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{jIAPS}

the journal of the international association of physics students

ICPS 2008: Krakow

ICPS 2008

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What is jIAPS?
jIAPS is the journal of the International Association of Physics Students (IAPS). IAPS is an international, non-political, non-governmental, non-profit-making, student-run educational association. It comprises students and recent graduates who are interested in physics (hereafter physics students). Its aims are to encourage physics students in their academic and professional work in an international context, to promote peaceful relations among physics students around the world and to expose them to the international community, help them to build professional relations and foster a collaborative attitude amongst young physicists across the globe.

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What's in this issue?

REGULARS

FEATURES

A few words from...

the IAPS Executive Committee

2007-2008 has been a busy year for IAPS. While the regulations committee has been hard at work setting out guidelines to make life easier for future ECs, some great events have taken place.

The IAPS trip to ESTEC and TNO in the Netherlands was a resounding success. Participants viewed the Herschel and GOCE spacecraft as well as some interesting research areas and had time to explore Amsterdam. APSKNU (LC Kyiv) invited IAPS members to attend the International Young Scientists' Conference on Applied Physics, which took place in June. The IAPS/MAFIHE (NC Hungary) summer school followed shortly in July, on the topic of nanophysics.

The IAPS website has been moved to a new host and redesigned, bringing back the original logo. Members should find it easy to locate the information they need while future EC members should have no trouble in keeping the site updated.

In your hands you hold a compilation of some of the articles from the two jIAPS issues published online this year. These issues included interviews with Nobel Laureate Gerard t'Hooft and astronomer Sir Patrick Moore, opinion pieces and many interesting science articles, all written by IAPS members. Not everything is available in the printed copy so be sure to look up the rest.

Looking to next year, the EC has begun investigating the possibility of a collaboration with the International Union of Pure and Applied Physics, with the aim of getting in touch with physics students in countries where we do not currently have members and perhaps of helping IAPS members in future. In the meantime, we are delighted to have made contact with students from Brazil and Peru, some of whom should be attending this ICPS.

Some of you may be attending SNEF, a physics conference run by our new friends from Peru, shortly after ICPS. IAPS members have also been invited to apply for the International Student Conference in Japan. In addition to these events, numerous ideas have been discussed for next year and beyond. Possibilities include a tour of renewable energy facilities in Portugal, a trip to CERN, ESRF and ILL, a visit to science facilities in Armenia and a nuclear power and ethics conference, with trip to Chernobyl, in the Ukraine. None of these things are definite yet and we're open to ideas, if you can think of an event IAPS should run or a way we can improve we'd love to hear from you.

None of the above would have been possible without the hard work of many volunteers. The EC would like to thank the regulations committee, jIAPS editors and authors and event organisers, including of course ICPS. We need people to continue with these tasks and many more, so if you are interested in helping out with anything mentioned here or with a new idea, please get in touch. You can stand for the EC or volunteer to run events, contribute to jIAPS or help out in many other ways. IAPS is your organisation, so make your suggestions, tell us your opinions and, if you have the time and the enthusiasm IAPS needs, work with us to make next year even better.

We hope you enjoy the XXIII International Conference of Physics Students and all that Krakow has to offer, and would very much like to see you all at future IAPS events.

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the Editors

Welcome to the ICPS issue of jIAPS. Within these pages are some of the best articles published in the journal over the last year. It was a tough choice deciding which to include, so be sure to take a look at the back issues online at iaps.info/jiaps to see what else almost made it.

Euan Monaghan & Danielle Wills

In brief

Sao Paulo's private 'ozone layer'

ALL BIG CITIES HAVE air pollution problems. For nearly twenty-million-inhabitants of Greater Sao Paulo, in Brazil, tropospheric ozone and particulate matter are the bad guys. But it's a good thing we have urban parks and leisure areas with "cleaner" air for exercise, right? Surprisingly, it's not quite true. Sometimes, even the other way around. In the biggest city of the Southern Hemisphere, ozone concentration levels inside urban parks and other leisure areas, such as the everyday football pitch, have been reported to be higher than in the car-filled avenues. To make matters worse, they seem to be even higher during weekends.

Ozone is good in the stratosphere, we know that, but at surface level it is highly toxic. It is formed by reactions in the atmosphere that include other pollutants emitted from fossil fuel combustion. These reactions are triggered by solar shortwave radiation. Ozone can also be destroyed by the same kind of compounds, especially in the absence of such radiation. In areas packed with cars it is formed but readily removed from the atmosphere, and doesn't accumulate much. But it seems that when ozone is formed in the avenues, before being consumed it is carried away by the winds. This means that it can reach higher concentration levels in areas with less or no cars. Normally, tropospheric ozone levels are low in the morning, but as cars fill the streets and sunlight hits harder, it stacks up, and by early afternoon it reaches its peak. It then decreases with the lowering sunlight and is consumed by pollutants emitted during the rush hour.

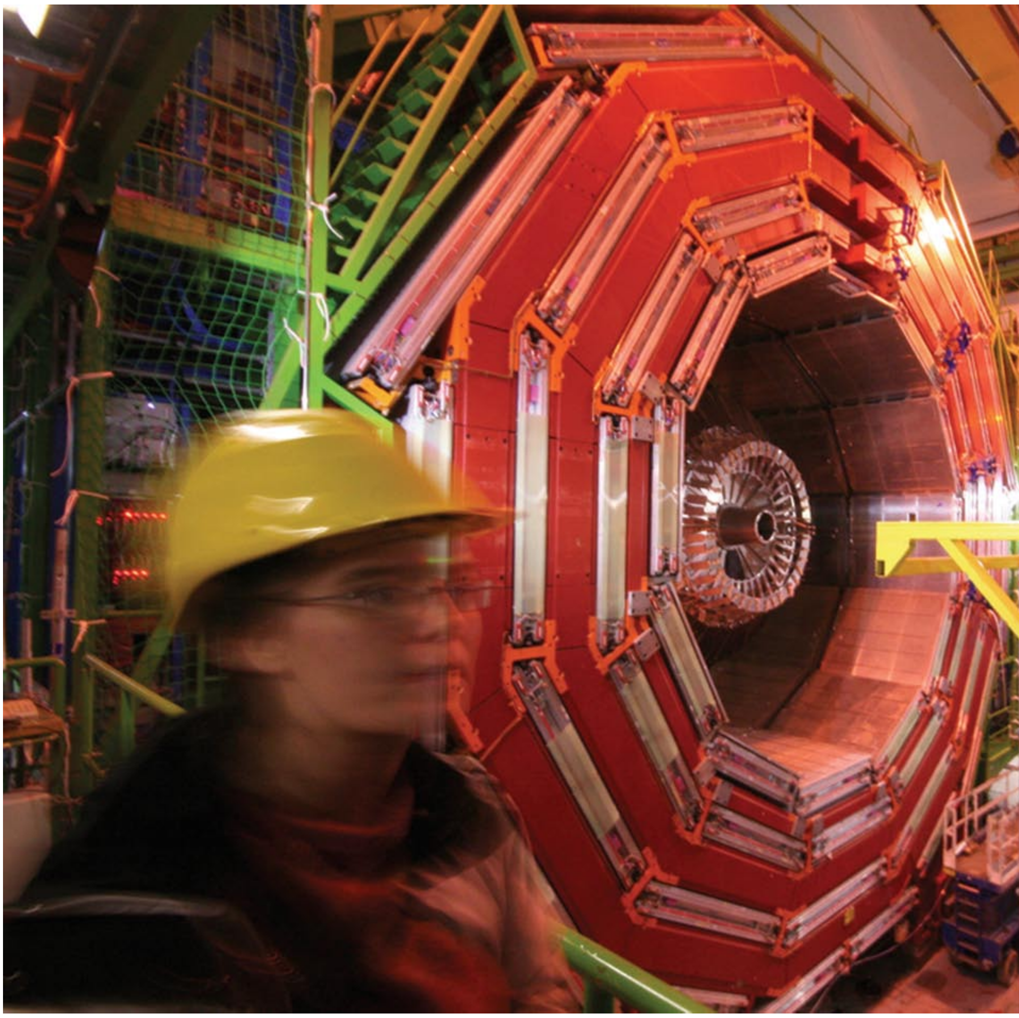
It seems that local variations in atmospheric composition are an important ingredient in this rather ironic picture. But the funny thing is, direct emission levels from car exhausts are decreasing in the city due to improved technology, resulting in cleaner air to breathe in the avenues. Despite this, ozone levels haven't decreased at all. In city parks near the urban centre, vehicular pollution is low, and so, depending on air circulation patterns, ozone can accumulate, especially when convergent air circulation takes place. Greater amounts of sunlight in those often open-air areas can also be blamed. Scientists are still figuring out how to deal with this and the so-called "weekend effect".

So, make sure you check your city's air quality management information before going out jogging in the park. Especially during a sunny Sunday afternoon.

"Ozone is good in the stratosphere, we know that, but at surface level it is highly toxic"

Júlio Barboza Chiquetto

Why the LHC will (almost certainly) not destroy the world



THE LARGE HADRON COLLIDER (LHC) looks like a Bond villain's lair come to life. The gigantic machine lies in a tunnel hundreds of meters under the border between Switzerland and France, forming a circle some 27 km in circumference. In order to look deeper into the fundamental building blocks of the universe, the scientists at the CERN facility will smash together beams of protons at energies approaching 7 TeV. This makes the LHC the most powerful particle accelerator in the world, so it's little wonder that there are some who are critical about its operation. They mostly seem concerned about black holes.

In nature, black holes are created when large stars collapse in on themselves, and even those same scientists at CERN don't discount the possibility that such a singularity would form. However, according to a recent report into the safety of the accelerator, "if microscopic black holes were to be singly produced by colliding the quarks and gluons inside protons, they would also be able to decay into the same types of particles that produced them".

So that's okay then.

Unsung hero: Thomas Young

LAST YEAR A BIOGRAPHY called 'The Last Man Who Knew Everything' hit bookshop shelves. The title was no exaggeration.

Thomas Young was born Somerset, England, in 1773, and from an early age he showed a startling aptitude for languages. By his mid-teens he had mastered Greek and Latin, and was familiar with dozens more tongues, both ancient and modern. It might seem surprising then that he trained in, and practiced medicine for most of his life – proposing the three-colour theory of retina colour detection in the eye among other things. It was in the course of discovering the cause of astigmatism in 1801 that he began to turn his attention to the general study of light. This path of discovery would lead him to make some of the most incredible contributions in the history of science.

Young's name might not have the same weight as his contemporaries like Joseph Fourier or Lord Kelvin, but glance at any physics text and he is virtually guaranteed to pop up at least a couple of times. Some of his main contributions include having the audacity to contradict Newton by proposing a wave theory of light, devising a measure of elasticity (Young's Modulus), and being responsible for the modern definition of the word 'energy'. The list goes on and on. And that's just physics.

