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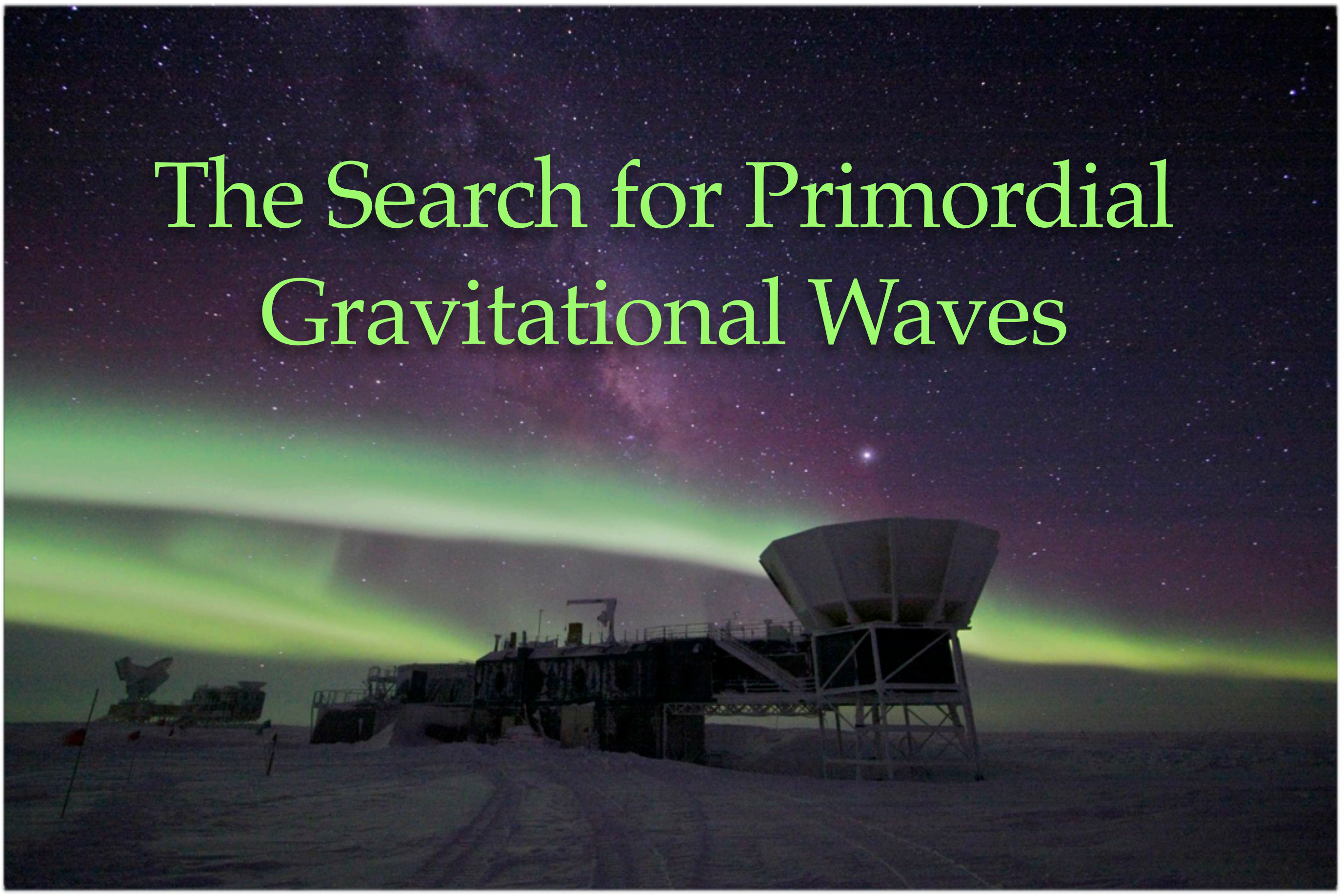
Physics Comment

A Southern African Physics Magazine



A Quarterly Newsletter Issue No 3 & 4

How does Managerialism effect physics students?

Dave Walker's analysis of modern university administration looks this time at the impact on studying physics (p. 23).

SA High School students run experiment at CERN

CERN environment transforms Johannesburg learners into scientists within one week, p. 4 and p. 9.

A whole extra second for 2015!

The background of the earth day, the leap second and modern time measurement, p. 26.

It's 2 minutes to 12 for the nuclear deal

The purchase of eight nuclear reactors has been debated controversially. Two more articles look at the issue, but time is running out, p.7.

Biographies of SA Physicists

Manfred Hellberg! p.12.

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Editor's Note

The unexpected dismissal of finance minister Nhlanla Nene, last week, has brought the nuclear deal, the plan to purchase nuclear power stations to produce 9.6 GW back into the spot light of public interest. According to a report by the Mail&Guardian, Mr Nene refused to sign the nuclear deal because he thought it was too expansive. Remarkably, an article in *Physics Comment* came to the same conclusion in last year's December issue of *PC*; the nuclear deal would be too expensive and not necessary. Ever since then, there has been a discussion among South African physicists whether the nation should spend approximately 1 Trillion Rand for eight new nuclear reactors. The hope of some was that a common position could be found to influence the government decision, possibly via the SAIP and the Academy of Science of South Africa. The latter is the body that can make scientific recommendations to government. This discussion is partly documented in the past two issues of *Physics Comment.* We continue in the current issue on p.7 with an article pro nuclear procurement by the CEO of Nuclear Africa, Dr Kelvin Kemm, and a critical article by a team of physicists from Durban. However, time is limited, since the decision of cabinet is expected soon. Meanwhile, you can make your voice heard and try to change the course of events, for example by a letter to the editor.

This issue of *PC* also features a report on what went wrong with the claim to have detected gravitational waves from the inflation of the universe by the BICEP2 expedition to Antartica, on p.17. In addition, we continue our series of biographies of South African Physicists with Manfred Hellberg's (p.13) and study the amazing effects CERN has on school learners from Johannesburg that won beam time (p.4,9).

With best wishes for the festive season!
Prof Thomas Konrad

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Caption of picture on frontpage: BICEP2 at South Pole (Credit and Copyright: Keith Vanderlinde).

Physics Comment is a journal published by the South African Institute of Physics (SAIP) and appears quarterly . The vision of the SAIP is to be the voice of Physics in South Africa.

News from Africa

South African High School students perform experiment at CERN

by Matilda Heron, CERN, Swizzerland. Reprinted from "[High-school students become CERN physicists for a a week](#)" published by CERN.

Watch related video report here: (https://www.youtube.com/watch?v=8mZLJjR3M44)

From 10–20 September, winners of the [Beamline for Schools](#) competition visited CERN to perform their experiments. Two teams of high-school students – "Accelerating Africa" from South Africa and "Leo4G" from Italy – were chosen from a total of 119 teams, adding up to 1050 high-school students.

"When we were told we'd won we never believed it. People's parents thought we were lying," says Michael Copeland from Accelerating Africa.

Students from Accelerating Africa work on their experiment (Image: Accelerating Africa)

The two teams shared a fully equipped accelerator beamline and conducted their experiment just like other researchers at CERN.

Edoardo Bartalesi from Leo4G working on the team's experiment (Image: Beamline for Schools)

Accelerating Africa is a collaboration of students from St John's College and Barnado Park High School. Their team's experiment used a crystalline undulator – including diamonds grown by specialists – to produce high-energy gamma rays. The team hopes that these gamma rays could one day be used to reduce the half-life of nuclear waste and to treat cancer.

"It makes the classroom come alive. When you sit in the classroom reading textbooks the topics are difficult to conceptualise but now we're living the life of a physicist and doing all of these things that people could only dream of," says Connor Mercer from Accelerating Africa.

Stefano Gagliani presenting Leo4G's experiment at the Beamline for Schools 2015 Prize-winner's event (Image: Sophia Bennett/ CERN)

The team Leo4G is made up of a class of 19 students at Liceo Scientifico Leonardo da Vinci school, 10 of which came to CERN to conduct their experiment. The rest of the students were invited to visit CERN and see the beamline on the last two days of the experiment. Leo4G customised a low-cost web-cam to test whether it could be used as a particle detector.

"The highlight for me was the first time we detected particles. We were so excited, and proud. When the camera was parallel to the beam we saw dots, but we didn't know for certain they were particles, they could have been noise. But when we turned it perpendicular we saw the tracks," says Sabrina Giogetti from Leo4G.

On Sunday [the 20. Sept.], the teams returned home, but the projects aren't finished yet. Both teams are hoping to turn their data into publishable scientific papers. So in between catching up on homework and bringing chocolate to their friends back home, they will be working on the data they took from the experiment.

Read [Accelerating Africa (link is external)](#) and [Leo4G (link is external)](#)'s blogs to find out more. [Because they are so captivating , we have reprinted exerpts from the first blog in this issue of PC - the Ed.]

The Beamline for Schools 2015 students and organisers at the Prize-winner's event (Image: Sophia Bennett/CERN)

Beamline for schools is a CERN & Society project, funded in 2015 in part by the Fund Ernest Solvay, managed by the King Baudouin Foundation, and funded in part by the Motorola Solutions Foundation. Find out more about CERN & Society projects and how to get involved [here](#).

SAIP Launches the SA Physics Olympiad

By Case Rijsdijk – SAPhO Convener and Ndanga Mahani – Projects Officer SAIP

The South African Olympiad is hosted by the SAIP with the aim of identifying young South Africans with ability in Physics, in the hope that these students will continue to study Physics at tertiary institutions and universities within South Africa.

SA, like many other countries, has a need for expertise in Science, Technology, Engineering and Mathematics education, and in particular, SA has started some major international collaborations, including the Square Kilometre Array, SKA, the Southern African Large Telescope, SALT, Laser Technology, Electron Microscopy and ITC: these all require highly skilled scientists. We should aim to use and develop our own talent, and this starts at school level by finding young people with ability in Physics, since Physics underpins all other sciences.

Using the results of the SA National Youth Science Olympiad, SANYSO, hosted by SAASTA, 60 learners from 26 schools were selected from the nearly 19 000 learners that wrote the SANYSO, to write the 50 question Multiple Choice SA Physics Olympiad, SAPhO, on 3 August, 2015.

The results and awards, announced on 18 August, 2015 were as follows. The average mark for SAPhO was 43% and the range of marks was 74% - 22%. The winner, L Geldenhuys, will receive a Gold Certificate, R1 500 as well as a special SAIP medal at the

Annual SAIP Conference dinner in Cape Town on 8 July 2016.

Ranking	Name & School	Result
Winner	L Geldenhuys, St John's College, Johannesburg	74%
Runner up:	H Y Mathivha, Mbilwi Secondary School, Sibasa,	70%
Third place	K Spies, St John's College, JHB.	62%

The runner up receives a Silver Certificate and R1 000. The Third place receives a Bronze Certificate and R 500. Merit Certificates are awarded to those scoring between 50% – 61%. Honourable Mention Certificates for those scoring between 40% – 49%, and Participation Certificates for all other participants.

These results were most satisfactory and it is hoped that next year the SAPhO can be extended to about 150 learners.A number of staff, at both the SAIP and SAASTA, are thanked for their support and making the SAPhO the success that it was.

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Words of wisdom for WiPiSA women

by Humairah Bassa, UKZN

Prof Aletta Prinsloo (second from left), president of WiPiSA, together with female physicists at UKZN.

"Don't be a victim! Take the credit where it is deserved, be thankful for the support you receive and live in the present! " These were just some of the unconventional survival tips for females physicists given by guest speaker Prof Alleta Prinsloo during the women in physics lunch at University of KwaZulu-Natal. The event, organised by Dr Yaseera Ismail on August 11, bought together 13 female postgraduate students and staff members within the department of physics. It was as a result of a WiPiSA initiative with the aim to stimulate interest in physics among females, encourage networking and generate a discussion about the challenges facing women in the field.

The luncheon provided an ideal platform for the attendees to network, share ideas and consider problems in a friendly environment while enjoying a delicious meal together. The issue of balancing a family life with a career in research and the guilt that females feel for any choice they make was discussed in detail. It was emphasised that it is important to take advantage of all opportunities that are presented as well as make one's voice heard in different situtations. On the whole, this event served to strengthen the support structure between females in a male dominated field.

SAIP implements new outreach strategies starting in Limpopo

By Ndanga Mahani – Projects Officer SAIP, Pretoria and Thomas Konrad, UKZN, Durban.

Outreach and public understanding of physics has always been a central objective of the South African Institute of Physics (SAIP), which just celebrated its 60th anniversary at the Annual SAIP conference in June. The new SAIP president, Prof Azwinndini Moranga, who is an expert in outreach, made it clear at the last annual SAIP conference in Port Elisabeth in June 2015, that the institute will emphasize outreach to preserve and grow the discipline and SAIP membership. There are currently more than 600 professionals, academics and students that are members of SAIP, 10% of which are from other African countries or further abroad.

