiated decay products, but if we make the crucial assumption that these products do not escape from the box and cannot *even in principle* be detected by someone outside the box, this complication will not affect any of our conclusions). The factor of 1/p2 is a conventional normalisation factor and _ is a relative phase (this phase is important, more about this later). Since the state of the cat (denoted by |alivei and |deadi) depends on the state of the nucleus, the state | i of the total system consisting of nucleus + cat should be written as

| i =
1
p2 _|_1i |alivei + ei_ |_2i |deadi_
(2)

which implies that the cat cannot be said to be definitely either dead or alive, but seems to exist in some limbo-like superposition state untill somebody opens the box and lets it know whether to die or not.

What's the Problem?

Several questions and popular paradoxes (which are not necessarily all that paradoxical given some thought) stem from this tall tale. The most obvious question that any layperson who encounters this story might ask (not always receiving a very good answer) is what the paradox here is. How is this different from just not knowing whether the cat is dead or alive, and why do we insist that the cat cannot be said to be definitely either alive or dead, rather than just saying that the cat is alive with some probability and dead with some probability? The crucial difference is that describing the cat and the nucleus in terms of a pure superposition state of the form in eq. (2) requires that there does not exist any independent information outside the cat-nucleus system itself that could be used to determine whether the cat is dead or alive. In other words, the cat and the nucleus in the box must not have interacted with the outside world in any way that could allow us even in principle to decide what the state of the cat is by looking at clues outside the boksz and without opening the box and making a measurement of the cat itself (for example if the cat falling down dead made a thump and some of this sound escaped out of the box, or if the radiation from the decaying nucleus escaped from the box, then in principle we could detect these soundwaves or decay products and use them to conclude that the cat had died).

If the cat did indeed interact with the outside world and gave away some clue to its state, then if we wanted to keep describing the cat by a pure superposition state, we would have to include the resulting state of the environment in this state, and as the information about the state of the cat spread further and further out, we would end up with an ever more entangled total state, encompassing a larger and larger part of the universe outside the box (unless we detected some of this escaping information ourselves, in which case the whole state would collapse into one in which the cat either definitely is or is not alive). If we do not want to keep track of this ever-expanding wave of quantum correlations, and have not already detected the escaping information, then we would have to describe the cat in terms of a *classical* probability distribution; the cat is definitely dead or alive with some given probabilities, and there is an independent record of this in the world outside the box that we just haven't bothered to check yet. So the main difference between classical probability distributions and pure quantum states like the cat state is that in the case of classical probability distributions we are ignoring some independent information about the system that we could in principle have obtained, while in the case of a pure quantum state we know everything that we could even in principle have known about the system (what is novel about quantum mechanics then is that even when we know everything we in principle could know about a system, there are still questions about the system that we cannot answer, such as whether the cat will be dead or alive if we observe it).

This "complete knowledge" is reflected in the presence of the relative phase factor _. Generally the system in the cat state will have other properties than just being "dead" or "alive" which we can know something about, but which we cannot know precisely at the same time as knowing whether the cat is dead or alive (like we cannot have perfect knowledge of both position and momentum for a particle at the same time). In other words, the phase _ carries information about some observable which is "complementary" to the life- or death-state of the cat (i.e. corresponding to a Hermitian operator which does not commute with the "life/death-operator"), and is determined by how the superposition state was prepared. In the experimentally realised cat-states mentioned above, it is usually connected with the energy or momentum of the system. Most importantly, the existence of the phase , along with the standard rules of quantum mechanics, implies that it should be possible to observe interference effects or other testable consequences of the superposition state which are incompatible with a description in which the cat is definitely alive or dead with some classical probabilities (although the larger the system is, the more difficult it will in general be to observe these consequences and distinguish the quantum superposition from a classical probability distribution). This then is the fairly long-winded answer to how the two descriptions of the state of the cat differ in practical terms.

How does the consciousness of the cat affect the problem? What about decoherence? And how big is "big" anyway? Find out in the next issue of JIAPS ...

Jan Ivar Korsbakken

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USA

References

[1] E. Schrödinger, Naturwissenschaften **23**, 807 (1935)

[2] M. Arndt et al., Nature **401**, 680 (1999)

[3] B. Julsgaard, A. Kozhekin, E. Polzik, Nature **413**, 400 (2001)

[4] J. R. Friedman et al., Nature **406**, 43 (2000)

[5] C. H. van der Wal et al., Science **290**, 773 (2000)

[6] D. M. Greenberger, M. A. Horne, A. Shimony, A. Zeilinger, Am. J. Phys. **58**, 1131 (1990)

[7] W. Dür, C. Simon, J. I. Cirac, Phys. Rev. Lett. **89**, 210402 (2002)

[8] A. Nemes Salgueiro, quant-ph/0402190 (2004)

[9] A. J. Leggett, J. Phys.: Condens. Matter **14**, R415 (2002)

[10] A. J. Leggett, Physica Scripta **T102**, 69 (2002)

[11] A. J. Leggett, J. Supercond. **12**, 683 (1999)

Diving Physics and Liquid Ventilation

Each year there are more and more new certified divers, and this sport is about to become more popular. Parallel to this, it is essential that divers are confident with the physical laws concerning this subject, concerning the problems of pressure and the human body, but this topic can be interesting for non-divers as well. The main questions are: what is happening with our body while it is exposed to pressure, how is it possible to dive 100 or even 300 metres deep…?