Widely regarded as the last true polymath, Young turned his versatile mind to many fields during his 55 years. Young's Temperament is a method of tuning keyboard instruments, Young's Rule is a method for determining drug dosage for children, and the term Indo-European language? Oh, that was him. Languages were always his passion, and by 1814 he had fully deciphered and translated the Rosetta Stone, in the process revolutionising the study of Egyptian hieroglyphics.

Physics was just one of the fields that fascinated Thomas Young. In Westminster Abbey, his epitaph states that he was "a man alike eminent in almost every department of human learning".

Truly the last man who knew everything.

University spotlight: University of Leiden

Founded 1575

Number of students 16,000+

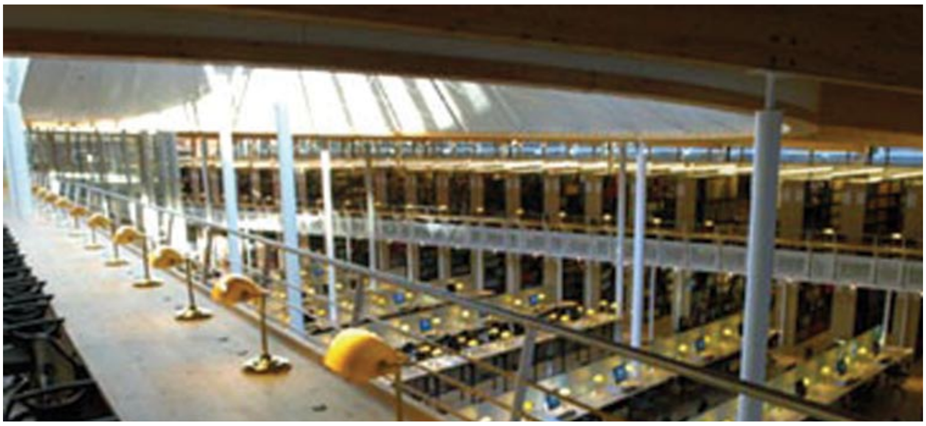
Famous for Leiden Observatory is the oldest astronomy observatory in the world, and it was in Leiden that Einstein received the great news that his theory of relativity had been confirmed.

Famous alumni Hendrik Lorentz and Pieter Zeeman, who were awarded the 1902 Nobel Prize for Physics for their discovery of the Zeeman Effect.

Motto Praesidium Libertatis (Bastion of Freedom)

Research Interests Theoretical Physics, Condensed Matter Physics, Quantum Optics and Quantum Information, Biological Physics, Molecular Nano-Optics and Spins, Astronomy and Cosmology

LEIDEN IS THE BIRTH place of Rembrandt, and home, it would appear, to the perfect Sunday morning croissant. Then for those of us students who don't partake in mornings, there are of course the late-night trains back from Amsterdam or Rotterdam, making Leiden the perfect little rabbit hole for you to bolt down when you are regretting that last coffee shop visit. That's not to say that Leiden isn't itself a bit of a party town – the many bars that line the streets are a testimony to that. Whether fresh flower and trinket markets are your thing, or shopping for hand-stitched corsets at the local goth shop, Leiden has it all. But with all this fun about who would find time for university? Well, luckily for the Leiden students, the University has produced enough world-class physicists to warrant a fair degree of lecture attendance…



The ESA astronaut selection process begins

DID YOU APPLY? The European Space Agency (ESA) began a large-scale astronaut recruitment drive earlier this year, the first for over a decade. Almost 10,000 people applied, and out of that number, 8413 provided the medical and other forms required to pass through to the first stage of the selection process. They are chasing just four vacant astronaut places.

The greatest percentage of candidates came from France (22.1%), followed by Germany (21.4%), Italy (11.0%) and the United Kingdom (9.8%). Women made up just 16% of applicants.

They now face what must be the toughest job application procedure in the world. Over the coming months the applicants will face two rounds of psychological testing, followed by a comprehensive five day medical. Only then, in late spring next year, will a final decision be made by ESA.

"We now have a large number of highly qualified applicants," said Michel Tognini, Head of the European Astronaut Centre in Germany. "I am confident that we will find the outstanding individuals we are looking for. "

For those brave few, the real test will be just beginning.

Events

Simposio Nacional de Estudiantes de Física 2008

Where?
Lima, Peru

When?
18th-22th of August 2008

The organisers of SNEF, the Peruvian national conference of physics students, have kindly offered IAPS a few free places for members who wish to present their work and take part in a physics students' conference in South America.

The conference will involve about 300 students with both guest and student lectures, posters, social activities and a tour of the local area. Lectures and posters can be presented in either English or Spanish, and translators will be available.

Places will be allocated on a first come, first served basis, after which we'll keep a waiting list in case anyone drops out. You will need to pay your own transport costs.

Places are very limited, so if you are interested in attending please sign up as soon as possible. When planning your travel, bear in mind that SNEF takes place the week after ICPS.

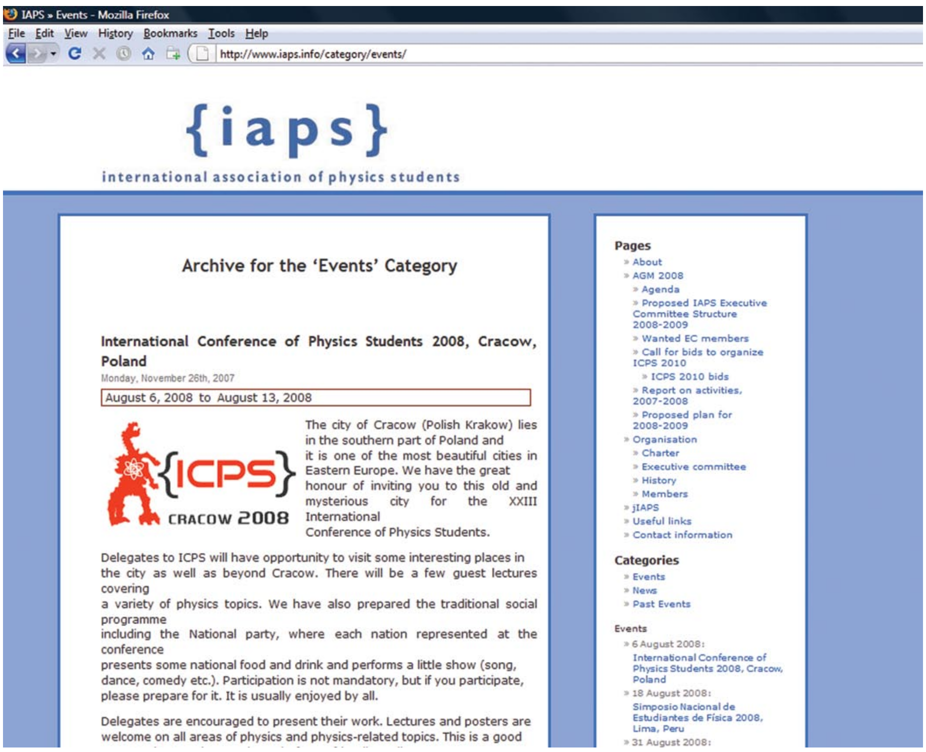
If you wish to attend, please email ec@iaps.info, and check out the SNEF website, which is linked from the IAPS homepage.

54th International Student Conference

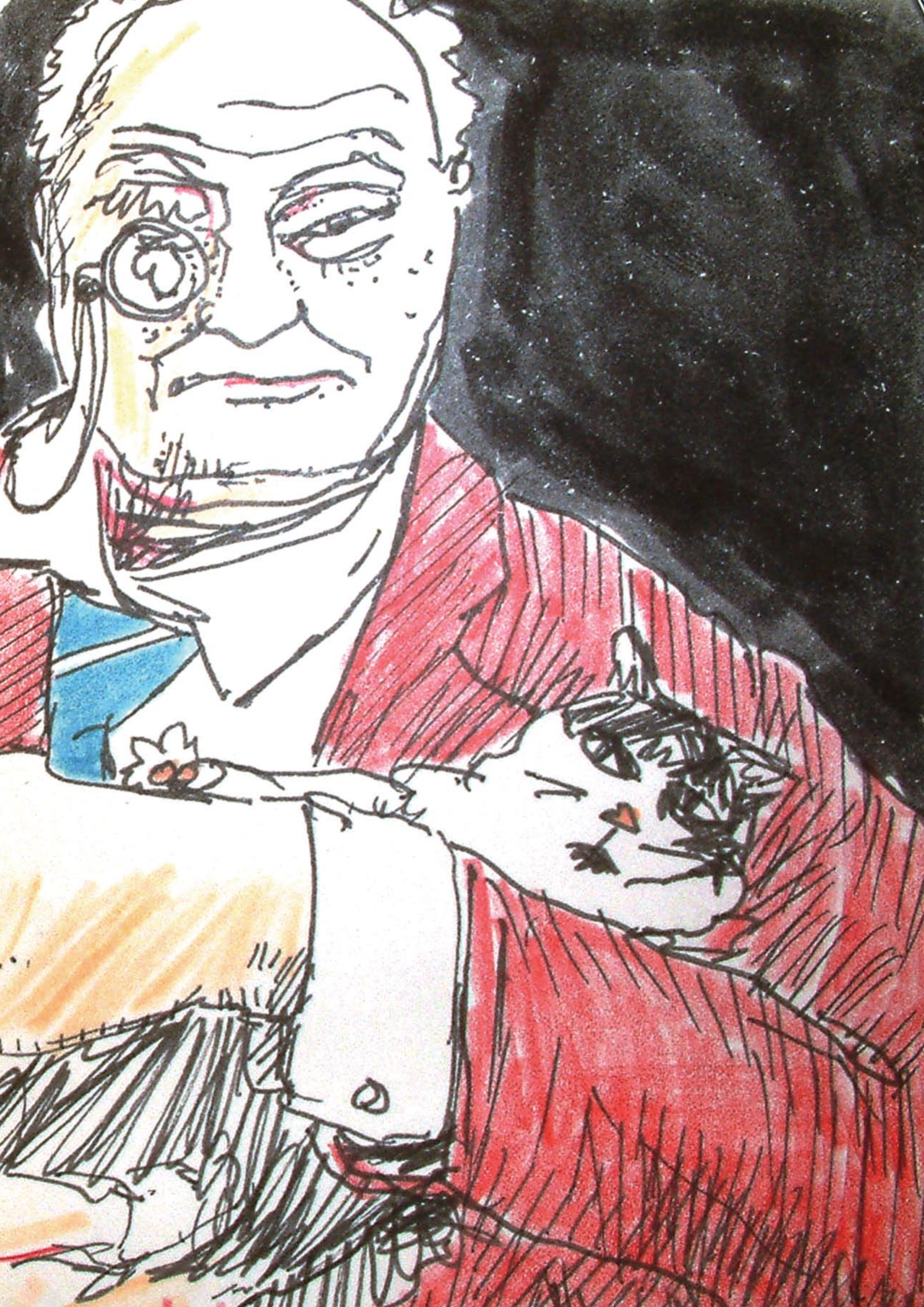
Where?
Tokyo, Japan

When?
31st of August - 12th of September 2008

IAPS members are invited to apply for a places at ISC54. ISC is held annually in Japan, with 30 Japanese and 30 foreign delegates. Delegates are chosen based on an essay (in English) submitted to the organisers. This year's conference is in two parts, starting with a study tour of Osaka, Kyoto, Kobe, Okayama and Kyusyu, followed by the main conference in Tokyo.