SAIP President Azwinndini Muronga emphasizes outreach to grow Physics.

One of the new strategies of SAIP is to start with outreach as early as primary school. An SAIP delegation headed for Limpopo to implement outreach activities and plans are in place to follow up next year with Gauteng and other provinces. The delegation was lead by SAIP president Prof Azwinndini Muronga and SAIP Marketing & Outreach chair, Prof Regina Maphanga. Also participating were the communication officer of the National Institute of Theorectical Physics and Nsanganeni Mahani, the SAIP Projects officer during the Limpopo visit which lasted for two days, the 7th and 8th October.

Physics outreach starts at primary schools

The delegates visited Mbilwi Senior Secondary in Sibasa, the University of Venda, Belemu Primary School and Makakavhale Secondary School in the rural villages of Lwamondo, the next day followed by University of Limpopo (Turfloop Campus).

At Mbilwi Senior Secondary on the 7th of September 2015 Muronga handed over a SAPhO (South African Physics Olympiad) Silver Award to H.Y Mathivha who had scored second place in the first South African national physics olympiad on 3. August 2015.

From left infront, Mr Lidzhade (headmaster), HY Mathivha (SAPhO Silver Award winner), Prof A Muronga (SAIP), Mr Tshivhase (Circuit Manager), Mrs Mathivha (Parent). Back from right, Mrs Rene Kotze (NIThep) and other educators looking on.

SAIP engaging with the learners at Belemu Primary School...

In an interesting twist of events, it was a personal journey for Prof Muronga. He retraced the the steps of his education as he attended Belemu Primary school then proceeded to Makakavhale Secondary School. After matric at Mbilwi Senior Secondary School Muronga went to University of Venda for his undergraduate studies.

... and Makakavhale Secondary school.

The delegation informed students at the University of Limpopo about career and bursary opportunities in Physics.

Further Outreach Activities of SAIP

By Ndanga Mahani – Projects Officer SAIP, Pretoria

An opportunity to strengthen SAIP outreach from as early as primary-school level presented itself during the National Science Week and the Eskom Expo. In addition these events were used to showcase Physics and the work of the Institute to a broader audience.

National Science Week

During the National Science Week, the Soweto Science Centre of UJ organized a two-day event (7. - 8. Aug.) for primary and secondary school learners at Nzhelele, Vhembe District, and Limpopo. SAIP was represented by the Council's President (Prof. Muronga) and Projects Officer (Ndanga).

A total of 2498 learners and 19 educators participated in the event. SAIP's objective was to introduce the learners to Science and inspire them to pursue a career in Science, Engineering and Technology.

Medunsa

SAIP contributed to a colloquium at the annual BSc carreer fair at Sefako Makgatho Health Sciences University (SMU, formerly MEDUNSA) held on the 15th August 2015. A total of 852 students plus guests participated. The aim was to inform science students at this University about bursaries, internships and possible carrier opportunities in science.

Eskom Expo

SAIP was invited to the Eskom Expo For Young Scientists, Gauteng South Regional Finals, that were held on Saturday 29th of August 2015 at UJ, Soweto Campus. The setting represented a good opportunity to inform learners about careers in Physics and SAIP projects such as the Teacher Development Workshop.

Young Scientist awarded Meiring Naudé Medal

Thomas Konrad, UKZN, Durban

Dr Adriana Marais

Adriana Marais, a post-doctoral fellow at UKZN, was awarded the Meiring Naudé Medal by the Royal Society of South Africa (RSSAf). Named after Meiring Naudé , a former president of the RSSAf who discovered the isotope N15, the medal is awarded annually to scientists below the age of 35, for extra-ordinary scientific contributions. Dr Marais, wrote her PhD thesis on photosynthesis under the supervision of Prof Francesco Petruccione and Dr Ilya Sinyaskiy and studies the origins of life in the framework of Quantum Biology. She has applied to travel and settle on Mars with dutch company Mars One, and is shortlisted together with 99 other candidates. More about Dr Marais' work, ambitions and interests can be found on her website: http://www.adrianamarais.org

Physics and Society

Discussion on planned Nuclear Power Plants

Editorial Note: Since the South African government announced plans in September 2014 to possibly purchase power stations with a total capacity of 9600 MW from Russia there is a debate on whether the country should invest so heavily in nuclear power. An article in PC by Hans Eggers from the University of Stellenbosch analysed the needs based on an updated integrated resource plan commissioned by the SA government. The article echoed the conclusion of the resource plan that, because of revised projections of future economical growth at most two nuclear power reactors are required, which produce not more than 2000 MW.

Members of the previous SAIP council started a discussion with the prospect to find a common view among physicists and thus to be able to give recommendations to society and government concerning the purchase. Part of this discussion was published in the previous issue of Physics Comment (PC June 2015). But the time to give recommendations is limited since, the Department of Energy stated that government was to start the procurement process in July and complete it by the end of the 2015 financial year.

In order to support the discussion in the Physics community and the SAIP Council, PC publishes in the following two articles on the subject, one by Dr Kelvin Kemm, the CEO of Nuclear Africa, a nuclear energy lobby group and the other by physicists from UKZN. Both articles appeared first in the Independent on Saturday (IoS) on the 29th September 2015. They are published here with kind permission of the IoS and the authors.

Pro Nuclear Energy

Kelvin Kemm, CEO of Nuclear Africa, Johannesburg

SOUTH Africa will be building a group of stations to add an extra 9 600 megawatts (MW) of nuclear power to the existing approximately 2 000 MW of nuclear power we generate from Koeberg nuclear power station near Cape Town, which is the only nuclear power station in Africa.

We will be building three nuclear power stations which will collectively produce the required 9600MW in total. We can place two or three nuclear reactors on each site, depending on the type and configuration we choose. That is where this story of five or eight, or any other number of plants comes from, that one reads about.

What were the lessons of Fukushima? The largest earth quake on record, in the Japanese region, produced the largest tsunami on record which then struck Japan's oldest power station. It was a 40-year-old power station built to an obsolete 60-year-old design, and was heading for retirement anyway.What was the result?

No people were killed or injured by nuclear radiation. Private property harmed by radiation also zero. Later, the UN commissioned a multi-country task team to investigate the potential long-term health effects on people, and the conclusion they came to was it would be zero.

So the lesson of Fukushima is that nuclear power is safer than anybody realised.

Koeberg is built to a larger earth-quake and tsunami specification than Fukushima, yet the Cape has no earthquake threat like that of Japan.

South Africa has been in the nuclear business since the 1940s, and is one of the oldest nuclear countries in the world, predating France, China, and Japan.

So why does South Africa want more nuclear power now? The answer is simple, but not apparent. South Africa is about the same size as the whole of Western Europe. There is no such thing as a German electrical grid or a French grid or an Italian grid, they are all heavily interconnected. There is one large pan-European grid in which electricity flows backwards and forwards over their borders all the time.

Even though the Italians claim to have no nuclear power, they are supplied with nuclear power from France, which even supplies to England by means of cables under the English Channel.

But South Africa is on its own, we have no big electricity producing neighbours to bail us out when we need extra power. We just get load shedding.

By far the largest portion of South Africa's electricity is supplied by coal. All the coal is in northern KwaZulu-Natal and Mpumalanga.

The distance from Pretoria, near the coal fields, to Cape Town is the same as the distance from Rome to London. Imagine if London drew its electricity from Rome? Koeberg supplies about half the power of the Western Cape, the other half comes from big coal stations.

A whole power station's worth of electricity is lost by heat and magnetic dissipation as the coal power is pushed all the way to the Cape.

So we have to produce a lot more big power in the south to supply the Western Cape and Eastern Cape, and to lessen the strategic risk to the country, of a very stretched system. Imagine all of Western Europe being supplied with electricity, all from essentially one place.

The only answer is nuclear power. We cannot carry coal to the Cape. In case there are readers saying: "What about solar and wind?" let me remind people that you only get solar in the day time, if there are no clouds or rain, and you only get wind when the wind blows. In any event, worldwide, wind and solar contribute a small amount, no matter what you read or hear.

South Africa built Koeberg on time and on budget. It is a French design but South Africans, working with French companies, built it.

People say to me that the foreign company may supply substandard parts or plans, and we would not know of it. Nonsense. We have highly competent nuclear scientists and engineers who know what they are doing and who know how foreign reactors work.

We also have a National Nuclear Regulator (NNR) which by law has to certify every step of an acquisition and construction process. In turn, our NNR, and our country, have formal legally binding agreements in place with the International Atomic Energy Agency (IAEA). These agreements allow for regular and random inspections by the IAEA during which, by contract, we have to show IAEA inspectors anything that they wish to see. Nothing is off-limits to them.

As far as nuclear sites are concerned, a number have been identified over many years. Three prime sites have been under intensive investigation for half a dozen years. The ground has been geologically drilled, the meteorology has been examined, fauna and flora monitored, tides and currents measured, and much more.

All the site requirement factors comply with IAEA specifications. There is absolutely no way that a nuclear power plant could be secretly built on the old Durban airport site, as some people on the Alice in Wonderland flight of fantasy have claimed.

South African nuclear professionals are good and are internationally recognised.

They know what they are doing and have monitored and guided the country's new nuclear programme every step of the way. Nobody is making a sucker out of us.

It is amazing to hear, at times, the completely way-out claims of self-appointed experts who sprout complete nonsense, and insult South African intellect into the bargain.

I am tired of reading of British or American professors of sociology, pronouncing from their countries, that nuclear power construction is beyond the capability of South Africans.

This country needs nuclear power. We plan to double national electricity output by 2035, Europe has no such objective. Many of our African neighbours are much worse off, being only 5 percent to 15 percent electrified.

Their electricity production must double, and double again, and again. They have to do that for social and economic stability. We have to stand by them for the sake of the stability of the subcontinent. So we have electricity commitments to contend with beyond our national borders.

Do not look to Europe for answers, they are not Africa. Here where the elephants roam and the bushveld seems half dead in winter, and the world's largest sardine shoals make an annual pilgrimage, we have to solve our own challenges, with assured self-confidence.

Author

Dr Kelvin Kemm is a nuclear physicist based in Pretoria and is chief of Nuclear Africa.

Nuclear Energy: Dream or Nightmare?

by Alan Matthews, Peter Krumm, Francesco Petruccione, Thomas Konrad, Durban

The South African government is currently looking at expanding its nuclear energy capacity. According to media reports, there is a strong likelihood that between six and nine nuclear reactors with a total output of 9.6 gigawatts (9.6 million kilowatts) will be ordered by 2016 for a total cost in the region of R 1 trillion, comparable to the government's annual budget. Do we need that additional nuclear energy? What are the benefits, and what are the risks?

That a shortage of electricity causes economic damage in the wake of load shedding was painfully experienced again this year. In order to secure energy, in 2011 Government approved the 2010 version of an Integrated Resource Plan (IRP) for power generation from a mix of energy resources. This provided measures for the period from 2010 to 2030 and was intended to be updated every two years to take into account changing energy needs due to new economic developments.

The 2010 version of the IRP recommended the purchase of 9.6 gigawatts of nuclear power, which is the current Government target. But an updated version of the IRP in 2013 [1] downscaled this to between zero and 4.9 gigawatts due to lower projected economic growth and electricity demand. In fact, the real economic growth stayed below the lowest expectations of the plan. The updated IRP recommends for the lowest growth scenarios no additional nuclear power before 2035.

Another important factor to take into account is the development of energy technologies. For example, related to the respective developments the costs for solar power stations are decreasing in contrast to the costs for nuclear power stations. The updated IRP concluded that it is better to delay the decision to purchase nuclear power stations "… before prematurely committing to a technology that may be redundant if the electricity demand expectations do not materialise (especially in the face of widespread embedded photovoltaic generation)" [1].

While the update of the IRP was commissioned by Government, it was never tabled in parliament nor approved or replaced by another update. This is surprising because it is essential for efficient energy security to take into account recent economic and technological developments.

The benefits of nuclear energy - that can make it seem like a dream - are as follows. First, the energy density of nuclear fuel is vastly greater than fossil fuel. One kilogram of natural uranium produces 40 000 kWh, the equivalent of 16 tons of coal, which means it needs much less space for storage and transport. Second, mainly due to its high energy density, nuclear fuel is relatively cheap and is predicted to be available for at least 200 years. Third, under normal operation, a nuclear power station runs day and night, producing constant and reliable power except for short periods of refueling. Fourth, burning nuclear fuel releases no carbon dioxide and thus helps to mitigate climate change.