In the first part I would like to go through the basic physical laws. Firstly, with every 10 metres of depth the ambient pressure increases by an additional 1 atm. This means that the snorkel, the long tube going to the surface for breathing, has got a maximal length: since the muscles to expand and contract the lungs during breathing are not strong enough the maximal snorkel-height was set at 60 cm. But since the difference of the ambient pressure 60cm deep and the atmospheric pressure coming through the snorkel is 0.06 bar which is already a figure that could tear the lungs, it is forbidden even to use 60cm long snorkels.

Concerning the compressibility of gases and fluids, the simple formula

$$\frac{\Delta V}{V} = -\kappa \Delta p$$

describes the behaviour, where k is for water and for an ideal gas. To compare: In the case of water the volume shrinks by only 0,5% at 100bar pressure-difference, so we could easily dive even 1000 metres deep if we didn't have any gas-filled organs. The huge difference between the compressibility-features of gases and fluids is the key to the diving problem. There are two main possible ways of getting under water: the first is the atmospheric pressure diving where eg. a submersible protects the diver's body from the ambient pressure. The second is the ambient pressure diving where the body is directly exposed to the ambient pressure and the dive is only possible by choosing a suitable gas-mixture to inhale.

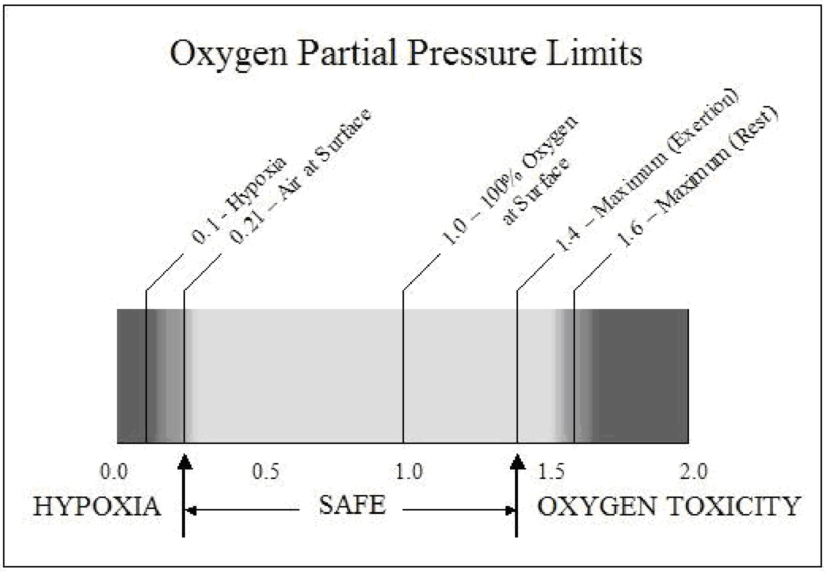

Figure 1

Our task now is to find a proper gas-mixture for a given depth we want to reach. We have to take into consideration Dalton's Law:

$$p = \sum_i p_i$$

which states that the total pressure exerted by a mixture of gases is the sum of the partial pressures that would be exerted by each gas as if it alone occupied the total volume.

And secondly Henry's law:

$$c_i = \frac{p_i}{H}$$

which means that in a fluid at a given temperature the amount of dissolved gas (*c*, concentration) is directly proportional (constant H) to the partial pressure of the gas. Hence, the higher the partial pressure, the higher the dissolved concentration of the gas in the blood.

The most important gas to deal with is probably nitrogen. It is an inert gas but it dissolves in the blood according to Henry's Law. Dissolved nitrogen's effect on the human body can be roughly compared with drinking Martini; every 15 m depths is equivalent to drinking one glass of Martini. This is called nitrogen-narcosis; the more and more dissolved amount of nitrogen in the blood affects the brain. However, it isn't this disease which causes the most problems. While ascending too rapidly, the biologically inert dissolved gas, nitrogen, comes out of solution as bubbles due to the reduction of the ambient pressure. These bubbles can be very harmful. If bubble-formation occurs in the vascular system because of the rupture of the alveoli, then it is the cause of arterial gas embolism. Air is being forced trough ruptured alveoli and air bubbles block arteries in the brain and the heart. Both illnesses are treated by recompression with oxygen in a chamber. To avoid decompression illness divers should ascend slowly in order to give the dissolved nitrogen time to come out of the body and secondly the bottom time/the amount of dissolved nitrogen should be strictly calculated in each case.

The only essential gas that has to be mixed to every gas-mixture is of course oxygen. But even with oxygen there are certain limitations (figure 1). Too high oxygen partial pressure is toxic, the 1,5-1,6 bar limit is reached 60-70 metres deep in case of compressed-air diving. This means that with compressed air it is impossible to dive deeper than 60 metres!