For more information and links to all of these conferences, visit **iaps.info**, and click on 'events'.



Interview: Sir Patrick Moore

How did you first become interested in astronomy?
When I was 6 years old, I picked up a small book my mother had, it's over there, called the story of the solar system. I read that book through, beginning to end, and I was fascinated. I was rising 7. It was an adult book and my reading was alright. I was just hooked on it, simple as that. Reading a book.

You were there at the start of the space age. Did the first launch, Sputnik, come as a big shock?
No. We knew the Russians were getting ready to do it. And the Americans could have done it first, but there was inter-service rivalry there, and they didn't take the advice of the one man who could have done it for them, and that was Werner von Braun, the German. When they told him he could get on with it, he had a satellite up in a matter of weeks. He could have done it earlier. I knew von Braun. Interesting, because he was building the V-2 rockets at Peenemunde, used to bombard London, and in 1943, the RAF bombed Peenemunde. A few years later, I was having lunch with Werner von Braun in New York.

How did the launch change public perceptions?
Very markedly I think. People were still saying space travel wouldn't come. And when suddenly Sputnik 1 was buzzing around the Earth, people realised we could send things into space and therefore we could go there. It was a very quick turnaround in public opinion. It was amazingly quick.

If you had to make a prediction back then about where we'd be now, what would you have said?
I got it wrong. I said then, when the first man, Yuri Gagarin, went into space, I said we should have bases on the Moon by 1980. And probably get to Mars by the end of the century. I was wrong there. Arthur Clarke got it right, he said get to the Moon by about 1969. So I was about ten years wrong. Other people got it even more wrong. The space age seems to have slowed down. It has for two reasons. First of all, the Americans put all their faith in the Shuttle. It cost more, took longer to build and had some nasty accidents. That's one thing. And of course when the Soviet Union collapsed, the Russian space programme didn't have the money. It's got to be through co-operatives now, it's got to be done. And of course if we're going to go to Mars, radiation. We don't know yet.

Is it true that the Russians used your Moon maps for their lunar probes?
Yes it is. As you know, the Moon keeps the same face to the Earth all the time. Therefore the edge is very foreshortened. I'd been mapping the edges, called the libration areas. They did use my maps, yes.

At the beginning of the space age, the engineers who were working on the space programme were all very young.
Yes, true, there were a lot of young people. Perfectly true. The German team were very young indeed. Von Braun was hitting it when he was 20.

Do you think it has an impact on how fast things are developed?
Well of course there's all the modern technology now, and resources of whole governments behind you which you hadn't then. Space research was very much a fringe thing, before Sputnik 1.

What do you think has been the single greatest benefit from space exploration so far?
The main thing I think, first of all,

international collaboration. That is happening now. And secondly, of course, space research is bound up with all other sciences. I'll give you an example. A little while ago, I went down to this test thing in the hospital there. It was testing an unborn baby for defects, using equipment developed for use in space. It's all bound up together. These are the main benefits I think.

Is manned flight to the Moon or Mars likely to detract from scientific robotic missions?
I don't think so. They go together. Our unmanned programme in space research has gone on apace. It's gone as quickly as we might have hoped. We've explored all the planets now, got telescopes in space. That's all gone terribly well. It's the manned aspect which seems to have been held up, you see, because of those two things, the shuttle and the Russians running out of money. Nowadays of course there's a new thing, the Chinese and the Japanese are trying too. The Chinese have just launched their first Moon rocket, Chang-e. Once the Chinese come in it's going to move rather quickly.

Do you think there is any willingness in the British government, to put British people into space?
With what our present government is doing, I don't know. I don't think they do, frankly. One day we might have a sensible government but I can't see it yet.

Do you think we will maybe collaborate with the European Space Agency to put people into space?
We are now. There's collaboration now. I'm all for collaboration with the European Space Agency. I want to get out of Europe, because I'm a strong member of UKIP. I want to get right out of Europe.

But we're not signed up to ESA's manned spaceflight programme.
We're all working together. There's no space race now. There could be one between the Americans and the Chinese of course. Dear old Bush has restarted the cold war. There could be a space race there. Not with the Russians any more.

Do you think manned spaceflight would help encourage young people into science careers?
I'm sure it will. After all, the invention is there. Like polar exploration used to be in my grandfather's time. It certainly will. There will be, of course, we should have colonies on the Moon. So far as Mars is concerned, it depends upon two things. First of all, politics. One more war and of course space research goes back to the start. Though if someone stops George W Bush it may help. Secondly, radiation. Once we're beyond the Earth's atmosphere, we are subject to radiation and we are not sure how dangerous it is, and we are not sure how to deal with it. That could be the real holding up point on the voyage to Mars. We're going to be in space, exposed to radiation for months.

What about the psychological issues of putting a small group of people in a confined space for a few years?
Select the right people. It can be done. Select your astronauts very carefully indeed, I quite agree.

You have presented 'The Sky At Night' since it started. How has it changed over the years?
Well the science has changed. The Sky At Night hasn't really changed very much, I've seen to that. The thing about background music, out. What we've tried to do, we've tried to keep people...

A cat enters the room.

Patrick: Jeannie, my black and white cat.

jIAPS: She's lovely.

Patrick: She is lovely.

jIAPS: Who's the other cat in your photographs?

Patrick: That's Ptolemy. Ptolemy's in the garden, two lovely cats. Jeannie is 7, Ptolemy is 2. I've always been very cat-minded.

jIAPS: It's nice to have animals around.

So, with your work on The Sky At Night, have you noticed any changes in the audience's level of education over the years? Are we better or worse now?
No, I think it's about the same. The people know more about space research than they did. There are two things we do. Try and keep people up to date, that's the main thing. And encourage people to take an interest. There are many people who began taking up astronomy by watching The Sky At Night and have become professionals. There are quite a number of those. That makes the programme worthwhile I think.

What's the main challenge of explaining astronomy to non-specialists?
Don't use too many words and don't go on too long I think. That's what I try and do. Whether I succeed I have left to others to judge, that's what I try and do.

Is there any particular area that's more difficult than others?
Yes I think there is. When you come on to beginnings and endings. Beginning of the Universe. We can go right back 13.7 thousand million years to the big bang. How did that happen? Frankly we don't know. Trying to explain that is a difficult matter. And you can't very well understand infinity. You can't put infinity into words people can understand. I can't do it, neither could Einstein. I know because I asked him.

Do the audience show more interest in difficult topics like that?
There's a wide spread of interests, all the way around I think. Certainly is there life elsewhere, is there life on Mars, how did the Universe begin, how will the sun die? We can give some answers, we can't give the full answers. No-one can.

There are some people who say that all astronomy is a waste of money you could spend on more practical things.
There were people long ago who will have objected to the development of the wheel. You always get people like that. You always get the incredibly bone-stupid minority. Solid concrete from the neck up, nothing you can do about it.

When you're doing astronomy,

“You can’t put infinity into words people can understand. I can’t do it, neither could Einstein. I know because I asked him”

what sort of telescopes do you use?
I originally had my three inch refractor. I’ve got now, my 15 inch reflector and my 12-and-a-half inch. Sadly I can’t get out there any more. My body has packed up. Old wartime injury in my spine has laid me low.

I’m sorry to hear that.
Can’t do anything about that. Infernal nuisance, but there it is.

You don’t get out at all to observe?
I can’t take any pictures. Other people use my telescopes. That picture of Saturn was taken with my telescope the other day. But I can’t do it now, very sadly. I’ve got old, It suddenly hit me. They said my spine was slipping, it happened when I was 30. It didn’t until I was 77. At the age of 77 I played my last game of cricket. And took 6 wickets.

What causes more problems for astronomy here, the weather or the light pollution?
Both. Here of course, we have a lot of cloud, but the best observing sites in the world don’t have that problem. I mean go to the VLT site in the Atacama desert, it’s clear for 361 days of the year. I think it rains once a century. We have variable weather here. This is not the country for really big telescopes. We have got to admit that. That’s why our main telescopes are in places like Hawaii, the Canary Island, where the weather is better.

Have you been to those?
Oh yes, I’ve been to all of them.

Any favourites?
I like the Lowell observatory in Arizona. I did a lot of work there in my Moon map days. That’s my favourite telescope, the Lowell telescope. There are far bigger ones nowadays, but that one I like very much. Hawaii is the most picturesque, so is the Atacama.

What’s the most impressive thing you’ve ever observed yourself with a telescope?
Oh, you’ve got to see a total eclipse of the Sun. When the Sun goes behind the Moon, the corona flashes out, it’s unbelievable. Have you ever seen a solar eclipse?

Yes, I went to Turkey for the last one.
You’re lucky, I couldn’t go. I’ve seen 7, but I couldn’t go to that one. The only one we had crossing England I was clouded out. The last one I saw was in the China seas. It was great. We had a Norwegian captain who of course got everything right.

We’ve got new spectral ranges for astronomy being opened up with satellites, we always seem to see something unexpected.
Yes you will, in astronomy always expect the unexpected. That’s certainly been demonstrated in our solar system. You get surprise after surprise. The fountains of Enceladus, chemical lakes on Titan. And many more examples. And now this weird comet, Holmes’ comet. Unlike any I’ve ever seen before.

Have you got any prediction for what will be the most interesting area of research to come?
Discovery of life elsewhere. Mars is the key here. No Martians, no little green men. If we find any trace of Martian life, it will show life will appear where it can. That’s a very strong point for life being widespread in the Universe. Whether we will find it I don’t know. We should know fairly soon.

What do you think of the possibility of life on Europa?
I would say less likely than Mars, on the whole. A sunless sea. Difficult to imagine life appearing there. It could, you never know. You have extremophiles. But I think on the whole, my bet’s probably on Mars.

Any specific predictions for the next 50 years or so?
It depends on two things. Politics is one. Getting into space. We’ll get more space telescopes, more space observatories. So far as travel to other worlds is concerned, beyond the Moon, it does depend how bad the radiation problem is, if there’s any way of combating it. That, to me, is the great unknown. If we can cope with that problem, learn how to survive without wiping each other out, then yes, the possibilities are endless. I know one thing. In 50 years from now, the world won’t be the same as it is now. It will either be much better, or much worse. It won’t

be the same. You will see it, I won't.

Have you got any message to give to young physicists?
Yes, you're living in exciting times. Keep abreast of things and strike out on your own. Don't stick entirely to routine. Do your routine stuff and also look out for your own particular subjects, and see wher you get. You may make any number of amazing discoveries and there is scope for it now. Keep in touch, collaborate with everybody. Look around and also if you find anything interesting, investigate it for all you're worth.

If we could go back to manned spaceflight, or just science policy in general. In terms of encouraging the public to get behind a space programme, I think your programme is very helpful.
We do our best.