On the other hand, nuclear reactors produce radioactive waste containing plutonium which has to be securely stored, for example in salt mines. The waste has to be guarded because the plutonium could be used for nuclear weapons. The practice in South Africa and other countries is to store the waste at the nuclear power station where it is produced. This is not a sustainable solution. Plutonium is radioactive for hundreds of thousands of years and the storage has to be safe against all kinds of catastrophes that may happen in such a long time span. Moreover, nuclear power stations have a life-span of 40 to 60 years after which they must be decommissioned. Estimates of the costs for decommissioning a nuclear power station range from 10% to 100% of the costs of building it. This means a further cost of R 100 billion to R 1 trillion when the eight nuclear power stations are eventually decommissioned.

The nightmare of nuclear energy is a nuclear accident that contaminates a large area of land with radioactivity. This is the highest potential cost of nuclear energy, not only economically, but also humanly and ecologically.

Although the risk of a serious accident in one of 10 reactors within their life span of 50 years is quite low, ranging from 0.01 % to 10 % [2] the consequences are catastrophic. Among the 560 reactors built worldwide since 1960 there have been two major accidents with a meltdown of the reactor cores and release of large amounts of radioactivity into the environment: Chernobyl in 1986 in the Ukraine and Fukushima Daiichi in 2011 in Japan.

The accidents at Chernobyl and Fukushima both led to exclusion zones of 30 km radius around the power stations, and heavily contaminated areas as a result of fallout from the radioactive plume, which are uninhabitable for at least a hundred years. Both involved the evacuation of around 150 000 people and led to costs between R 500 billion and R 1 trillion at Fukushima and between R 200 billion and R 3 trillion for Chernobyl. If a similar accident were to happen at Koeberg when the wind blows from the north, it could require the permanent evacuation of Cape Town and its surrounding wine lands.

Could South Africa live with such a disaster? If the answer is no, then we should search for viable alternatives to nuclear power. Renewable energies such as solar, wind and hydro are the best candidates. Solutions to the problem of energy storage - the main problem with renewables - already exist, at least at limited scale. For example, the Redstone solar plant in the Northern Cape will provide 12 hours of molten salt storage. Costs of renewable energy are falling, and technology is improving. A mix of renewable energy, combined with a smart grid and energy efficiency, is the scenario we should explore.

References

[1] Report commissioned by government: Update of Integrated Resource Plan (IRP) for Electricity 2010 -2030 from 2013 (www.doe-irp.co.za/content/IRP2010_updatea.pdf).

[2] Presentation of the Japan Atomic Energy Commission at 2013 OECD Nuclear Energy Agency workshop: www.oecd-nea.org/ndd/workshops/aecna/presentations/documents/YoshihiroNAGAOKI-EstimationofAccidentRiskCostofNPP.pdf

Authors

Dr A. Matthews is a computational physicist, Prof F. Petruccione and Prof T. Konrad are quantum physicists and Dr P. Krumm is a retired nuclear/plasma physicist. They all live in Durban.

Physics Blog

Accelerating Africa

Excerpts from the blog written by high-school students and their teacher that visited CERN to carry out an experiment. The complete blog can be read here

Editorial note: Johannesburg high-school students from St Johns College and Barnado Park High School won the School beam-line Beamline for Schools competition of CERN together with a school from Italy in a competition with 119 schools from all over the planet. The team was mentored by their teacher Dr Colleen Henning (St Johns) and obtained scientific assistance and training from Prof Simon Connel (University of Johannesburg). The students visited CERN to perform an experiment to create coherent X-ray radiation by accelerating a positron beam through the diamond lattice of Carbon nuclei. A similar form of a "X-ray laser" could possibly be used to recycle nuclear waste. In the following we publish their blog entries indicating an exciting and transforming journey within their 10 day visit from the 10th to the 20th of September 2015.

Safety training at CERN

On the 11 September most of our day was spent learning the different types of safety regulations concerned with the CERN workplace.

We were trained how to react in case a fire breaks out and actually used a fire extinguisher in a simulator. We also learnt different facts about computer security ex. your password is like your toothbrush, you don't share it and change it regularly.

The training was separated into two sections, in France, this is where we learnt fire fighting and how to act in different situations if something were to go wrong and on CERN campus.

Later the day we received all the safety equipment that we are going to use while carrying out experiments ex. a helmet, shoes and a dosimeter which is used to determine the amount of radiation you have been exposed to.

The day's security training ended off with various tests to determine if we are ready to carry out our experiments. Hopefully we have learnt a lot and we can use the training that we have been taught here at CERN at home and in other places

Thrown Into The Deep End.

Imagine walking into the office. It's your first day and you're incredibly excited. You've purchased a new computer, stationery and other necessary utensils to complete the job.You walk in with a sense of purpose and a wiff of arrogance. Your boss asks what you have planned for the day but then you realise that you are in no way qualified to make an informed decision.

This scenario would adequately describe my initial interaction with CERN.

Although we had prepared long in advance – even during our holidays, there was an overwhelming sense of inadequacy. However, we have quickly become 'acclimatised' and we are now in our element with our fears cast a side and the aim of the experiment taking centre stage.

Team members in the counting room learning the ropes

Nevertheless, many difficulties are yet to sporadically appear and multiply; In the world of physics there are no constants.

But the overwhelming passion and yearning for success will help us to 'push frontiers' and I am positive we will do our utmost to make this project a success and bring our new found knowledge back home.

Connor Mercer, team Accelerating Africa

The BGO and the LG calorimeters

Yesterday on the 13th of September, Accelerating Africa and Leo4G had a glimpse into the much anticipated T9 Building where each team will be conducting their experiment. As Accelerating Africa, we were calibrating the BGO calorimeter with different GeV's, first running the whole process without a magnet. However, we encountered a few problems such as the Cherenkovs having differences in their readings and the beam not focusing properly. Therefore it was too wide to gather enough statistics to analyse. Hopefully we can fix all of that today with the help of CERN experts.

A view looking from the calorimeters back towards the beam origin

A view into the counting room spying on a discussion

Another Day of Calibration

The events of 15 September presented us with an ocean of problems and challenges. We couldn't afford to waste any of the time which had been allocated to us. This led to one of the greatest challenges of the day– waking up at 7 o'clock. After we had all dragged our feet out of our beds, some of us slower than others, we had breakfast and proceeded to the analysis room for a team meeting.

We summed up what we wanted to get out of the day. The main goals for the day were to pump out one Cherenkov and remove one Scintillator to reduce the bremsstrahlung radiation and complete the calibration of the BGO.

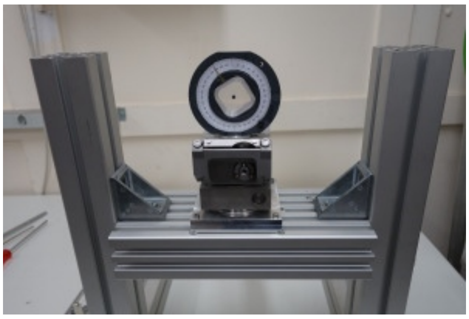
Testing started off and we had to come to an agreement on whether we should or should not change the focus of the beam onto the Italians CCD. It was decided the Leo4G team should temporarily place their CCD camera in front of the veto scintillator which enabled them to detect their first particles.

Professor carefully measuring distances

Measurements of the distances were checked and recorded

Team having a discussion with the experts about the placement of the veto scintillator

Dr Henning in the experimental area next to the bending magnet that will sweep charged particles away from the BGO detector



Our diamond sample holder is complete and is shown mounted on the goniometer. We can now move the diamond around three axes.

A hectic day – 16 September

The 16 September was a hectic day, with all members of the team being engaged in a wide range of activities.

The day started as usual with a status meeting on the experiments. This morning we were fortunate to be visited by Peter Jenni, the former spokesperson of the Atlas Collaboration, one of the big experiments at CERN.

It was fascinating to hear about the history and development of Atlas as well as to gain

CERN should be role model for leaders in all fields

some insight into how to manage a collaboration of over 3000 people working on a project. The CERN model is one that should be an example to leaders in all fields […].

Peter Jenni at our morning talk

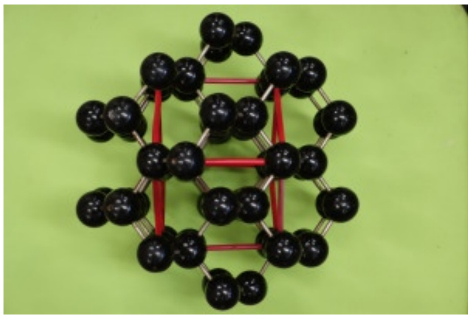
Final experimental runs

September 19 saw us being true physicists wishing for more beam time. We spent many more hours analysing some of the data we already had and making final decisions about the orientation of the E6 Undulator and the changes we wanted to make to our experiment for the final run.

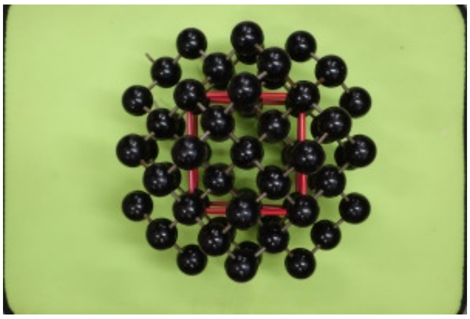
In order to observe undulator radiation, we needed to make sure that the beam was incident on the sample on the 110 direction.

We took some photos of our model diamond. It can be seen from the three photos that the 110 direction is the most open.

C A Henning, Accelerating Africa Teacher



The 110 direction



The 100 direction

Muons in Disguise

After much excitement, and many days of attempted calibration of the beam, the team finally thought that we'd found what we were looking for – photon peaks in the energy detectors. To our extreme disappointment, the peak was simply a collection of troublesome muon particles, with very meddlesome properties! Quite simply, for our experiment, muons = bad. Basically, our brief few hours of victory were silenced when we took the peak for what it really was. We took the misjudgement as fuel for further investigation.

As our experimental time is drawing towards the end, our work load has increased significantly, especially for our experimental supervisors and coaches. Our enthusiasm coupled with daunting stress owing to the impending deadline, spurs us to work late into the night. Amusingly, some people become slightly giddy when required to work after hours.

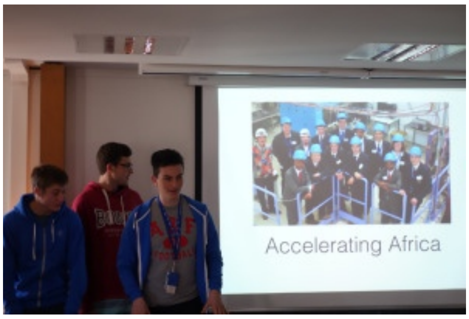
At some point the analysis room becomes a troupe of easily-humoured sloths, or, on the other end of the spectrum, a pen of uncontrollably energised workaholics. Eventually, everything dissipates into demotivation and distraction creeps in, like listening to music, before we finally drag ourselves to bed. I now understand how science knows no bounds. I think a reduction in the price of coffee would be appreciated.

[...] Although the project does not end after our final day of beam-time here at CERN, the prospect of returning to school without having fully achieved our objective, seems somehow anticlimactic, and along with the long-haul flight home, is therefore not eagerly anticipated… This incredible experience has certainly given me, and I am sure my team-mates too, great respect for the work ethic of scientists who work like this on a full-time basis.

Brandon MacKenzie, Team Accelerating Africa

Farewells and more data

It is hard to believe that we have been at CERN for 10 days. It has been the most amazing experience of our lives.



The day started with each team giving a report back of the status of our experiments as well as expressing our gratitude to all the people at CERN who had made the competition possible as well as for supporting us in conducting our experiment.

The Accelerating Africa Team

The team was really sad to have to give back our access cards and dosimeters as it just made it more real that our time at CERN was over.

It has been the most amazing experience of our lifes

The South African and Italian Teams had lunch together and then it was one final adjustment to the experiment.

Fortunately, we could keep using the beam until 8am the next morning. Beam time is very precious.

The teams outside Restaurant 1 after lunch. CERN really is a most magnificent place.

Markus and Tim accompanied us to the airport and then it was time to say farewell and take one last photo. We will always be grateful for this most incredible opportunity.

The good news is that we have a lot more analysis to do and we have seen a tantalizing hint of what we are looking for. The team will continue working and writing up our experiment once we are home.

Hopefully, one day we will be able to visit CERN again.

C A Henning

Obituary

Humairah Bassa

by Thomas Konrad, UKZN, Durban.