To conclude, if we want to dive longer and deeper both the oxygen and the nitrogen percentage of the gas-mixture have to be reduced.

Longer but not very deep dives (maximum 40 metres) can be realised with the gas-mixture "Nitrox" which has a reduced percentage of nitrogen to allow longer bottom times with the same risks of decompression illness. The name Enriched Air Nitrox also indicates that the rest of the gas mixture is oxygen. The

Depth (m)	Bottomtime (minutes) Air	Nitrox (32% O_2)	Nitrox (36% O_2)
15	72	167	251
21	31	57	76
27	18	30	38
33	12	19	24
39	9	14	–

Table 1

table 1 compares two types of Nitrox, one with 32%, the other with 36% oxygen. We can see that especially for shallow dives these mixtures allow very long dives (15 metres deep 251 minutes with EAN36 in contrast to only 72 minutes with compressed air).

One solution for deeper dives is helium which is an inert gas as well but doesn't cause narcosis like nitrogen. The other advantage of He is that it is less dense at 90 metres than N_2 is at sea level. On the other hand it has also serious disadvantages. As He is a small molecule it dissolves into blood and tissues much faster than nitrogen does. Therefore, the decompression-times are much longer.

So how is it possible to reach a hundred metres depth? The gas-mixture called "Trimix" is made out of oxygen, nitrogen and of a high percentage of helium. As table 2 shows with the suitable mixing of these three gases it is possible. One can even reach 600 metres and not exceed the 1.4bar partial oxygen pressure if a mixture containing only 2% of oxygen is used!

No matter what kind of special gas mixtures we use, much greater depths are impossible to achieve. However, liquid-ventilation could be a solution since there wouldn't be any compressibility-problems; in the film Abyss there were divers who applied this technique. Liquid-ventilation, however, is not anymore present only in films, it has become reality. What we need is a special fluid, perfluorocarbon (PFC) which is colourless, and insoluble in water and lipids. An essential requirement is that it has to be able to dissolve enough oxygen. The perfluorocarbons are similar to hydrocarbons with the hydrogen replaced by fluorine. There are already perfluorocarbons in which there can be 20 times more O_2 and 3 times more CO_2 dissolved than in water. Liquid-ventilation experiments have started in the 1960s on mice and today Liquid-ventilation is also performed in humans. There are two main forms of it: during Total Liquid Ventilation (TLV) the lungs are filled with the substance and a liquid ventilator makes the patient breathe PFC. During Partial Liquid Ventilation (PLV) one performs gas ventilation of the PFC-filled lungs using a gas mechanical ventilator. PLV-experiments on patients with severe respiratory failure show that there have been improvements in gas exchange. The adverse effects were self-limited, transient and manageable.

Could even divers profit from this technique one day? At the moment it seems unlikely, since the muscles are not strong enough to breathe a dense substance like a fluid without any ventilator. If scuba divers obey the rules and are aware of the risks of compressed gas diving, diving is easily enjoyable between the limits. But who knows what the future will bring?

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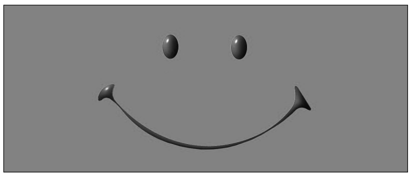
This article is based on a talk given at ICPS 2004.

Depth (m)	Mixture O_2 (%)	He (%)	N_2 (%)
50	23	33	44
60	20	43	37
70	17	50	33
80	15	56	29
90	14	60	26
100	13	64	23
110	12	67	21
120	11	69	20
130	10	71	19
140	9	73	17

Table 2



The Physicist's Bill of Rights

(Author Unknown)

We hold these postulates to be intuitively obvious, that all physicists are born equal, to a first approximation, and are endowed by their creator with certain discrete privileges, among them a mean rest life, n degrees of freedom, and the following rights which are invariant under all linear transformations:

1. To approximate all problems to ideal cases.

2. To use order of magnitude calculations whenever deemed necessary (i.e. whenever one can get away with it).

3. To use the rigorous method of "squinting" for solving problems more complex than the addition of positive real integers.

4. To dismiss all functions which diverge as "nasty" and "unphysical."

5. To invoke the uncertainty principle when confronted by confused mathematicians, chemists, engineers, psychologists, dramatists, and other lower scientists.

6. When pressed by non-physicists for an explanation of (4) to mumble in a sneering tone of voice something about physically naive mathematicians.

7. To equate two sides of an equation which are dimensionally inconsistent, with a suitable comment to the effect of, "Well, we are interested in the order of magnitude anyway."

8. To the extensive use of "bastard notations" where conventional mathematics will not work.

9. To invent fictitious forces to delude the general public.

10. To justify shaky reasoning on the basis that it gives the right answer.

11. To cleverly choose convenient initial conditions, using the principle of general triviality.

12. To use plausible arguments in place of proofs, and thenceforth refer to these arguments as proofs.

13. To take on faith any principle which seems right but cannot be proved.