All science programmes are probably very good for that. Do you think there is enough science on TV? Could there be more?
You don't want to overdo it. There certainly could be more. I've stopped watching TV quite frankly. I watch the test matches, Wimbledon, the occasional news bulletin, and one superb programme: Yes Minister, superb programme.

Might that be the way to get people interested in science, through the media?
You've got to do it well. It's so easy to make a good subject boring. I remember hearing a lecture, I think it was on Mars, by an astronomer, some years ago, and even I couldn't keep awake. You've got to have people who can put it over. Some can, some can't.

Sometimes a big science documentary gets things wrong. Do you think that causes major problems?
Oh yes, you can easily get things wrong. There have been many, many boobs. There was the American sugar bowl radio telescope. They built this base and when they put the stuff on it the entire thing would collapse. So they filled it in and forgot it. Had magnesium flares in the spectra of late-type stars, couldn't understand this at all. Apparently what it was, someone had just lit a cigarette. It was the match.

I see a picture of you and Brian May there. What do you think of his taste in music?
Brian May is one of my closest friends. I don't like his music, it's not my music at all. He's one of my great friends. He's an astronomer. His degree is in astrophysics and his speciality is in zodiacal dust. That's what his thesis was on.

I heard he recently got his PhD.
He's a very clever astronomer. But his music is not mine.

Multi-talented man.
He is, he's a first class photographer too. One of my closest friends. We wrote a book together, called Bang. Seems to have done well.

He went back into academia, didn't he, after a very long time.
He began doing his thesis. He got his BSc, then began doing his thesis. Then Queen came along. For 30 years, he had to play in the band. And there it was. Five years ago, I said to him, 'look Brian, you're going back to finish your PhD'. He was rather reluctant, I must say, I bullied him and bullied him. So he said 'alright, I will'. He had one bit of luck, his thesis was on zodiacal dust. He'd done original research about 30 years ago. No-one had done much since. Therefore the research he had done, a long time ago, was still absolutely valid. Instead of going right back to the start, he could build on that. And he did so. He's now officially Doctor Brian May,

"Look around and if you find anything interesting, investigate it for all you're worth"

Did you ever think about going to university after a certain amount of time?
The point is, I had my Cambridge place. I went into the RAF. At the end of the war I came out of the RAF and my Cambridge place was still there. But it meant taking a government grant, that went against the grain. I prefer to stand on my own feet. I thought 'I'll do a bit of writing, and I'll pay my own way through'. The book took off and I never had time.

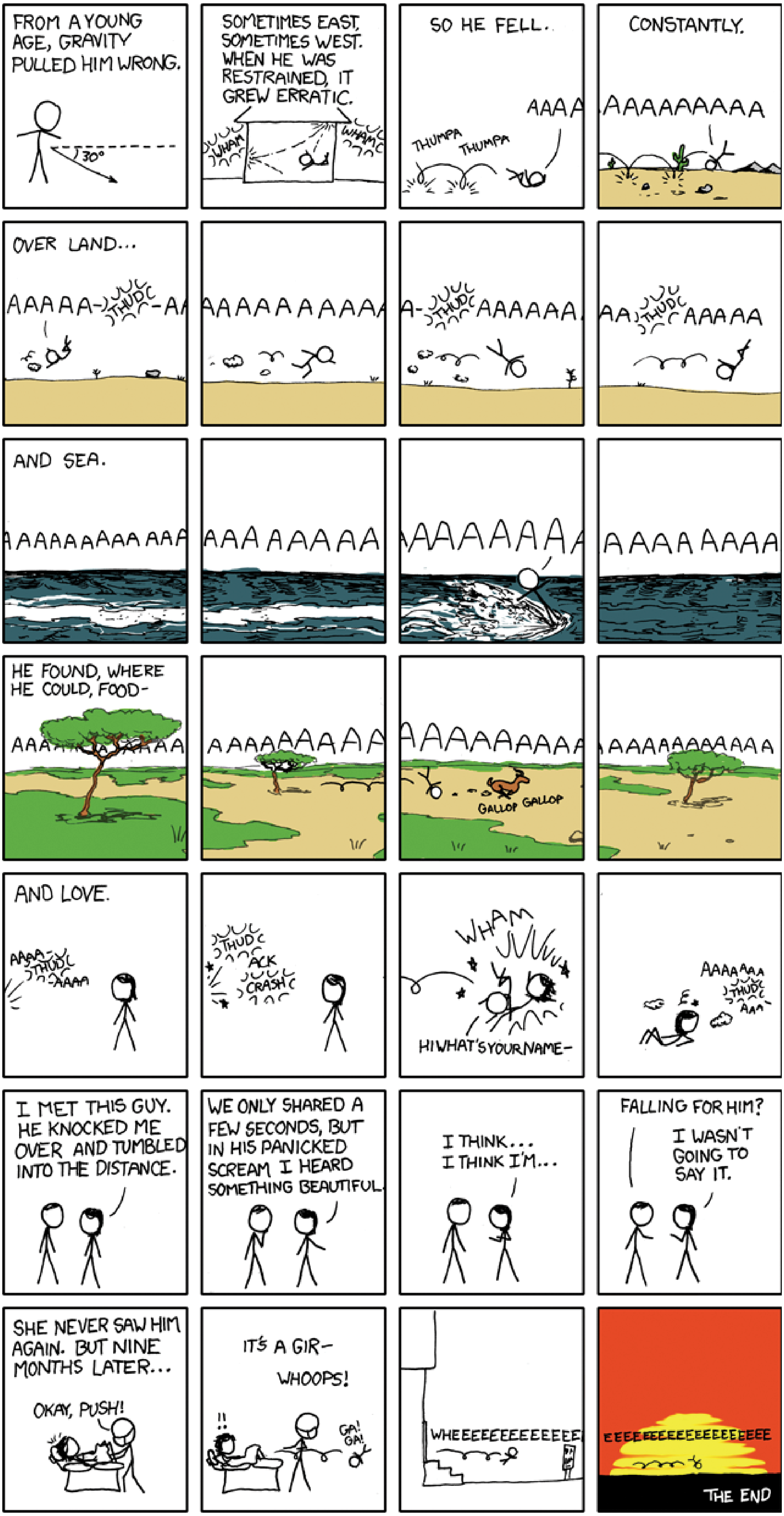
You never looked back?
I never had time! I always meant to do it, I just didn't have time.

I've noticed two typewriters. Which is the famous one you write all your books on?
That's my old Woodstock. Everything since I was 8 years old. I had a good way of teaching myself to type. When I was 8, I picked a book on the Moon. I wanted that book and I wanted it badly. Out of print of course. One copy in the RAS library and a friend of ours was a fellow and managed to borrow it for me. I had a 7,000 word book in my possession for a month. I remember thinking, 'if I type this book out, I'll have the book I want, I'll be able to type and I'll be able to spell'. It worked like a charm. There's a copy up there. By the end I was touch typing. With my two middle fingers I could type 90 words per minute. Now of course it's not so easy, my hands have gone. Damn nuisance.

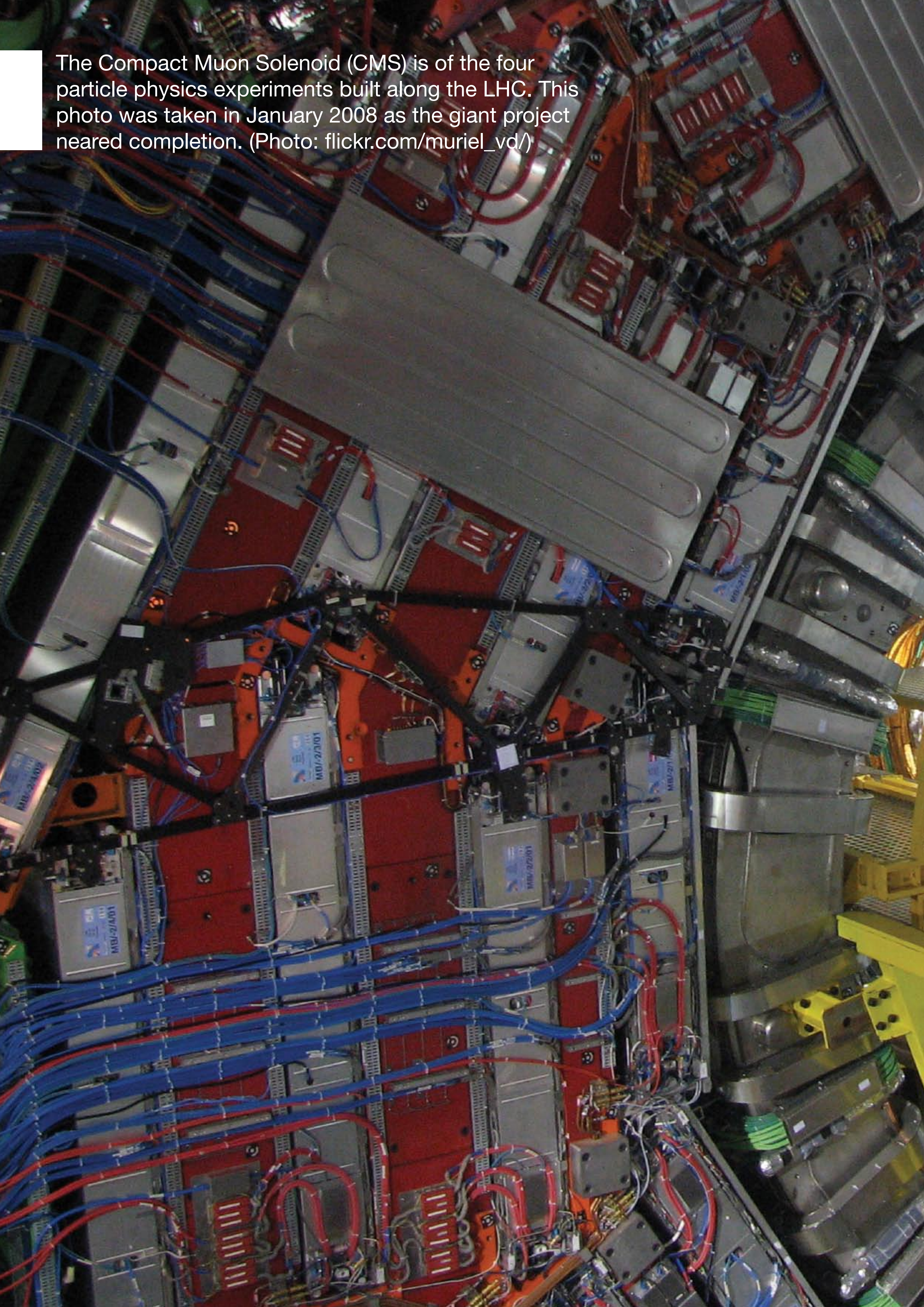
Patrick was interviewed by Laura Rhian Pickard, Nick Powell and Job van der Zwan