It is with deep regret and sadness that we note the untimely death of Miss Humairah Bassa, who passed away after a car accident on Monday, 30th November 2015. She was only 26 years old. Ms Bassa wrote a new item for this issue of *Physics Comment* *(p. 5).*

Ms Bassa was a very talented and exceptionally bright PhD student in my research group at the School of Chemistry and Physics at UKZN. She was top of her Honours class, finished her Masters with summa cum laude and won several awards for her research. She was poised with a great career in science in front of her and students and staff at the School of Chemistry and Physics at UKZN found it hard to comprehend her leaving us now. Moreover, Ms Bassa was a very friendly and unpretentious person, always ready to help others. Her dream was to play a role in uplifting her community. She was a role model for women, in particular of Indian descent and Islamic faith, to follow their professional vocation successfully.

Ms Bassa was very open-minded and interested to learn about different cultures. She used her studies for extended research visits over several months to the University of Freiburg in Germany and to the Wigner Institute in Budapest. Between her Masters and her Phd studies she spent half a year at the University of Konstanz in Germany with a "studium generale". On her most recent visit overseas she went with my research group to the Institute of Mathematical Sciences in Chennai, India. Our hosts, Prof Sibasish Ghosh and Prof R. Simon were fascinated by her scientific talent and her winning personality. She planned to go on Wednesday the 2 December on an extended research visit to her co-supervisor Dr Hermann Uys of Stellenbosch University, to finish her work on the design of a new atomic clock based on unsharp measurements.

Ms Bassa was also a gifted and passionate teacher who was very interested and active in outreach events.

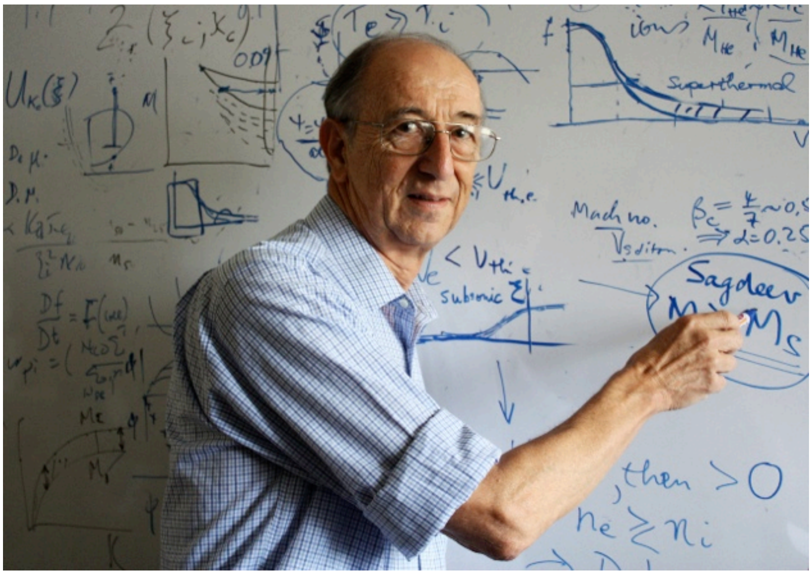
While she studied measurement and control of quantum systems with particular interest in trapped ions for her PhD, she designed for her MSc an implementation scheme for a search algorithm encoding information in a cluster state of four photons.

The following comments stem from academics that have worked with Ms Bassa.
Dr Stef Roux (NLC): "*She was an amazing student with so much promise.*"
Prof Andrew Forbes (Wits): "*I have only fond memories of my time working with Humairah. I found her to be the most peaceful of students: she had an aura of calm about her that one seldom finds. I had the pleasure of several interactions with her in the course of our joint work on quantum computing, spending many hours together in deep technical sessions, and found her to be humble yet technically excellent. In fact, we have our first joint paper coming out soon. It is tragic that we have lost so talented a young lady as Humairah, and so early in her blossoming career.*"
Prof Lajos Diosi (Hungarian Academy of Science): "*Why the beaming young person?* "
Prof Sibasish Ghosh (IMSC, Chennai): "*It is really a shocking news for all of us at IMSc as well as my family members who happened to interact with Ms. Humairah Bassa during her recent visit to Chennai.*"

Biographies of South African Physicists

Professor Manfred Hellberg

Autobiography



Manfred Hellberg was born in Durban in 1938, descended from Lutheran missionary grandparents who came to South Africa in the late 19th century. His father, a language teacher, carried out historical research as a hobby for most of his life, and the hobby led to a PhD at the age of 55. This example had a strong influence on him.

At Rondebosch Boys' High School the teaching of "Tickey" de Jager inspired him to become a nuclear physicist.

At UCT, with distinctions in Physics and Mathematics he entered the first BSc Hons in Theoretical Physics started by Prof John Irving, in 1959. Irving had changed his research from nuclear to plasma physics, setting up a theta pinch experiment with Willem Cilliers, who was later joined by Steve Driver and John Hey.

As a consequence, when Hellberg started an MSc it was not in nuclear physics but in theoretical plasma physics, the subject of his life's work.

His MSc was to model the collapsing shock-front of an imploding cylindrical theta-pinch plasma. In 1960 UCT did not have a computer, so he had to turn to a Marchant electro-mechanical desktop calculator and sheets of foolscap paper to solve a highly nonlinear differential equation numerically. The mathematics of the model related to blast waves, as formed by exploding wires (wires carrying huge currents) and atomic bomb blasts!

Marchant electro-mechanical desktop calculator from the 1960s.

Before the project was completed, he was awarded a Strakosch Memorial Scholarship to Cambridge University where he embarked on a PhD under John Dougherty in the Department of Applied Mathematics and Theoretical Physics (DAMTP) in April 1961. Dougherty later became the founding editor of Journal of Plasma Physics in 1967.

Some South African contemporaries in the Cavendish and DAMTP were David Walker, George Ellis, Gerald Lemmer, and others. He also shared an office with Stephen Hawking until the latter's illness became so severe that he could not climb the stairs.

His PhD involved a theoretical investigation of a rocket-borne RF probe used to measure electron densities in the upper atmosphere. The standard analytical approach required the simultaneous solution of a very large number of differential equations. This could not easily be done on the Cambridge computer, EDSAC[1]. Hellberg turned to Keith Roberts, head of numerical work at Culham Laboratory near Oxford. Roberts

- 1 Described in the brief biography of David Walker (PC Dec 2013) suggested a particle simulation experiment. He offered access to the UKAEA mainframe at Aldermaston, but this did not simply lead to what one now might call remote networking.

At Culham there was a small computer driving a card reader, a magnetic tape unit and a printer, and it was purely an I/O device. The Fortran program was produced on punch cards, one per line of code, the program was then uploaded onto magnetic tape and the tape transported to AWRE (about 56 kms away) by taxi! As Aldermaston was the home of the UKAEA weapons program, it is likely that they had one of the fastest computers in the country. The output from the program was uploaded onto tape, which was brought back by taxi to Culham, where the results were printed. To extract the data from the printout one drew graphs by hand.

Comment by the editor: The Atomic Weapons Research Establishment (AWRE) at Aldermaston used an IBM 7030 (picture, Copyright © 2006 David Monniaux), also known as Stretch. The price of this first transistorised supercomputer of IBM in 1960 amounted to $13.5 Million.

Such computer simulation was a new technique in plasma physics – and so Hellberg carried out the first plasma particle simulation study in the UK, following on some US and French work. Towards the end of his thesis work, Hellberg was appointed a Research Associate at Culham, where he was involved *inter alia* in setting up a general purpose differential equation solver, while writing up the thesis in the evenings.

After completion of his PhD late in 1965, Hellberg became a Lecturer in Physics at the University of Natal in Durban (UND) under Prof Desmond Clarence, and a year later was appointed to a vacant Senior Lectureship. Clarence, who worked in atmospheric electricity and whistler wave propagation, headed a very happy and successful team in Physics. He later was Vice-President of SAIP for three terms and became Vice-Chancellor of UN.

There was already plasma activity at UND under John Martin. An MSc student of Martin's at the time was Krish Bharuth-Ram, before he went to Oxford to do a DPhil in nuclear physics. The university had just acquired its first computer. Later Peter Krumm joined the experimental effort. The plasma research group grew, even after the departure of Martin to the USA. The arrival of Peter Barrett, with experience at Harwell and UCLA, in 1972 saw a switch in experimental interest to electrostatic waves and instabilities in plasmas. With a PhD from Iowa, Michael Alport returned to SA and brought further plasma wave expertise. Max Michaelis and Peter Cunningham built up laser-plasma and hot-gas lens studies, and John Hey later brought plasma spectroscopy research to the group.

In 1971 Hellberg spent a sabbatical year at the Princeton Plasma Physics Laboratory in the group of John Dawson, modelling plasma diffusion to the walls of the vacuum chamber of a large toroidal fusion device, the Stellarator. It was a very exciting experience, with the young postdocs, particularly, working extremely hard. The work ethic was quite infectious! During that time, he experienced what was a major computing breakthrough, the introduction of screen editing replacing jobs submitted on punched cards.

Later sabbaticals and extended research visits included 5 visits to the Max Planck Institute for Plasma Physics in Garching, Germany, as an Alexander von Humboldt Research Fellow and as a Max Planck Fellow, as well as research at the MPI for Extraterrestrial Physics (Garching), Institute for Fusion Studies at the University of

Texas (Austin), Royal Institute for Technology (Stockholm), University of Ghent, Ruhr University (Bochum), and Sydney University.

With support from the then Atomic Energy Board, the University established the Plasma Physics Research Institute in 1979, with Hellberg as Director. This promoted strong interaction between the AEB and UND until in 1992 the AEB stopped work on its small tokamak, and ended their support of the University's plasma research.

Much of Manfred Hellberg's research interest up to that point related to the study of waves and instabilities in fusion-related plasmas. With the demise of the AEB project, his interest turned to waves in space plasmas instead. The emphasis has been on obtaining better understanding of wave phenomena, both linear and nonlinear, rather than on space physics *per se*. A particularly fruitful development has been his studies, with collaborators, of the effects of high-energy particles found in the non-Maxwellian tail of many observed velocity distributions in space. These may be represented by the so-called kappa distribution.

Internationally, Manfred was involved in a variety of activities. He served on the IUPAP Commission C16: Plasma Physics for 3 terms, from 1987 to 1996, including a term as Secretary of the Commission. He was on the Editorial Board of the journal Plasma Physics and Controlled Fusion, published by the UK IoP and Pergamon Press, for two terms from 1985 to 1988, and was then a member of the International Editorial Advisory Panel for the IoP Plasma Physics Series from 1990 to 1996. He has served on the international advisory committees of about 20 conferences. In particular, he was a member of the IAC of the major plasma physics meeting, the International Congress on Plasma Physics (ICPP), for 25 years, covering 13 conferences, before standing down last year. Together with Ramesh Bharuthram, he co-convened the 5th International Conference on the Physics of Dusty Plasmas in Durban in 2002.

In 1992, Manfred was elected a Fellow of the University of Natal (now UKZN) and the Royal Society of South Africa, on whose Council he subsequently served for one term. In 1998 the Institute of Physics (London) elected him to Fellowship, and in 2000 he was elected a member of the Academy of Science of SA, and was a member of the Council of ASSAf from 2004 to 2010.

He first attended the annual Conference of SAIP as an Honours student in 1959. From 1965 he participated regularly in the conferences. He chaired the committee that led to the establishment of the first annual Postgraduate Winter School in 1983, and served on the Council from 1991 to 2001. From 1993 to 1997 he was Vice-President (including 6 months as Acting President) and was President from 1997 to 1999. He was elected an Honorary Member in 2003 and in 2014 was awarded the 20th SAIP De Beers Gold Medal, together with election as Fellow of the SAIP.

Panel "Shaping the Future of Physics in SA" from the left: Manfred Hellberg, Professor Sir Arnold Wolfendale (UK), Dr Kenneth Evans-Lutterodt (USA/Ghana), Dr Igle Gledhill, Prof Krish Bharuth-Ram, Prof Gebre Tessema (USA/Ethiopia), Professor Jim Gates (USA), Prof Martial Ducloy (France).

Hellberg served on the National Liaison Committee for IUPAP from 1985 to 2000, including acting as Chairman from 1991 to 1996. He led the South African delegations to the IUPAP General Assemblies of IUPAP in 1993 and 1999. The latter meeting coincided with the centenary celebrations of the APS, at which he and Prof Frank Nabarro represented the SAIP. He also served on the National Astronomical Facilities Board (1994-99) and the Advisory Board of the National Laser Centre (2000-07).

He has contributed in particular to three activities that have helped to strengthen aspects of physics in South Africa. While he was President of SAIP, the Optics group reported to him that the major laser-based isotope separation project at NECSA was threatened with closure. He immediately took steps to interact with DST and NRF on this matter, and they provided strong support to ensure that the laser activities not only survived, but were considerably strengthened through the subsequent establishment of the National Laser Centre.

From the left: George Miley, Renee Kraan-Korteweg, George Ellis, Manfred Hellberg, Harm Moraal and Sunil Maharaj.

In the first years of this century, many in our physics community were concerned about a drop in student numbers, and what that would imply in future for both physics and science more generally in South Africa. The SAIP Council obtained the support of DST and NRF to appoint an 8-member international panel to carry out an investigation entitled “Shaping the Future of Physics in SA” in 2004. Manfred Hellberg was appointed as convenor of the group, which included Igle Gledhill and Krish Bharuth-Ram, together with 5 leading international physicists. The panel produced a 110 page report containing numerous recommendations, aimed both at funders and at university Physics Departments and others. Many of the proposals fell on receptive ears, and, thanks to the continued drive by successive SAIP Councils, and support from the DST and NRF, a number of important recommendations have come to fruition.

From the left: Dr Phil Mjawara (Director General of the Department of Science and Technology), Manfred Hellberg and Mrs Naledi Pandor (Minister of Science and Technology).

In 2010, he was appointed by the Minister of Science and Technology, Mrs Naledi Pandor, to prepare a report on strategies and policies to develop Astronomy in South Africa. This step was taken a few months after the unfortunate “Phil Charles affair” affected the local astronomy community. A 5-member Reference Group, consisting of 4 South Africans (George Ellis, Renee Kraan-Korteweg, Sunil Maharaj and Harm Moraal) and George Miley, the Vice-President of the International Astronomical Union, was appointed to provide him with expert advice in regard to different aspects of both astronomy and the related South African science scene. The Minister accepted most of the recommendations in the report. Ramesh Bharuthram was then appointed to head the Astronomy Desk during the implementation phase, which led inter alia to a consolidated 10 year plan for astronomy.

Since 2003 Manfred has annually lectured in the NASSP MSc programme, and has enjoyed the cultural mix that the students represent. His many research students include Ramesh Bharuthram, Satya Baboolal, Igle Gledhill, Diane Grayson, Richard Mace and Thomas Baluku, while he has also enjoyed fruitful collaboration with Frank Verheest (Ghent) and Ioannis Kourakis (Belfast) and their students.

Although he formally retired more than 11 years ago, he is still enjoying his research on kappa distributions and electrostatic solitons in plasmas. There is little sign of his "hanging up his boots," as he continues to be productive with the help of a number of co-authors, and citations are running at up to 400 p.a.

However, he is looking forward to spending more time with his wife, Karin, who has patiently provided him with outstanding support in all his endeavours over the last 52 years, their two daughters (in Hilton and in Winchester, UK), and their four grandchildren.

Articles

In search of primordial gravitational waves from the Big Bang: the aftermath of BICEP2

By Martin Bucher, Laboratoire Astroparticules et Cosmologie, Université Paris 7 (Denis-Diderot) (*) and ACRU, School of Mathematics, Computer Science and Statistics, University of KwaZulu-Natal.

The Harvard-Smithsonian Center for Astrophysics announced a press conference for 17 March 2014 the subject of which was left unspecified, but it was made known that something big was going to be announced. Rumors and speculation abounded, and the number of people trying to connect to the internet simulcast was so large that the Harvard servers were brought down, resulting in a blackout for those not physically present in the lecture theater. At the press conference Harvard's John Kovac flanked by the other three BICEP2 PIs announced that BICEP2 using its single *150* GHz channel had observed a B mode signal of the polarization of the microwave background having a magnitude substantially larger than expected. The BICEP2 team attributed this signal to primordial gravitational waves generated during inflation [1,2]. A few days later Stanford Public Relations posted on Youtube a video clip of Stanford professor Chao-Lin Kuo showing up at his theorist colleague Andrei Linde's door to present him with a bottle of champagne to celebrate. The generation of very long wavelength gravitational waves was a prediction of cosmic inflation. In the 1980s Andrei Linde had played a substantial role in the development of the theory of cosmic inflation. The Youtube video was viewed almost *3* million times, a Stanford record beaten only by Steve Jobs' 2005 commencement speech.

FIGURE 1: BICEP2 at South Pole. BICEP2 is a 26 cm CMB telescope with 500 highly sensitive bolometric detectors situated at the South Pole, a location ideally suited for minimizing atmospheric interference because of the low water vapor column density there. In March 2014 the BICEP2 team announced having discovered primordial gravitational waves from inflation with a tensor-to-scalar ratio of $r = 0.20^{+0.07}_{-0.05}$. *Subsequent analysis, however, cast doubt on this claim on account of an underestimation of the contribution of the polarized emission from interstellar dust in our own galaxy. BICEP mapped a small patch of the sky in a microwave band centered around 150 GHz. (Credit: Keith Vanderlinde).*

Inflationary cosmology at the classical level provides a mechanism for erasing whatever irregularities may have existed prior to inflation and can explain why our universe appears very smooth – that is, almost homo-

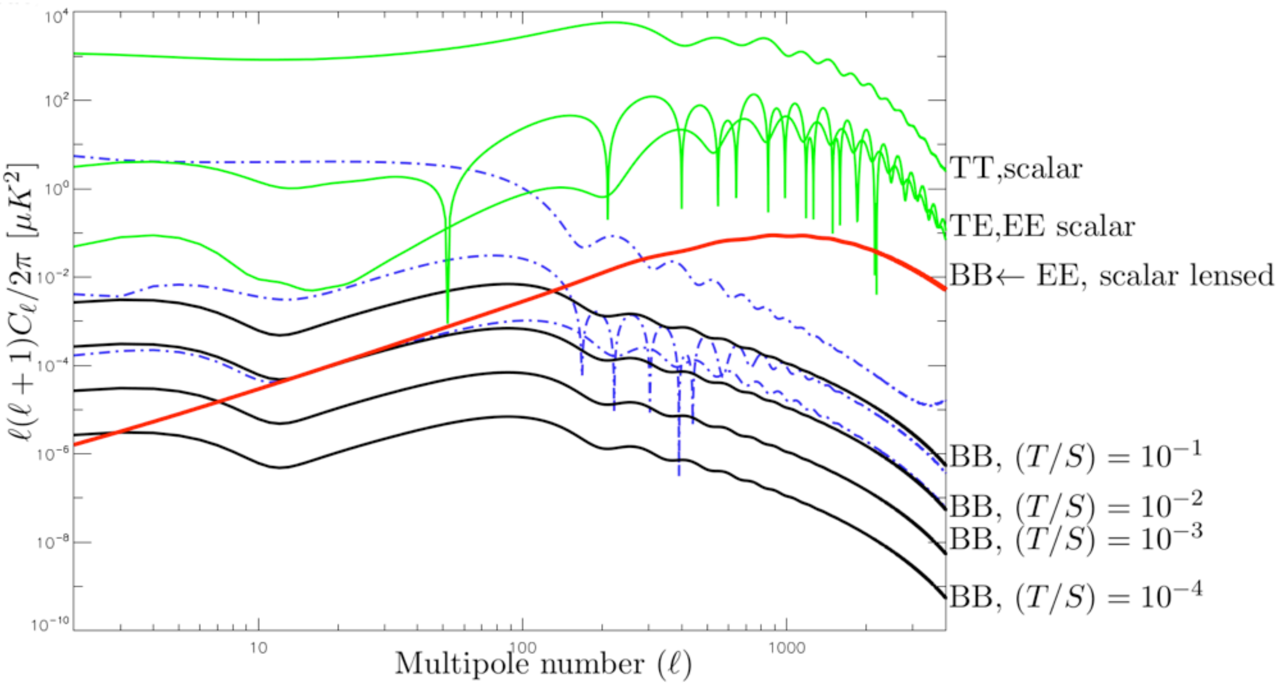


FIGURE 2: Theoretical predictions for CMB power spectra from inflation. Shown are the CMB power spectra predicted by a simple inflationary model assuming values for the cosmological parameters inferred from the Planck data. The horizontal axis represents the multipole number (ℓ) and the vertical axis shows the power in units of μK^2 defined so that the value indicated corresponds to $dP(\ell)/d[\ln(\ell)]$. The green curves represent the power spectra resulting from the scalar cosmological perturbations, those arising from quantum fluctuations of the inflaton field. Power spectra may be defined using auto- and cross-correlations of the T (i.e., Stokes intensity I) component and the two components of the polarization: the E mode and the B mode. The E mode is the polarization component that can be represented using a scalar potential on the celestial sphere and the B mode is the other component that cannot be so represented [for a more detailed discussion see for example Ref. 7]. The B mode is an especially powerful probe of gravitational waves, or tensor modes, produced during inflation because at linear order `scalar' cosmological perturbations cannot excite the B mode. For this reason searching for B modes is the most powerful, and moreover most model independent, way to uncover small values of r. At nonlinear order, however, scalar perturbations excite the B mode with a small amplitude through gravitational lensing. But this nonlinear correction (shown in red) is small and calculable, and therefore can be accounted for when searching for values of $r \approx 10^{-2}$. The dashed blue curves represent TT, TE, and EE power spectra from the tensor perturbations assuming r=0.1. However the value of r is presently unknown. Since a logarithmic scale has been used for the vertical axis, these curves rigidly slide up or down as the value of the tensor-to-scalar ratio, denoted as r or T/S, is varied. The black curves show the B mode spectrum for several values of r. The goal of B mode experiments is first to detect a nonzero value of r at high statistical significance and then to characterize the shape of the tensor spectrum as measured through the B modes. One should appreciate the broad range of scales spanned by the vertical axis, from as large as ≈ 30 μK for the $c_{TT}^{(scal)}$anisotropy (first discovered by COBE in 1992) down to a few nK for the tensor B mode for $r \approx 10^{-3}$ which is the goal coveted by future B mode experiments presently being planned. (Credit: M Bucher)

geneous and isotropic – on the largest scales observable to us. However when quantum fluctuations during in flation are taken into account, a universe with predictable departures from homogeneity and isotropy results. For a given inflationary model these predictions can be calculated (using free field theory) and confronted with observations. To date the so-called 'scalar' perturbations of the universe have been mapped with exquisite accuracy [3]. In inflationary cosmology these perturbations result from quantum fluctuations of the scalar inflaton field, which advance or retard the moment when inflation ends. But the scalar inflaton field is not the only field that becomes disordered in this way. The graviton field (as any quantum field on account of the uncertainty principle) also suffers such quantum fluctuations. This disordering of the graviton field during inflation manifests itself today as gravitational waves having substantial power on large scales, extending to wavelengths as large as our present causal horizon. The amplitude of the gravitational waves, or tensor modes, generated during inflation is quantified by the tensor-to-scalar ratio $r = T/S$ where S and T are the primordial power of the scalar and tensor cosmological perturbations, respectively. Prior to BICEP2 the best limit on r came from the Planck temperature power spectrum, giving $r < 0.11$ at 95% confidence in the framework of the minimal six-parameter concordance cosmological model [3]. Because r is directly proportional to $E_{\rm inf}/M_{\rm pl}$ where $E_{\rm inf}$ is the energy scale of inflation and $M_{\rm pl}$ is the Planck mass, a determination of r would provide a new window on quantum gravity and on physics beyond the standard model, far beyond the energies that could ever be probed with future accelerator experiments. A measurement of r would provide badly needed clues and hard constraints for theorists trying to tackle quantum gravity and physics near the Planck scale. The discovery of primordial tensor modes would constitute a confirmation of a remarkable prediction of inflation. [See Ref. 7 and references therein for a recent, in-depth review of many of the issues discussed in this article.]

The aftermath of the BICEP2 announcement involved many twists and turns over several months. Initially the BICEP2 claim was greeted with great enthusiasm, both by the world press and by many in the scientific community excited to learn of a new breakthrough in our understanding of the primordial universe. However as scientists specialized in the Cosmic Microwave Background (CMB) and in galactic astrophysics began to scrutinize the BICEP2 interpretation of their single channel B mode detection, serious doubts began to emerge whether the B mode signal in the 150 GHz map could only be explained as arising from a primordial signal as the BICEP2 team had argued. In particular questions were raised as to the likely contribution from polarized thermal dust emission from our own galaxy. In the BICEP2 paper the possibility that such dust emission could account for the observed signal had been peremptorily dismissed. In their paper the BICEP2 team reported forecasts from six distinct dust models, but the details of these models as well as their observational basis were not specified. One of the obstacles was the absence of publicly available data required to serve as a basis to render credible a polarized dust model for the BICEP2 field.