xkcd.com

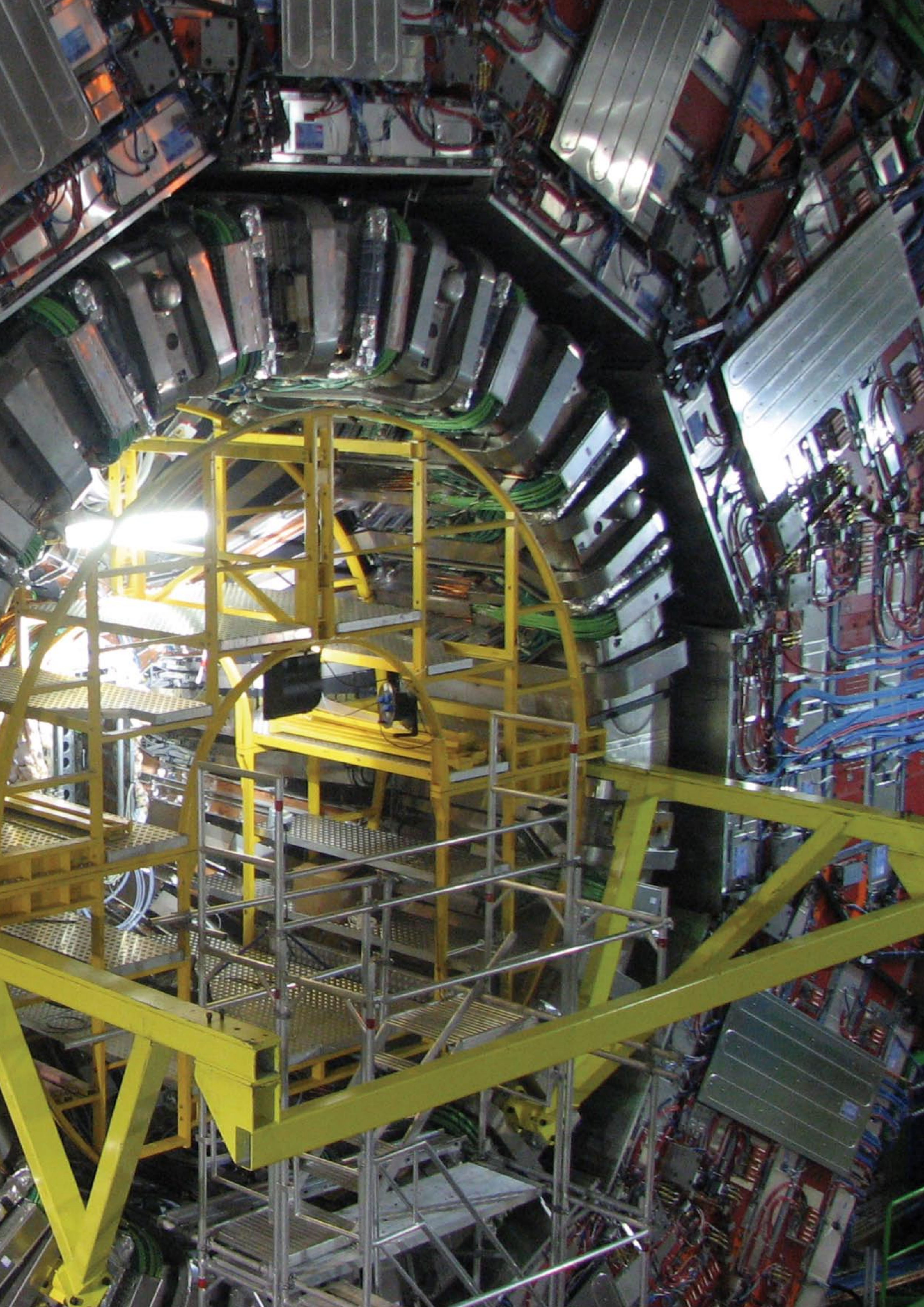
a webcomic of romance, sarcasm, math, and language.



Strip originally conceived in conversation with Jeph Jaques. Soon to be a major motion picture.



The Compact Muon Solenoid (CMS) is of the four particle physics experiments built along the LHC. This photo was taken in January 2008 as the giant project neared completion. (Photo: flickr.com/muriel_vd/)



for love or money?

MORE AND MORE GRADUATES are using their academic grounding in physics to secure high-earning-jobs in finance. In a 2004 survey, 12.6% of physics graduates in the UK entering employment ended up in business and financial professions – the second largest sector after clerical and secretarial occupations. The finance sector typically seeks physicists who have completed a PhD or one of the new specially designed financial physics masters' courses that gear them up for a life in finance. While the benefits to the individual are obvious - good money and an office with air con - some in the physics community are concerned by the trend. So is financial physics just another career path or is it a waste of good physicists?

As the world of finance relies more and more on maths and computing, the need for graduates with practical experience in both is rising. Physicists are prized for their skills in programming, modelling and data analysis. The majority of these physicists eventually become quantitative analysts ("quants"), who typically develop models to support traders and risk managers in large corporations.

While there are some similarities between physicists and quants the key difference is their goals and philosophies. The quant develops methods to assist the corporation in making more money. Meanwhile the physicist normally works by building on others achievements to discover something new or find innovative and useful applications for completed research. Most important, the research is shared through peer-reviewed journals, allowing it to be critically assessed and for others to build on the findings.

> **"the last thing we need is trained physicists being turned to the dark side"**

The other obvious difference is the salary: typically, a PhD graduate with no finance experience can expect a starting salary of £35,000, rising quickly to six-figure sums that a physics researcher can't compete with. Also working in finance has the advantages of a structured career, regular promotions and greater job security; in research, most graduates are on fixed term contracts.

So why do people jump ship? Perhaps after a few years at university they realise that physics is not for them. The lure of money is the key. Any mathematics-related PhD has a special pass into the world of finance, while physics graduates in particular have proved their numeric and analytical skills. All a company needs to do after stealing them from science is to mould them into money-driven business machines.

It seems such a shame to see bright would-be physicists swallowed into the world of finance and business. With their numbers dwindling, the last thing we need is trained physicists being turned to the "dark side" with the promise of high salaries and company cars. If we study physics because of our desire to know how things work, surely those abandoning the subject haven't appreciated the wonders that physics has to offer. Physics promises the answers to so many of life's mysteries, and a career in science gives the chance to do something for the wider world. To forgo these opportunities for a mundane life of numbers, money and suits seems a crime. Surely a quest for knowledge is a more rewarding goal?

I doubt that many people begin a physics degree with the aim of selling their souls to finance. They must have started with greater aspirations, so where does it all go wrong? There are fewer students taking A-level physics and fewer physics graduates, yet there is an increasing demand for them in research, industry and especially education. It is essential to not let their number drop any lower. If no action is taken in the near future then it's only a matter of time before the scientific research output grinds to a halt.

The only way to reverse the flux of potential researchers turning to finance and other such sectors is to promote their position in society: scientific research is not seen as glamorous as the world of finance, yet physicists get access to supercomputers, miniature black holes, particle accelerators and much more. People need to be better informed about scientific careers by allowing students greater research experience earlier in their careers. In addition, the teaching and education of physics must be further updated to keep the original motivation and intellectual spark burning far longer than the latest stock-market trend.

Leila Sattary

>>second opinion

Phil Symes got a job as a risk consultant in London shortly after finishing his PhD in particle physics in early 2006. The work involves calculating the probabilities associated with financial risks.

"Finance companies are reliable employers, and jobs are readily available. On the other hand, there aren't enough jobs in physics, and those that are available are massively underpaid and only last for 2-3 years. By the time you have done a degree and a PhD, you will be at least 25, probably older, and will have no savings, pensions, etc.

"This is all fine if you intend to stay single or marry well. Otherwise, if you want to receive the market rate for the work you do, motivated more by a sense of fairness than by greed, then you will have to "sell out" to finance or industry.

"Financial services is the UK's biggest economic sector, contributing 18% to the country's GNP, and this sector is growing. London is fast overtaking New York as the world's biggest financial centre, and the money made is vital to the country's economy.

"It is therefore important that many of the country's highly skilled and quantitatively able people work in the financial sector. Work in finance ranges from the menial (such as auditing) to the glamorous (derivative pricing). This is an exciting time to be working in the field, and the work can be rewarding.

"The question for many is not whether to get into finance, but how to get a job that will maximise their potential as soon as possible. In fact, if we can change the image of physics from that of a hard subject done by geeks into the subject that is a gateway into finance and good jobs, then maybe we can reverse the decline in undergraduate physics applicants".

Jim Grozier, a mature PhD student at Sussex University, says he would never even contemplate going into finance.

"But then I am in the lucky position of having the big expenses behind me: my flat paid for, my children grown up. We have got to find a way of giving young physics graduates, with all those responsibilities still to come, an incentive to remain in the field, which means better salaries and more job security. After all, society needs physicists; it does not need financiers.

"At our university we have recently lost a very good lecturer to the finance industry because he could not afford to bring up his young family on a post-doc's salary, nor could he afford to risk the responsibility of a mortgage on a short term contract. Mind you, there are other factors; I once met a PhD student who was determined to go into finance when he graduated because "academia is too laid back for me – I'm too much of a driven person". You can't please everyone!

"I also cannot help feeling that if people want to go into finance they should study finance, and not physics. I'm aware that finance needs certain mathematical and problem-solving skills, but I'm sure these skills could be taught instead in a financial context, as part of a financial course. Using physics as a route to finance for those already committed to it, as Phil suggests, might help to boost departmental intakes, but would seem to me to be a rather perverse and dishonest solution to the problem. And purpose-built financial courses would presumably also serve to prepare the unwitting employee for the dog-eat-dog nature of the culture for which he or she is heading, where secrecy, short-termism and the narrow interests of the company replace the concepts of openness and the greater world good. Physics PhDs who have become used to such things as peer-reviewed publications will have a nasty shock awaiting them when they swap the lab for the stock exchange".

Jim Grozier remembers

Sir Joseph Ro

SIR JOSEPH ROTBLAT – PHYSICIST, Nobel peace prize winner and honorary member of IAPS – died on 31August 2005, at the age of 96.

Born in Warsaw in 1908, the young Rotblat grew up during World War I. The war damaged his family's prosperity so much that in order to achieve his dream of becoming a physicist, he had to work as an electrician during the day and study by night. Leaving Poland just before Hitler's invasion, Rotblat moved to England and worked in Liverpool with James Chadwick (discoverer of the neutron). In 1944 he moved to Los Alamos in the USA to work on the atomic bomb. He left the project when it became clear that its original motivation – the threat of a Nazi atom bomb – was no longer a possibility.

After the war, Rotblat learned that his wife – who had remained in Poland in 1939 because she was ill – had died in the Warsaw ghetto, possibly at the hands of the Nazis.

For the rest of his long life, he campaigned against the manufacture and use of nuclear weapons. In 1955 he was one of a small group of physicists who signed the Russell-Einstein Manifesto, calling for a halt to the production of nuclear weapons. He also applied his knowledge of nuclear physics to medicine as a professor of physics at London's St Bartholomew's Hospital where he pioneered the use of both cobalt-60 and iodine-131 for radiotherapy and diagnostics respectively. His techniques were initially opposed by the physicians who must have felt that a pure scientist had no place in a hospital.