Most CMB experiments observe the microwave sky in several bands spanning a broad range of frequencies. This allows one to characterize and exclude non-primordial contaminants from the final CMB maps. The NASA WMAP satellite, launched in 2001, for example, produced maps of the full microwave sky in 5 bands centered at *23*, *33*, *41*, *61*, and *94* GHz. The subsequent ESA Planck satellite, launched in 2009, produced maps in *9* bands at *30*, *44*, *70*, *100*, *143*, *217*, *353*, *545*, and *857* GHz. BICEP2, by contrast, observed using only a single frequency channel centered at *150* GHz. Unlike WMAP and Planck, BICEP2 did not observe the full sky, but rather integrated deeply over a small patch covering only about *1%* of the sky, which had been selected for its small dust emission in unpolarized intensity.

The BICEP2 strategy, similar to that of competing groups, might be summarized along the following lines. Rather than building an experiment that would straight off both detect a B mode signal and convincingly demonstrate its primordial origin, the strategy would be to first build an instrument that could detect B modes at a single frequency, and then in subsequent observing seasons add channels at other frequencies in order to remove contaminants and thus determine the primordial B mode contribution. This strategy makes sense for a number of reasons. Firstly, the search for B modes requires unprecedented sensitivity. This does not just mean raw detector sensitivity but also correspondingly stringent control over systematic errors. In an experiment with one or a few frequency channels more constraining cross checks are available than in an experiment with a very large number of channels. Secondly, inflationary theory unfortunately does not make a clear prediction for the expected amplitude of the tensor modes. For a space experiment such as WMAP and Planck such an evolutionary strategy is not an option. For observations from space everything must be planned out in advance and perform perfectly the first time around. Ground and balloon based experiments typically involve a succession of observing seasons over which an instrument can be deployed in stages and modified taking into account the results and experience from previous observing seasons.

In May 2014 Flauger, Hill and Spergel released a preprint criticizing the BICEP2 assessment of the possible contribution from dust arguing that dust could account for all of the B mode signal. Discussions abounded on the web and in blogs. Finally in September 2014 the Planck team released a preprint providing a detailed characterization of the degree of polarization of the dust emission over the whole sky based on the Planck high frequency maps, in particular the maps at *217* and *353* GHz. This paper broadly corroborated the arguments of Flauger et al. It was found that the fractional degree of dust polarization was greater in regions where the intensity of dust emission is small.

While showing that dust could account for all of the signal, the Planck analysis of the dust polarization could not exclude the possibility that part of the signal in the BICEP2 map could be primordial B modes. A more telling analysis required studying the cross- and auto-correlations of the BICEP2 and Planck maps, and since neither of the groups had released their raw maps, this required an agreement to work together on a joint analysis for which an MOU was agreed upon. This joint analysis also included data from the Keck Array, a next-generation telescope of the same collaboration as BICEP2 having *2560* detectors at *150* Ghz. While the BICEP2 and Keck Array maps of the square degree BICEP2 patch at *150* GHz were greatly superior in sensitivity to the Planck *143* GHz map, the Planck polarization map at *353* GHz, a frequency in the Wien tail of the CMB spectrum and thus containing almost exclusively polarized dust, provided the essential template for assessing the contribution from dust. Ground based microwave observations above approximately *200* GHz become extremely challenging because of atmospheric interference and thermal loading.

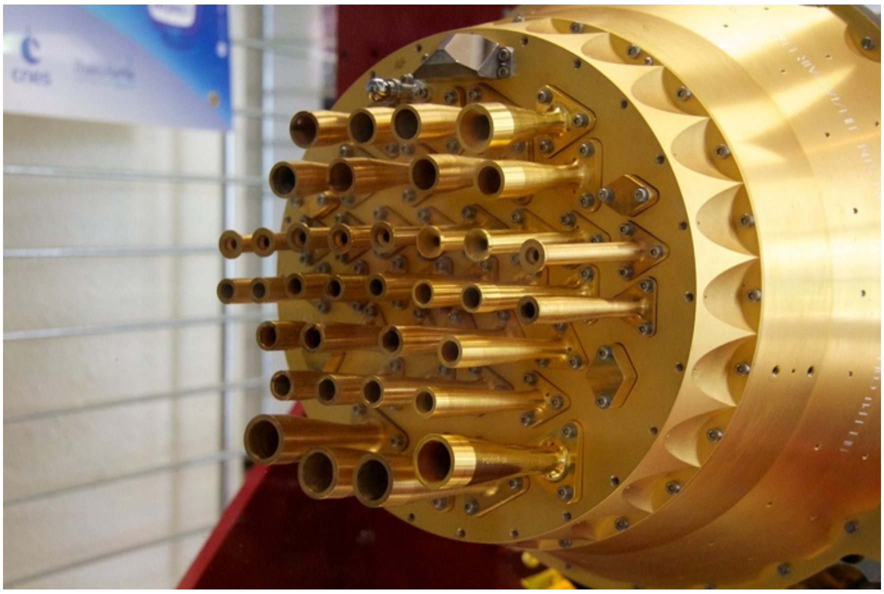


FIGURE 3: Focal plane of the Planck HFI instrument. Planck was a satellite launched by the European Space Agency in 2009 with the aim of mapping the entire sky both in temperature and in polarization over a broad range of microwave frequencies using 9 bands ranging from 30 to 850 GHz. Shown are the 34 microwave feed horns on the focal plane of the Planck High Frequency Instrument (HFI) used to map the microwave sky in the Planck bands at 100 GHz and above. The Planck high frequency maps proved invaluable for determining the contribution of polarized galactic dust emission to the B mode signal seen at 150 GHz by the BICEP2 team. (Credit: European Space Agency/Photograph by Mike Peel)

The joint analysis resulted in an upper limit on the scalar-to-tensor ratio rather than a detection [6]. Even though the numerical upper limit of the BICEP2/ Keck and joint analysis of the primordial B mode signal is almost identical to the constraint previously inferred from the Planck temperature power spectrum alone, this new upper bound represents a substantial improvement because of its robustness. While the previous limit was highly model dependent, the new limit does not rely on assumptions regarding the simplicity of the underlying cosmological model. This new limit represents the first time that a competitive limit on *r* was obtained by exploiting the B mode polarization alone.

We have already explained the physics of the primordial CMB B mode signal and now turn to describing the various non-CMB contributions to the microwave sky with an emphasis on those components that are polarized. The two principal polarized foreground contaminants are non-thermal synchrotron emission and polarized thermal dust emission. Synchrotron emission arises from galactic cosmic rays radiating as a result of their acceleration as they spiral around in the magnetic field of our galaxy. Synchrotron radiation is non-thermal having a Rayleigh-Jeans (R-J) brightness temperature[1] that increases with decreasing frequency. Its spectrum is smooth and well approximated by a power law. The ga-

[1] The Rayleigh-Jean brightness temperature is the specific intensity I_ν converted into a temperature using the power law for the Rayleigh-Jeans (classical) part of the the blackbody spectrum regardless of its validity.

lactic synchrotron emission is polarized, the direction of its linear polarization determined by the orientation of the magnetic field appropriately averaged over the line of sight.

Polarized dust emission, by contrast, has a Rayleigh-Jeans brightness temperature behaving in the opposite way – that is, $T_{R\text{-}J}$ increases with increasing frequency. It has been apparent since ancient times that interstellar dust permeates our galaxy. In areas with no urban light pollution, the sky as seen by the naked eye exhibits dust obscuration along the galactic plane. Absorption is greatest at optical and higher frequencies, but toward lower frequencies where the wavelength is greater than the dust grain size (typically of order 10-100 nm), the obscuration diminishes, for the same reason that radar can penetrate through ordinary clouds that are opaque in the visible. At very low frequencies a dust grain may be thought of as a dipole oscillator, or more precisely as a triplet of dipole oscillators along three spatial directions that radiate as a consequence of stochastic thermal fluctuations of the constituent charges within the grain. The dust spectrum at low frequencies is typically approximated by a power law of the form $T_{R\text{-}J}(\nu) = (\nu/\nu_0)^{\beta} B(T_{R\text{-}J};\, T_{\text{dust}})$ where $B(T_{R\text{-}J};\, T)$ is the spectrum of a blackbody at temperature T and β is the dust emissivity index (found by Planck to be $\beta \approx 1.6\text{-}1.7$) and T_{dust} is the dust grain temperature $T_{\text{dust}} \approx 20$ K. If all dust grains were spherically symmetric, thermal dust emission would not be polarized at all. Likewise, even if the grains are non-spherical but without there being a mechanism to create a common average alignment, the net polarization averaged over many dust grains would be completely negligible.

In 1949 Hiltner and Hall discovered that interstellar dust grains are aligned, presumably by the galactic magnetic field. They observed that starlight is linearly polarized at the few percent level. In the years that followed this discovery, a series of theoretical papers appeared elucidating various possible mechanisms to explain the observed grain alignment. The problem is more challenging than one might think at first sight on account of the weakness of the galactic magnetic field, which must overcome competing stochastic disalignment mechanisms. Although much of the relevant physics was considered shortly after the Hiltner and Hall discovery, over the following decades new elements of physics that had been overlooked were pointed out, and it is not clear that our present understanding is the last word on the subject.

In a nutshell, our understanding of dust alignment can be summarized as follows. A simple "compass needle" alignment mechanism is not able to produce the required degree of alignment because of the counteracting disalignment tendencies, for example from collisions of gas molecules with the dust grain. This conclusion follows from statistical mechanics assuming plausible magnetic properties for the dust grains. It was later realized by E.M. Purcell in 1979 that dust grains spin suprathermally – that is, the energy in the rotational degrees of freedom of the dust grain far exceeds $O(k_B T)$ where T is any temperature that could be used to characterize the grain environment. This is possible because the grain and its environment are out of thermal equilibrium. For example, a grain may absorb photons in the UV having a very high effective temperature and expel the heat thus absorbed in the IR, which is at a much lower effective temperature in such a way that coherent torques result. Thermodynamically this process is much like an engine where work can be extracted by absorbing heat at a higher temperature and expelling it at a lower temperature. The recoil from catalytic production of molecular hydrogen (H_2) from atomic hydrogen at a small number of sites on the grain surface constitutes another plausible mechanism for generating coherent torques. A rapidly rotating grain, which may be thought of as a sort of top or gyroscope, is much less affected by random collisions with gas molecules than a grain rotating thermally.

The fundamental problem is aligning this dust grain gyroscope with the magnetic field, and two basic mechanisms have been proposed. Before describing these two proposals, we briefly digress to explain how the dust grain acquires a magnetic moment and why as a result of a hierarchy of time scales this magnetic moment on the average can only be aligned parallel to the magnetic field line. For a grain composed of a non-ferromagnetic material, a magnetic moment of a rotating grain can arise in a number of ways, for example from a nonuniform distribution of electric charge within the grain. Moreover, if there are free spins, as a result of the Barnett effect these spins will align themselves to absorb part of the total angular momentum thus reducing the bulk angular momentum in order to minimize the free energy. Such a magnetized grain will precess in the galactic magnetic field, so that its average orientation is always parallel to the magnetic field. But all these effects are conservative, and what is needed to produce net alignment is some sort of dissipation tending to tip the spin in a direction more parallel to the magnetic field lines. The first scenario is known as the Davis-Greenstein (D-G) mechanism, which relies on magnetic dissipation to produce alignment as a result of the imaginary part of the magnetic susceptibility. In principle this mechanism would create alignment, but when realistic numbers are inserted it turns out that the Davis-Greenstein mechanism time scale is extremely long, perhaps much longer than the time scales associated with competing disalignment from random torques. For a long time the D-G proposal was the only game in town, so it was thought that parameters must be so that it worked. Later a second scenario was proposed that involves radiative torques, which can create alignment if the UV illumination of the dust grain is anisotropic, as explained in a series of papers by Draine and Weingartner [8]. Under anisotropic illumination at short wavelengths (so that the wavelength does not greatly exceed the grain size), there is a small torque associated with each orientation of the grain with the anisotropic illumination resulting in a non-conservative dynamical system. In a study based on a few conjectured irregular grain shapes, Draine and Weingartner showed that these torques could produce the required alignment.

The lesson to take away is that the physics of interstellar dust, especially as it relates to grain alignment and polarized emission, is complicated and not yet completely understood. Polarized dust emission may well not be as simple as hoped. Its degree of complexity will determine how hard it is to remove it to produce CMB polarization maps that are uncontaminated at the required level, which obviously also depends crucially on the value of r.

Currently there is much discussion on how best to proceed in the quest to discover tensor modes, or alternatively to establish the best upper limits on the tensor-to-scalar ratio r. On the one hand, there are many ground based experiments in progress. At the South Pole BICEP2 has been upgraded to the Keck Array, which in turn will be upgraded to BICEP3, with more detectors and increased frequency coverage. SPTpol is also located at the South Pole. In the Atacama desert in Chile, another superb location for observing the CMB, there are the Polarbear (in the process of morphing into the Simons Array) and ACTpol experiments. SPIDER, PILOT, and PIPER are balloon-borne CMB and dust polarization experiments. Researchers at UKZN are actively involved in the ACTpol and SPIDER experiments. These experiments have thousands of detectors, but the US is considering a future experimental program called Stage 4 that would deploy of order 10^5 detectors to achieve the ultimate performance possible from the ground. Ground based experiments suffer from a number of handicaps, in particular atmospheric interference that severely limits the available frequency bands, which must be designed to avoid those parts of the spectrum with large atmospheric opacity, especially toward the higher end of the spectrum that will be crucial for removing polarized dust contamination. This atmospheric interference introduces thermal loading of the detectors, so that one detector in space would be equal to about $(T_{\rm sky}/T_{\rm cmb})^2$ detectors on the ground if the atmospheric interference did not fluctuate with time due to atmospheric turbulence. But the atmosphere also fluctuates in time and the sky temperature varies with zenith angle. Even though many forecasts have been made concerning what can be done from the ground and from balloons, these forecasts entail significant extrapolation. Thus what can actually be achieved is highly uncertain. The BICEP2 experience has taught us that dust is everywhere, even in the cleanest few percent of the sky. There are no holes between the clouds through which pristine polarized CMB can be seen, even for such high values of r as 0.2, and the values of r being targeted with planned experiments go down to $r \approx 10^{-3}$ and lower.

Another approach is to observe from space. Several space missions have been proposed to follow on Planck with a satellite dedicated to the ultra-precise mapping of the polarized microwave sky. In Europe ESA has considered a series of proposals including B-Pol (2007), CorE (2011), PRISM (2013), CorE+ (2014), and probably another similar proposal will be put forth for the ESA Cosmic Vision M5 slot in 2016. But none of these proposals have been selected. In the US, CMBPol and EPIC are similar proposals that have been considered as well as PIXIE, another proposal using a quite different technology. The Japanese have proposed a satellite called LiteBIRD, and this proposal seems to be progressing toward definitive selection. (See for example ref. [9] and references therein for more details on future space based observations.) From space a much larger range of frequencies can be probed under observing conditions with exquisite stability. Moreover from space it is possible to access the largest angular scales where the so-called re-ionization bump is located. It is doubtful that this window can be accessed from the ground, although a telescope called CLASS aims to cover *70%* of the sky from a site in the Atacama desert in Chile, thus targeting $r=0.01$.

In summary, B modes have not yet been discovered, but the search continues at great intensity following a number of competing approaches, both suborbital and likely from space. Since its discovery in 1965 by Penzias and Wilson, the CMB has played a pivotal role in providing the observational foundation for modern cosmology. Since the discovery of the CMB anisotropy in 1992 by COBE, the temperature (Stokes I parameter) of the CMB has been mapped out with exquisite precision. The E mode of the polarization too has been mapped with high although lesser precision. Improved observations of T and E could tighten parameter estimates by a factor of about *2* or *3* before cosmic variance becomes the limiting factor. However the search for the B mode is the area where improvements of about two orders of magnitude over present limits can be envisaged. While except very close to the galactic plane galactic foregrounds are subdominant for mapping the temperature anisotropies, the Planck dust maps and the BICEP2 experience have taught us that foregrounds dominate at all frequencies and everywhere in the sky, even in the cleanest patches, and must be dealt with through careful multi-frequency observations. Whether the ambitious goal of pushing the sensitivity to r down to 10^{-3} or even beyond can be achieved will largely be determined by the complexity of these foregrounds. The search for B modes is one of the foremost frontiers of current CMB research and it will be interesting to see how this story plays out in the following years.

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Some impacts of managerialism on the pursuit of physics

A D M Walker, School of Chemistry and Physics, University of KwaZulu-Natal.

> *“…the university as an institution is generally ill-suited to perform research: it is the professor at a university who performs research, not the institution.”*
>
> Steven Muller (10th President of The Johns Hopkins University)
> Technological Innovation in the Eighties, (ed. J. S. Coles, Prentice-Hall 1984)
>
> *“There is only one proven method of assisting the advancement of pure science — that of picking men of genius, backing them heavily and leaving them to direct themselves.*
>
> James Bryant Conant, (President of Harvard University, 1933 – 1953)
> Letter to The New York Times, August 13, 1945
>
> *Managerialism came to universities as the German army came to Poland.*
>
> Don Watson, Death Sentence: The Decay of Public Language, Random House, 2003

Over the past thirty years Universities all over the world have moved inexorably from a collegiate model towards a corporate model. By this I do not mean corporate “universities” such as the McDonald's Hamburger University, but ordinary universities that act as businesses, generating visions, mission statements, key performance indicators, endless meetings, workshops, reports and policies expressed in impenetrable jargon, and a strict attention to the bottom line.

There is nothing wrong with being business-like: too many Universities used to be run in an amateur fashion. Business-like means ensuring that your accounting is efficient, that the posts are filled with excellent people, and that the key products are delivered effectively. With that last phrase I descended into business-speak. What are the “key products” of a university? Rather ask what is the purpose of a university – its *raison d'être*. The chief purpose of any University is the *advancement of knowledge*, achieved by:

- Engaging in research or scholarship;
- Educating the next generation;
- Applying new knowledge to technology and the problems of society.

Being business-like means achieving this purpose with the maximum efficiency. It is fair to ask whether the application of managerial principles has improved our ability to do this.

Generally it is probably true that, from the point of view of Physics, the financial resources available, meagre as they may seem, are much better than forty years ago. Can this be attributed to more managerial universities? Do the changes in structure make it easier to advance knowledge in the field of Physics?

There is no doubt that the relative cost of management processes is substantially higher than in that distant time. The management of universities implies managers. In the USA from 1993 to 2007 the ratio of full-time administrators to students at research universities grew by 39%, while the ratio of teaching, research and service staff to students only grew by 18% [1]. I do not have the comparable figures for South African universities. An anecdote from my own experience suggests that the situation here may well be similar. When I was first appointed at the University of Natal in 1972 (about 8000 students at the time) the entire Personnel section was the responsibility of the Assistant Registrar, who ran it with his secretary and one full-time administrative officer. The current Human Resources section at UKZN, which hosts about 5 times as many

1 Callier et al, 2015; http://www.universityworldnews.com/article.php?story=201503102211432

students now, has an organogram showing 54 staff members reporting to the Executive Director[1]. Has this made academic activity better supported than before. I suggest that most academics would answer "No!" The general feeling is that bureaucratic dead weight has a stifling effect on academic activities. The question is whether this is because more active management is inherently bad or whether it is badly implemented.

In the "good old" (bad old?) days few would have denied that there was a great deal of room for improvement. There were instances of despotic and autocratic departmental heads, of departments in which the evidence of scholarship was small or non-existent, and of individual academics who continued year after year to short-change students through neglect of their teaching reponsibilities. A more business-like approach was undoubtedly needed. The problem is that "businesslike" does not mean a managerialism more suited to a motor assembly plant than a university. The academic community, all over the world, has often abdicated its responsibility for ensuring that the academic environment is good for scholarship; it is easier to avoid administrative reponsibility and complain, than to accept some of these responsibilities.

Managerialism (a deplorable bit of jargon that I will use to describe the uncritical application of management principles where they do not necessarily apply) has affected physics in many ways. I will concentrate on one only: a naïve faith that the existence of a number means that one has measured something. Two things on which this has had an effect are evaluating the performance of academics and evaluating the performance of students. I dealt with a local example of the former relating to physics in an earlier article[2]. Performance management indicators taken uncritically measure quantity not quality, and the quantity that they measure may be entirely divorced from the actual quality. Physics in this country is by no means unique in this respect.

Other countries and other disciplines have the same problems. Consider the astonishing antics at Queen Mary College, London[3] where redundancies were declared for 11 biologists and 29 medical academics on the basis of a strategic plan with performance management indicators retrospectively applied. When the Professor of Biochemistry protested publicly he was informed that disciplinary proceedings would be brought against him. Robert Buckingham, the Dean of the Faculty of Public Health at the University of Saskatchewan in Canada wrote an article criticising the University's management strategy. Management forbade its publication but he published it.He was summarily dismissed and escorted from the campus by security. Happily he was reinstated and the Provost of the University retired instead[4]

One hundred British academics in a letter to the Guardian[5] write

This deprofessionalisation and micro-management of academics is relentlessly eroding their ability to teach and conduct research effectively and appropriately. A compliant, demoralised and deprofessionalised workforce is necessarily underproductive, and cannot innovate.

There is a deplorable instance of business-speak in this, but "deprofessionalisation" does describe the case. Physicists and other academics used to be regarded as professionals: now they are evaluated like workers on an assembly line.

Another effect of managerialism has application to the assessment of students, and it is this on which I want to spend some space as it is one that receives less attention.

A physics examination is meant to supply an assessment of a student's understanding of and proficiency in the subject. In the end its outcome is a result – a judgement of whether the candidate is excellent, good, adequate or inadequate. For much of my academic career this was achieved by placing the candidate in the first, second, or third class, or by failing the student. The university specified the examination marks required for each class, but the assignment of a mark was certainly not regarded as an absolute determination of the merits of the

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1 http://hr.ukzn.ac.za/Organogram.aspx

2 Walker, Bureaucrats, bean-counters, and bungles, *Physics Comment*, March 2015,

3 Lab Times editorial, 2012, www.labtimes.org/editorial/e_328.lasso

4 http://www.cbc.ca/news/canada/saskatoon/returned-u-of-s-prof-robert-buckingham-gets-hero-s-welcome-1.2650317

5 http://www.theguardian.com/education/2015/jul/06/let-uk-universities-do-what-they-do-best-teaching-and-research

candidate. The last departmental stage of the process was a meeting of the examiners, at which the external examiner (always from another university) was present. This meeting discussed the standard of the examination including anomalies in the performance for specific parts of the examination and whether the pass mark had been set at a level that made sense. Finally, the individual cases that fell close to the borderlines between classes and between pass and fail were individually discussed. The resulting decisions were reflected in the marks awarded. The individual marks were not released. Only the classes appeared on a candidate's results.

The first cracks in this system appeared as a result of pressure from scholarship and bursary awarding institutions who wanted to compare the relative merits of individuals: the marks were released to them in confidence. As time went on the pressure from students and other sources for "transparency" led to the switch that we have today where the actual mark is released. At this point the bureaucrats take over. They now have a number. This must be an objective assessment. It can be audited, assessed and analysed. Processes can be put in place for controlling it and making it consistent across all disciplines. The public can be assured that all is well.

Both these managerial processes, the assessment of staff through performance indicators and the assessment of students through examination marks, overlook a fundamental fact. Assigning a number, whether it be a publication count or an examination mark, to the result of some activity does not mean that one has been objective. It is a mapping of some sort. The assessment of individual performance, of necessity, has a substantial subjective component and you ignore that at your peril. Blind acceptance of the numbers without critical thought leads to absurd situations such as those at Queen Mary College or at UKZN.

I would not presume to prescribe to an historian or a classicist how other historians or classicists should be assessed. The best assessment, no matter how imperfect, must include a very substantial component of peer review. In the same way, the nature of student assessment must be controlled by the experts in the subject.

Physicists need to take back control of their professionalism.

> *"Felix qui potuit rerum cognoscere causas"*
> *(Happy is he who has been able to learn the causes of things)*
> Virgil, Georgics, 2. 490

A Whole Extra Second for 2015!

By Catherine Webster, Communications Officer SANSA Space Science

This year clocks gained an extra second and were adjusted from 23:59:59 to

As we rush about our busy lives, time may seem as though it's speeding up but in reality days are actually getting slightly longer every year. Our planet's rotation is slowing down due to tidal forces between Earth and the moon as well as weather changes and tectonic forces. According to NASA, roughly every 100 years, the day gets about 1.4 milliseconds longer. While this may sound insignificant it sure is big enough to cause problems in the highly accurate world of timekeeping.

"One solar day is gradually getting longer than 24 hours due to the Earth's slowing rotation," says Dr Pierre Cilliers of the South African National Space Agency (SANSA). "A day measured by atomic clocks is exactly 86,400 seconds. However, the Earth's rotation is not quite so precise. It takes our planet about 86,400.002 seconds to complete one rotation."

Those fractions of a second per day slowly add up until the difference between solar time and atomic time mounts up to one second. To make up for this time difference an extra second known as a leap second was added to the calendar for the first time in three years on 30 June 2015. We are now in synch, for a while!

Just as an extra day is added every leap year to keep the Gregorian Calendar aligned with the Earth's orbit around the sun, a leap second, is added every couple of years to make up for the longer solar days.