Otto Frisch, the discoverer of nuclear fission, worked with Rotblat at Los Alamos; in his autobiography, What Little I Remember, Frisch said: "He was a kind, outgoing person, always looking after others, always trying to help people. He … has done as much for peace as anyone I know."

In 1957, Rotblat organised the first of many Pugwash Conferences on Science and World Affairs. These conferences gave rise to the Pugwash organisation of concerned scientists which has campaigned for 50 years against nuclear weapons. Rotblat was its first Secretary-General. In 1995, his efforts were recognised with the Nobel Peace Prize, awarded jointly to Pugwash and Rotblat.

I remember Sir Joseph Rotblat speaking at the first ICPS I ever attended, in 2001, when he was 92 years old. He gave an impassioned speech and then opened up the meeting for contributions from the floor, and it turned into a debate about ethics in science. Afterwards, many of us signed the Pugwash Pledge:

"I promise to work for a better world, where science and technology are used in socially responsible ways. I will not use my education for any purpose intended to harm human beings or the environment. Throughout my career, I will consider the ethical implications of my work before I take action. While the demands placed upon me may be great, I sign this declaration because I recognize that individual responsibility is the first step on the path to peace".

In summer 2005, the Pugwash organisation sent out an announcement about the 50th anniversary of the Russell-Einstein Manifesto on July 9th, and encouraged supporters to write to Rotblat and congratulate him on the anniversary and on all the work he had done to promote peace. (I guess they knew he was dying by then). I made a mental note to do this, but missed the anniversary, and consequently, when I did write, was able to place it in the context of the terrible bombings that had occurred in London two days before. I wrote:

"I understand that Saturday July 9th was the 50th anniversary of the Russell-Einstein Manifesto, when you and your colleagues stood up and spoke out about the evils of nuclear weapons. Two days before that, of course, we had a horrific, but timely, reminder about the evils of using science to kill and destroy. OK, the terrorists' bombs were maybe simple devices which did not need a scientist to make them; but the bombs which prompted the attack were much more sophisticated. I recently learned, to my horror, that a satellite technology department at a university near me had been

tblat

involved in the Iraq war, and that very probably, the work of physics students like myself had contributed to the death and destruction there.

When it seems that "they" - the military machines and the people they serve - have all the trump cards, it is good to know that Pugwash, and organisations like it, are there to support those of us who recognise the ethical implications of our work."

I also reminded him about his ICPS lecture and told him that if London succeeded in its bid for ICPS 2007, I would try for a re-run of the 2001 debate. A few days later I got the following reply:

"Dear Jim Grozier,

Thank you very much indeed for your kind letter of congratulation. I was most gratified to read it.

I wish you all the best with your bid to acquire the ICPS for London in 2007, and particularly support putting the Pugwash Pledge on the agenda. I don't know whether you know the Hans Bethe quote:

"Today we are rightly in an era of disarmament and dismantlement of nuclear weapons. But in some countries nuclear weapons development still continues. Whether and when the various Nations of the World can agree to stop this is uncertain. But individual scientists can still influence this process by withholding their skills.

Accordingly, I call on all scientists in all countries to cease and desist from work creating, developing, improving and manufacturing further nuclear weapons - and, for that matter, other weapons of potential mass destruction such as chemical and biological weapons."

I would like to see an endorsement of this call by the scientific community.

Thank you again for your kind letter.

Yours sincerely,
Joseph Rotblat."

Six weeks later, Rotblat was dead.

To my shame, and despite the dying wish of a great man, I have not pushed for the inclusion of an ethics slot in the ICPS 2007 programme, and it now looks unlikely that there will be one. However, another idea has occurred to me. ICPS 2008 will take place in Poland, Rotblat's native country, and it will be the centenary of his birth. What better time and place to continue the work of this pioneer of human values in science?

Student Pugwash is a lively, vibrant organisation and is concerned with all fields of science, not just nuclear weapons.

Find out more at **student-pugwash.org**

The Big Story

How sure are you that spacetime is continuous?

Steven Johnston

June 20, 2008

In the 20th century two main pillars of physics were developed. The first of these, the general theory of relativity provides our best description of gravity. The second of these started as quantum mechanics, developed into quantum field theory and culminated, in the 1970s, with the Standard Model—our best description of the electromagnetic, weak and strong fundamental forces. Both these theories are experimentally well-tested but differ greatly from one another in the ideas they use to describe the universe.

General relativity is a completely classical theory in which no quantum mechanical effects are included. It describes gravity as the result of curved spacetime. Quantum field theory (including the Standard Model), by contrast, is a fully quantum mechanical theory of matter but within a fixed, flat spacetime background. In particular no gravitational interactions are included in the Standard Model.

One of the biggest tasks for 21st century physics is to unify these two pillars together: to develop a theory of *quantum gravity*. Physicists working on this are driven by the belief that the universe should be described by *one* physical theory—rather than two which apply in different physical regimes.

Clearly unifying these two pillars is a difficult task. Many clever physicists—including a number of Nobel prize winners—have worked on theories of quantum gravity but, as yet, no consensus has been reached. The difficulty is that the effects of *both* quantum mechanics *and* gravity only become important in physical situations so extreme they cannot currently be produced on Earth—even in the most powerful particle accelerators. This means there is little experimental evidence to lead physicists towards the right theory. This drought of relevant experimental data has let theorist's imaginations run free and many of their quantum gravity theories contain very speculative ideas. Extra dimensions, new symmetries of Nature and a plethora of as-yet-undiscovered particles are amongst the most popular.

Whatever the worth of these ideas it seems likely that either general relativity or quantum field theory (or both!) will need to be modified before a successful theory of quantum gravity can be obtained. It is worthwhile therefore to look at the basic assumptions that sneak into the theories and see if they can be modified. Here we look at one approach—causal set theory—which questions the assumption that spacetime is continuous.

Continuous or discrete?

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In both general relativity and quantum field theory spacetime is assumed to be continuous. This means that for any point in spacetime there are other points arbitrarily nearby—any finite spacetime region can be subdivided into smaller and smaller parts without limit.

One obvious modification is to take spacetime to be, in some sense, discrete. This would mean that a finite region of spacetime cannot be subdivided arbitrarily many times—that there is, in some sense, a smallest piece of spacetime. There's a variety of motivations for discrete spacetime and we'll look at one from quantum field theory and one from general relativity.

A major obstacle to the development of quantum field theory was the presence of infinities as answers to physical questions. These infinities (or divergences) were eventually side-stepped by the process of renormalisation in which the infinite values were reassigned to unmeasurable quantities while the physical quantities received (experimentally correct) finite values. One can argue that the occurrence of the infinities is due to the theory's use of continuous spacetime. The infinities can be traced back through the calculations to the small-scale behaviour of the theory and their presence may indicate that continuous, infinitely divisible spacetime should not be used.

Within general relativity there are spacetimes with singularities where the laws of physics "break down". The most famous example of a spacetime with a singularity is a black hole. Inside the black hole there is a singularity at which the gravitational forces on an object become infinite. The presence of these singularities possibly indicates that the small-scale theory of spacetime requires modification.

Allowing the *possibility* of discrete spacetime then what's the next step? Just declaring spacetime to be discrete is not enough—the spacetime events would just drop into a pile of formless dust. We need to describe how they fit together, how they acquire structure.

In causal set theory spacetime is discrete and causality is used to define its structure. In particular the causal relations between events in spacetime play a fundamental role. Causality is so important an ingredient that we'll now give a short review of its role in the continuum spacetimes of general relativity. If the review gets too mathematical then don't worry—just concentrate on the ideas.

Spacetime and causality

The special theory of relativity was the first theory to use a unified "space + time = spacetime" description of physics. Its spacetime model is 4-dimensional *Minkowski spacetime* (this was later also used as the background spacetime for quantum field theory).

In general relativity, to include gravity, spacetime is allowed to be curved. The flat Minkowski spacetime is replaced by a general 4-dimensional *Lorentzian manifold* (M, g). Points in the manifold M (spacetime events) correspond to locations in spacetime. At each point in M there exists a tangent space containing the tangent vectors at that point. The Lorentzian[1] metric g is just a map

[1]Lorentzian means that if we write g as a 4×4 matrix then it has 1 positive eigenvalue and 3 negative eigenvalues. Here we're using the $+ - - -$ signature convention.

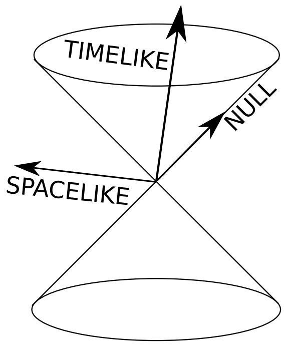

Figure 1: Tangent vectors and the light cone

(linear in each argument) that assigns real numbers to pairs of tangent vectors. With this metric we can classify tangent vectors at a point into three different types. For X a tangent vector we say it is

- Timelike if $g(X, X) > 0$
- Null if $g(X, X) = 0$
- Spacelike if $g(X, X) < 0$

Timelike vectors lie within the point's light cone, null vectors lie on the light cone and spacelike vectors lie outside the light cone.

We will also assume the manifold is *time-orientable*. This means we can consistently choose past and future timelike and null directions everywhere within M. Given a timelike or null tangent vector we can therefore classify it as either past-directed or future-directed.

A *future-directed causal curve* is a curve in M whose tangent vector is always future-directed and either timelike or null. These curves are central to the notion of causality in general relativity. They can be thought of as possible worldlines for a material particle—they take the particle from the past to the future and always stay within their future light cone.

For two spacetime points x and y in M we say "x causally precedes y", written $x \preceq y$, if there exists a future-directed causal curve from x to y. We may also say "x precedes y", "x is to the causal past of y" or "y is to the causal future of x".

If the manifold contains no closed causal curves (that is, curves that travel forward in time, staying within their light cones, but return upon themselves in the past!) then we say the Lorentzian manifold is *causal*. In this case the relation $\preceq$ is a *partial order*. This means it is:

- Reflexive: $x \preceq x$,
- Antisymmetric: $x \preceq y \preceq x$ implies $x = y$,

- Transitive: $x \preceq y \preceq z$ implies $x \preceq z$,

for all points x,y and z in M.

A causal Lorentzian manifold (M, g) therefore defines a *partially ordered set* (or *poset*). In general a poset is a set together with a partial order defined on pairs of elements from the set. Here the *spacetime poset* is $(M, \preceq)$ with the set of spacetime events M and the partial order $\preceq$.

The partial order $\preceq$ on spacetime points can be contrasted with the total order $\leq$ on the integers. For *any* two integers we can tell if one is greater than or equal to the other: $-1 \leq 2$, $4 \leq 4$ etc. This means $\leq$ is a *total* order. The causal order $\preceq$ on events in spacetime is only a *partial* order because we can only tell if one event precedes another for *some* pairs of events. In particular if no future-directed causal curve can connect two events then it's meaningless to say which is to the causal past or future of the other.

The causal ordering for spacetime events contains a lot of information about the structure of the spacetime. A 1977 theorem by Malament shows that, under appropriate conditions, two Lorentzian manifolds (M, g) and (M', g') with the same causal structure[2] are the same, up to a *conformal factor*. This means 1) the manifolds M and M' are "the same" (i.e. there is a one-to-one, onto map from one to the other) and 2) the metrics g on M and g' on M' differ only by a conformal factor: g and g' are equal up to a rescaling by a positive number which varies from point to point in the manifold.

This fairly technical theorem means that a Lorentzian manifold can be almost uniquely specified by the causal ordering of its events. The word "almost" here refers to the conformal factor that's left unspecified by the causal order. This conformal factor can be related to the spacetime volume assigned to regions of spacetime. Fixing the conformal factor is therefore equivalent to fixing a *volume measure* that assigns non-negative real numbers (i.e. volumes) to regions of spacetime.

The conclusion we can draw is that spacetimes in general relativity may be viewed as a partially ordered set together with a volume measure. From this viewpoint the usual metrical, topological and differential structures of a Lorentzian manifold are secondary to the causal order and volume measure.

Causal sets

Causal set theory throws out the model of spacetime as a continuous Lorentzian manifold. Instead it models spacetime as a *causal set*. As in general relativity this is still a partially ordered set $(C, \preceq)$ but there is a crucial difference. The set (C) still represents spacetime events and the partial order relation $(\preceq)$ still represents the causal order between pairs of events but we now impose a *new* condition that this spacetime poset be *locally finite*.

A poset is locally finite if, for every pair of elements x and y, there are only finitely many elements z causally between them (i.e. finitely many z such that $x \preceq z \preceq y$). It is this condition which introduces *discreteness* into causal set theory.

[2]Meaning there exists a map $f : M \to M'$ such that $x \preceq y$ in M if and only if $f(x) \preceq f(y)$ in M'

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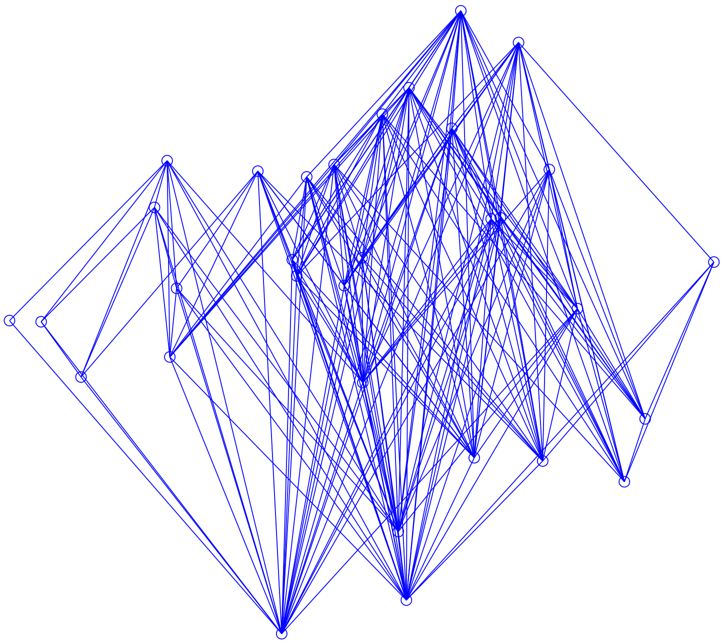

Figure 2: A small causal set drawn as a Hasse diagram. Spacetime events drawn as points and causal relations drawn as lines from lower to higher points.

In the continuum we needed both the causal order and a volume measure to completely specify the structure of spacetime. In a causal set we have the causal order but what about the volume measure? Since the local finiteness ensures a form of discreteness we can simply *count* the number of elements in a region to find its volume. The volume of causal intervals (i.e. all z such that $x \preceq z \preceq y$ for fixed x and y), for example, will always be finite because they contain finitely many elements. We can picture each element in a causal set being assigned a tiny spacetime volume. Counting these tiny volumes up for all elements in a region gives the total volume for the region. For a realistic theory we expect the individual smallest piece of spacetime volume to be of order the Planck 4-volume. The Planck length $\ell_P = \sqrt{G\hbar/c^3}$ is the only quantity with dimensions of length that can be formed from the gravitational constant G, Planck's constant $\hbar$ and the speed of light c. The Planck time $t_P = \sqrt{G\hbar/c^5}$ is similarly the only quantity with dimensions of time it's possible to form. The Planck 4-volume is then $V_P = \ell_P^3 t_P$. It's very small: $V_P \approx 2.2 \times 10^{-148}\mathrm{m}^3\mathrm{s}$. It's this small size that explains why we haven't noticed any spacetime discreteness yet!

At the end of the 19th century most scientists believed matter was continuous. Under a weight of accumulated evidence the theory of continuous matter was thrown out and replaced by the atomic theory of matter. Perhaps the development of quantum gravity will require a similar shift in our understanding

5

of spacetime. If so, causal set theory presents a simple model for discrete spacetime. Hopefully this article has given you a taste of what causal set theory is based on and the review articles listed in the references include more motivations and further references.

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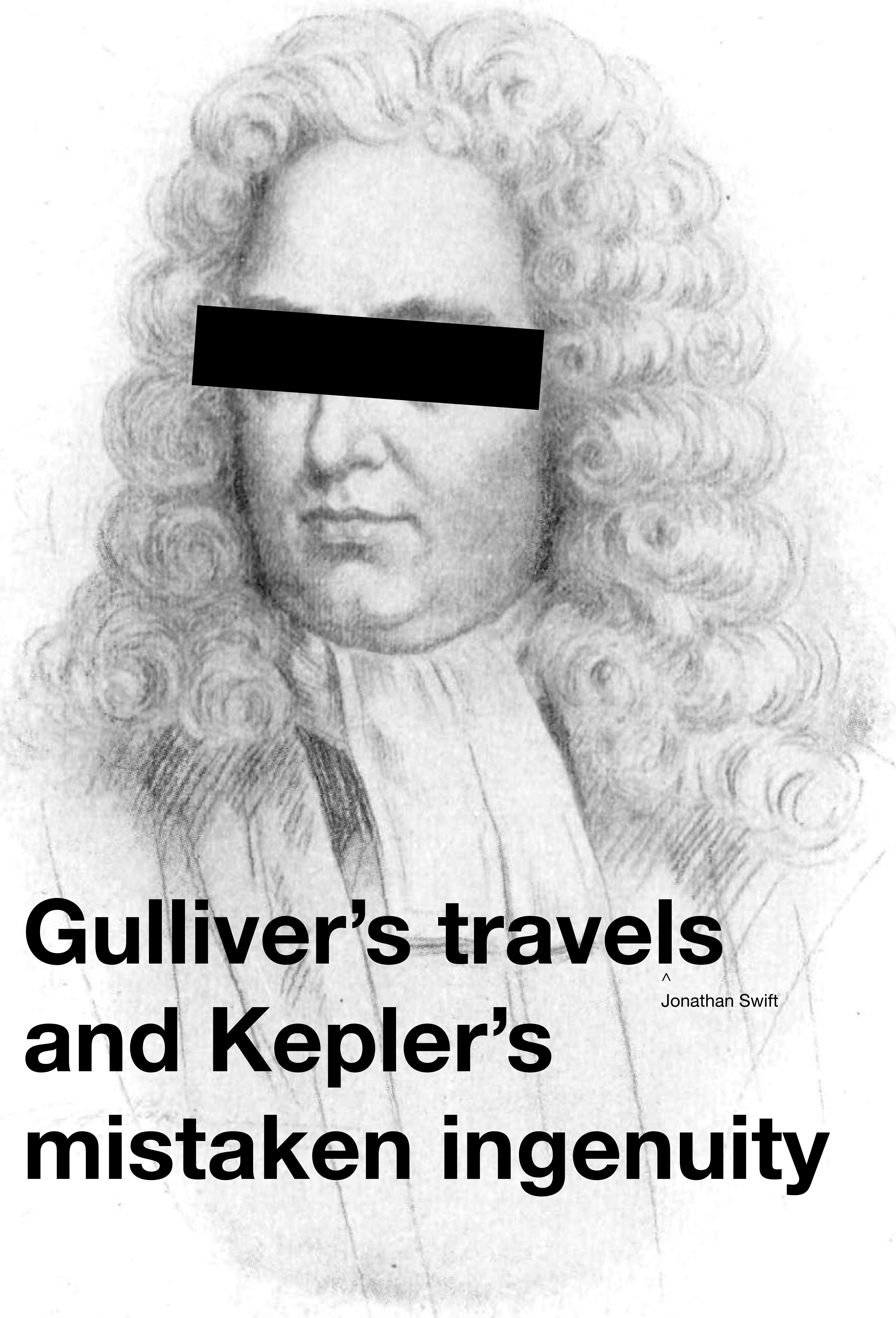

Gulliver’s travels and Kepler’s mistaken ingenuity

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Jonathan Swift

This intriguing tale illustrates how the physics of Kepler's third law of planetary motion influenced the thinking of Jonathan Swift's epic novel 'Gulliver's Travels'. Exploring the relationships and physics discoveries of Galileo Galilei, Johannes Kepler and Jonathan Swift, a proposal is set forth to explain one of the most puzzling passages in 'Gulliver's Travels' and to attempt to find out if Swift really knew the planet Mars had two moons, over 150 years before they were officially discovered.

I first came across the following tale in the excellent book by Derek York, 'In Search of Lost Time'. Since then I have found numerous references and opinions on this tale and developed some of my own. Using Derek York's book as a primary source and supplementing facts from other sources (included in the references) I put together a presentation. The aim of this presentation was to promote interest in physics through the use of mathematics, influential characters and humour. This presentation won the Institute of Physics Young Physics Conference Post Graduate lecture competition 2005 (Dublin, Ireland) and was later presented at the International Conference of Physics Students 2006 (Bucharest, Romania). This is the tale…

Gulliver's Travels – the epic story by the Irish author Jonathan Swift – was first published in 1726. After adventures in Lilliput (a land of little people) and Brobdingnag (a land of giants), the central character, Gulliver, finds himself in LaPuta, a land inhabited by highly intelligent people. It is at this stage of the book (Part III:III:IX) the following 'puzzling' passage appears…

"Certain astrologers… have likewise discovered two lesser stars, or satellites, which revolve about Mars, whereof the innermost is distance from the centre of the primary planet exactly three of its diameters, and the outermost five; the former revolves in the space of ten hours, and the latter in twenty-one and a half;…"

Swift's "two lesser stars, or satellites, which revolve about Mars" are quite obviously a reference to the two moons of Mars, Phobos and Deimos. Although Swift's numbers for the moons' orbital distances and diameters are not completely correct, they are in the right range, differing by approximately 30% from their true values. But here is the puzzle; the two moons of Mars were discovered by Asaph Hall, at the US Naval Observatory, Washington DC in 1877. But this is 151 years after the first publication of Gulliver's Travels. So the question is, did Jonathan Swift just guess Mars had two moons or did he have some scientific insight into his choice, and if so, what?

Immanuel Velikovsky (1895-1979), a Russian psychiatrist, believed he knew the answer. In his well read book 'Worlds in Collision' (1930) Velikovsky claims "The collision between major planets… brought about a birth of comets... at least one of these comets in historical times became a planet (Venus)". He apparently believed that approximately 3000 years ago, out of the belly of Jupiter came forth a comet which hurtled its way through the solar system. This comet narrowly missed Mars (then lying in an inner orbit between the Earth and the Sun) but passed close enough to pull away its atmosphere and send the planet into a highly elliptical orbit around the sun. The comet itself became trapped in the sun's gravitational field and eventually settled down into what we now know as the planet Venus. At this time Mars, during its highly elliptical orbit, passed close to the Earth on a number of occasions. So close in fact that people could not only see Mars and its two moons, but were also able to make detailed observations of the two moons' approximate sizes and periods. These observations, Velikovsky believed, were recorded in an ancient manuscript. Swift, managed to get his hands on this ancient manuscript, hence find out Mars had two moons, but unfortunately this manuscript is now… lost!

Perhaps today's science community would have little trouble dismissing Velikovsky's theory as mere fantasy, so let us look at another possible solution to the two moon problem. Johannes Kepler (1571 - 1630) was conceived on 16th May 1571 at 4:37am. Now, if his parents kept records like that how did they expect their son to grow up to be anything but a scientist! He grew up in a time surrounded by witchcraft and astrology and is probably best know today for Kepler's laws of gravitational motion.

Introducing another great scientist of Kepler's era, Galileo Galilei (1564 - 1642) had been announcing a series of spectacular astronomical discoveries with his telescope. Now it is important to note that Galileo did not invent the telescope, although he did make his own. A man by the name of Thomas Harriett was making detailed maps of the moon in Oxford with his own telescope in 1609 before Galileo had made his first. Galileo was however the first to publish results based on his telescopic observations and hence became associated with the telescope itself. Although not always just, the academic credit generally goes to those who publish results first, as is the case today.

As with many telescopic astronomical observations of the time, initial discoveries came fast but verifications of discoveries took months or even years. The prudent Galileo, knowing well the trade off between publishing first and the time delay to verify results, devised an ingenious system. He would announce his potential discovery in a (Latin) statement, scramble all the letters up into an anagram and send this anagram to his rivals, without spending potentially wasteful time trying to verify their results. If his discovery turned out to be true (i.e. verified by someone else) Galileo would then release the key to unscramble the anagram and hence claim the discovery as his own. Similarly, if the discovery turned out to be false, he would never release the key and hence no one would be any the wiser.

In 1610, Galileo discovered using his telescope what he thought were two moons of Saturn, (they later in fact turned out to be the rings of Saturn). And he wrote:

I have observed the highest planet (Saturn) in triplet

Well, in truth he wrote this in Latin which is:

Altissimum planetam tergenimum observavi

and then scrambled this up into the anagram:

SMAISMRMILMEPOETALEU-MIBUNENUGTTAVRIAS

Now, Kepler got his hands on this algorithm and knowing Galileo had a telescope, was intrigued to determine what Galileo had discovered. Using great ingenuity, Kepler managed to decode this anagram, or at least he thought he had. He unscrambled the letters to form the following Latin phrase:

Salve umbistineum geminatum Martia proles

which Koestler translates as:

Hail burning twin, offspring of Mars

Kepler believed that Galileo had discovered two moons around Mars. This was great news to Kepler because he was a big fan of geometry in the solar system. He knew that Venus had no moons, the Earth one; for Mars to have two, with Jupiter four, created the series 0,1,2,4… which fitted in perfectly with his geometric outlook of the planetary system. Granted, the letters of his unscrambled version didn't perfectly match the anagram, but Kepler was convinced that he had decrypted Galileo's anagram. Now to pose another question, could the idea of Swift's "two lesser stars, or satellites" have originated form Kepler's "twin, offspring of Mars"? Perhaps, but in order to give any credibility to this connection, a link must be shown proving that Swift knew of Kepler and his writings. First, let us take a quick look at Kepler's 3rd Law of planetary motion. It states: The square of the period of any orbital body is proportional to the cube of the semi-major axis of its orbit. Mathematically this can be expressed

$$T^2/R^3 = 4\pi^2/GM$$

Where T = period (time for one complete revolution), R = orbital distance (distance between the centre of mass of each body), G = universal gravitational constant (6.67 x 10-11 N•m^2/kg^2), and M = the mass of the larger (centred) body.

Basically what the equation is saying is that the property period squared over the distance cubed in any closed system is equal to a constant. Or alternatively, that period squared is proportional to the distance cubed. Taking a brief example of the Earth going around the Sun; T = 365.25 days, R = 1 AU (astronomical unit) then T^2/R^3 = 133407 units. Compare this to Mars going around the Sun where Mars has a period T = 686.98 days, R = 1.52 AU this gives T^2/R^3 = 133410 units*. To all intents and purposes the same number (differing only by a fraction of a percent). The equation works. Now, let us look at the rest of the passage from Gulliver's Travels which was started above. It continues:

"…so that the squares of the periodical times are very near in the same proportion with the cubes of their distance from the centre of Mars, which evidently shows them to be governed by the same law of gravitation that influences the other heavenly bodies."

Here Swift is making a direct reference to Kepler's 3rd Law. Let us substitute Swift's values for the periods and distances of his two moons orbiting Mars. The innermost moon (Phobos) has T = 10 hours and R = 3 Mars diameters, which gives T^2/R^3 = 3.704 units†. The outermost moon (Deimos) has T = 21.5 hours and R = 5 Mars diameters, which gives T^2/R^3 = 3.698 units†. To all intents and purposes the same number (differing only by a fraction of a percent). Swift did know of Kepler's writings.

At this point Velikovsky is well within his right to jump back into the tale claiming Swift proves his (what seems outrageous) theory. The reason your moons obey Kepler's Law is because they came from his previously mentioned lost manuscript. This manuscript contained recorded observations of actual moons (as Mars was closely passing by Earth in its highly elliptical orbit!) and actual moons would obey Kepler's laws because that is the way moons behave.' One has to admit, however unlikely, that this is a good argument. Good, but with one small flaw. In 1726 when Gulliver's Travels was first published, the mass of Mars was not known. What has that got to do with anything one might ask. Let us look at the following example: the right hand side of our equation contains all constants, with M being the mass of Mars in this case. Substituting in the true mass of Mars as known today (0.64 x 10^{24} kg) we get a constant of 22.22 units†. Using the value that Swift used for the mass of Mars we get from above a constant equal approximately 3.7 units† as seen previously. But these constants differ by over 600%. Sorry Velikovsky, real moons can't deviate from nature by 600%. Your argument is invalid. Swift knew of Kepler's writings and yes Swift's values equalled the same constant but they equalled the wrong constant. Swift guessed the mass of Mars to make his values work.

So in summary, how could Swift have known about Phobos and Deimos? He could have guessed, it would have been a pretty amazing guess but perhaps a guess none the less. He may have had psychic powers or maybe the Martians told him! He may have got the idea from another writer or philosopher from that era. Voltaire (1694-1778) a French philosopher of the time had mentioned he believed that Mars had two moons, but more so for artistic reasons than scientific ones. Swift may have learnt of the two

* Days^2 / AU^3

† Hours^2 / Mars Diameters^3

moons from Velikovsky's ancient lost manuscript. Or maybe, Swift's "two lesser stars, or satellites" could actually have been Kepler's 'twin, offspring of Mars', which were actually Galileo's 'two moons of Saturn', which were actually the 'rings of Saturn'?

To conclude, did Jonathan Swift just guess Mars had two moons or did he have some scientific insight into his choice, and if so: what? The answer? Well, you decide!

Keith Lambkin

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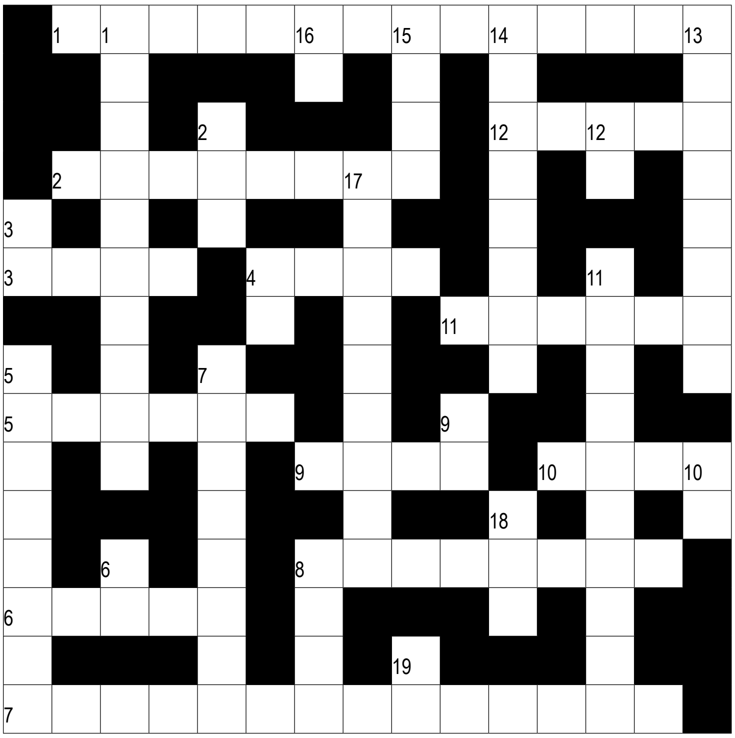
The crossword



Space for scribblings:

Down:

1 Comparatively confusing yet trivial (10)
2 Where quantum mechanics keep their particles (3)
3 Dissolved in water (abbr.) (2)
4 Us, not them (2)
5 Cat story kind of cold (8)
6 Child (2)
7 Positive outlook (8)
8 Dry (4)
9 Alright, comes up from knockout (2)
10 Element 54 (2)
11 Seems like material fallen from the sky (10)
12 Element 88 (2)
13 So far undetected, force carrier particle (8)
14 Creates illusion, sounds like empty unit of mass (8)
15 Titanic moon, mother of gods (4)
16 Therefore (2)
17 To make something less weird (9)
18 Something moving in the sky, don't know what (3)
19 Element 30 (2)

Across:

1 Braking radiation (14)
2 Neutrino could be own antiparticle (8)
3 Joke (4)
4 Conduit for moving electrons (4)
5 Server ate your paper. Course of action? (6)
6 Falling off the stair broke both my ankles (5)
7 Heat and movement collide so my mind rot aches (14)
8 Fly with thin sheets of metal (8)
9 Absorber of heat, particles or whatever you are currently studying. Seen in kitchen. (4)
10 Spaghetti grows on trees, apparently (4)
11 Posh variant on a tent (6)
12 Young insect (5)

Scan and send your solutions to jiaps@iaps.info and be in with a chance to win a copy of **On the Shoulders of Giants** edited by Stephen Hawking. The closing date for entries is September 1st.

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