To understand all of this let's go back in time to 1945 when Isidor Rabi, a physics professor at Columbia University, suggested a clock could be made from a technique he developed in the 1930's called atomic beam magnetic resonance. Scientists realised they needed a more precise timekeeping system than the Earth's rotation could provide and Rabi's new method sounded promising.

In 1967 the atomic clock was officially recognised by the National Institute of Standards and Technology (NIST) as the most accurate form of timekeeping. The definition of a second changed! It was no longer based on the length of a solar day but on extremely predictable electromagnetic vibrations in caesium atoms.

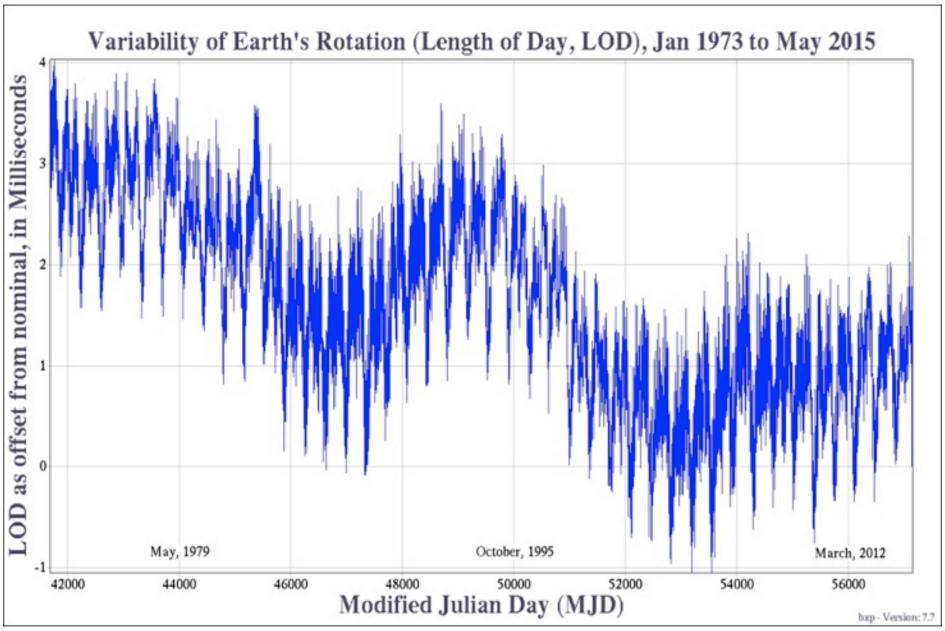
The NIST-F1 caesium atomic clock can produce a frequency so precise that its time error per day is about 0.03 nanoseconds, which means that the clock would lose one second in 100 million years.

Most people around the world rely on the time standard based on the cesium atom: Coordinated Universal Time (UTC). "In order to accommodate the increasing difference between atomic time and solar time, UTC time was adjusted this year by inserting an extra second at the end of the day," said Cilliers. "Hence for the first time since 2012, the last second of 30 June 2015 was 23:59:60 instead of the usual 23:59:59."

"At SANSA in Hermanus we mostly rely on GPS receivers and NTP time correction to handle the time shift due to the leap second. Instruments used for data collection provide a date-stamp with each observation which is synchronized with UTC. The extra second might generate an additional data point, but it is left up to the data administrators to decide if they will use the extra data point or not," said Herman Theron, SANSA ICT Manager. "On systems that only generate one minute values, such as the INTERMAGNET geomagnetic observations and the ionospheric scintillation parameters, there is nothing to worry about. The scripts on our ICT systems normally run at fixed timing intervals (absolute time, not period) – so the extra second will not cause an issue."

NASA is currently working on the Deep Space Atomic Clock set to launch in 2016. The miniaturized, ultra-precise mercury-ion atomic clock is far more stable than today's best navigation clocks and will greatly improve future space navigation. Credit: NASA/JPL

While at SANSA's satellite mission control centre in Hartebeesthoek, accurate synchronization of local clocks with clocks on board the satellites they control is essential, it may be a different story. "If ground control stations and satellites are not synchronised to the required level, measurements of satellite orbits will be incorrect leading to inaccurately calculated orbital parameters which has repercussions to successful operations," said Eugene Avenant, SANSA Chief Engineer. "This can lead to ground antennas not pointing correctly when trying to track low earth orbiting satellites, thereby losing valuable Earth observations or science data. It may also lead to commands for orbital corrections to be sent in error or at the wrong time, causing even greater problems for the spacecraft in orbit."



'The observed variation of the Earth's rotation in milliseconds since the adoption of the leap second. Image credit: The United States Naval Observatory

Earth's rotation has slowed by almost half a minute over the last 50 years. An extra second has been added to the clocks 26 times since 1972, usually on 30 June or 31 December of a leap second year. Scientists at the International Earth Rotation and Reference Systems Service (IERS) in France are responsible for adjusting Earth's time when needed. Leap seconds are announced well ahead of time, typically six months, so that businesses can get systems in place to adjust their clocks.

You may be wondering whether or not it's really necessary to keep atomic time perfectly in line with solar time. Would anyone really notice if we were a couple of seconds out? In a world that is increasingly dependent on information and communications technology; absolutely yes!

Navigation and communication systems all depend on exact timing. Financial systems can experience errors if clocks at the transmitting and receiving end of a transaction are not synchronized. Scientists also use time to determine the position of planets, stars, satellites and other objects in our solar system. Measurements come down to fractions of a second to maintain accuracy and consistency.

Some computer systems, however, have difficulty processing a 61-second minute and can't complete normal operations. The 2012 leap second resulted in internet servers of several businesses crashing. Qantas grounded 400 flights when its check-in system went haywire while LinkedIn, Reddit, Mozilla and numerous sites running Linux all experienced technical glitches.

This year to avoid complications the NASDAQ stock exchange closed early on 30 June, to ensure the scheduled leap second didn't occur during trading hours. Google and several other businesses have adopted a "smear" campaign by introducing the leap second in millisecond chunks spread out over the course of the day, rather than in a "massive" one second jump at the end of the day.

The debate about the best way to manage the difference between atomic time and Earth rotation time is ongoing in the International Telegraphic Union (ITU). The USA leads the case for abolishing leap seconds, and is supported by Japan, Italy, Mexico, and France. The UK, Germany and Canada want leap seconds to stay.

A group of scientists have suggested that leap seconds should be replaced with the insertion of leap hours every few centuries, which could be planned for well in advance. The ITU will consider the abolition of leap seconds at the upcoming World Radio Communication Conference in November 2015.

Is the future of the leap second secure? Or will we have to find another way to keep our clocks and systems in check.

Opportunities

Critical Skills Visa Letter

Brian Masara, SAIP Office, Pretoria

The South African Institute of Physics is now a SAQA registered professional body, hence it can provide critical skills letters required for the application of a Critical Skills VISA and Permanent Residence Permits to Registered Professional Physicist.

An application for a Critical Skills Work Visa has to be accompanied by proof that the applicant falls within the critical skills category and the following;

- A confirmation, in writing, from the professional body, council or board recognised by the South African Qualifications Association (SAQA), in terms of Section 13(1)(i) of the National Qualifications Framework Act, or any relevant government department confirming the skills or qualifications of the applicant and appropriate post qualification experience.
- If required by law, proof of application for a certificate of registration with the professional body, Council or board recognised by SAQA in terms of Section 13(1)(i) of the National Qualifications Framework Act.
- Proof of evaluation of the foreign qualification by SAQA and translated by a sworn translator into one of the official languages of the Republic.
- SAIP is recognised by SAQA and can provide you with the confirmations you require to comply with requirements 1 and 2 above.

Register as a Professional Physicist with SAIP

Brian Masara, SAIP Office, Pretoria

The SAIP is inviting its members to register as Professional Physicists (Pr.Phys) with SAIP. The short abbreviation for the designation will be Pr. Phys. A member registered with SAIP as a Professional Physicist can use the letters Pr.Phys after their name e.g. George Brown Pr.Phys

Download the Pr.Phys application form here

Physics is a basic science that is a basis for all science and technology disciplines. This results in its graduates working in every sector imaginable. Therefore we must cater for a wide range of industries and economic sectors. Hence any physicists who graduated with at least Physics Honours Degree working in either; industry, commerce, government, academia, research, theoretical physics, experimental physics, and uses physics skills and thought processes in their job/career is eligible to apply.

A person **first has to qualify to be an SAIP Ordinary member** before they can be registered as a professional physicist. Check the SAIP constitution regarding the criteria:

SAIP Constitution

This designation will represent the highest standard of professionalism, competence and commitment to keep pace with advancing knowledge in the field of physics. It is hoped that this designation will give a professional standing and recognition of physics by the South African society.

Justification

Academic qualifications are only the beginning of a career in physics and its applications. The need for continuing professional development is widely recognised to be the mechanism by which professionals maintain their knowledge after the formal education process has been completed. P.Phys demonstrates a commitment to maintaining competence, continuing your professional development and abiding by an acceptable code of conduct.

Benefits to physicists

The certification as a Professional Physicists will be an important addition to a physicist's personal credentials.

When competing for a job the designation will distinguish one from other applicants with similar qualifications but no professional designation

Benefits for employers

Supporting the recruitment process, many recruiters these days want to know if one has a professional designation

The designation can be used as a criterion for promotion, skills and salary benchmarking. It demonstrates that someone who possesses this designation believes in professionalism, continuous skills development, belongs to a professional body and accepts ethical standards.

Opportunities

Purchase the book Physics in South Africa

Order from SAIP Office!

The book is currently available from the SAIP Office in Pretoria in hard copy and currently priced as

a) Hard covered Copy R500 per copy

b) Soft covered Copy R250 per copy

Courier and postage fees is for the customer's account To order your copy please Email or Phone +27 12 841 2655/2627

WiPiSA Departmental Lunches Funding Opportunity

Aletta Prinsloo, University of Johannesburg

Two of the main objectives of WiPiSA are to

- encourage and stimulate an interest in girls and women to study physics.
- support girls and women to work in physics-related careers and assist in removing/overcoming obstacles and barriers for girls and women in their studies and at the workplace.

To meet this objectives we initiated an idea to have departmental lunches across Universities within South Africa. The lunch activity is expected to bring women in physics together; academics, those in leadership roles and students (both undergraduates and postgraduates), to enjoy a meal together while encouraging and stimulating interests to study physics, networking and to talk about some challenges they are facing as women in physics.

WiPiSA will provide a funding of R3000 only for your institution to organize the lunch. We therefore request you to help us accomplish this goal, or forward the name and contact information of the representative from your department to facilitate this activity. We would appreciate if the lunch event can be held before the end of November 2014 as this will help us to compile a report. WIPiSA expects you to send us:

- A short report about the event (venue, number of attendees, activities, etc).
- The outcomes of the event (students were motivated, links established, etc).
- Few event pictures.

Please do not hesitate to contact me at alettap@uj.ac.za for further enquiries.

MSc and PhD Opportunities with UKZN

The research group of Prof T. Konrad at UKZN offers MSc and PhD positions in Quantum Computation and Quantum Communication with photons as well as in quantum measurement and control. Contact Prof Konrad: konradt@ukzn.ac.za

Upcoming Conferences & Workshops

Bring International Physics Conferences to South Africa

The SAIP Office would like to help South African physics community to bring international conferences and workshops to South Africa. The SAIP can help with hosting these conferences as well as preparing bidding documents, budgeting and fundraising.

The SAIP office has helped in hosting very successful international physics conferences and workshops.

Please email the conferences you want us to help bring to South Africa to info@saip.org.za

IUPAP CCP2016 from 11 to 14 July 2016 St George Hotel Gauteng South Africa

We are glad to inform you that SAIP will be hosting the IUAP International Conference on Computational Physics in 2016 (IUPAP CCP2016) from 10-14 July 2016 at the St George Hotel in Pretoria. This immediately follows SAIP2016 which will take place at UCT, and is the first time that this prestigious conference will take place on African soil. This is considered to be the premier international conference on computational physics that occurs on an annual basis. The SAIP proposal to bid to host CCP2016 emphasised several important aspects: the need for computational physics education, the strength of South Africa's astronomical interests in computations, the need for participation of African scientists, the interest in encouraging the development of new fields such as computational biology, etc. The conference format will include plenary lectures (1 hours each), and parallel sessions comprising invited talks (30 min each) and contributed talks (20 min each) as well as poster presentations. This will be an excellent opportunity for South African scientists to showcase their own work in computational physics, but also to learn from international experts about new trends in this rapidly growing field.

Proposed key dates are

- First Announcement and Call for Abstracts – 30 November 2015
- Abstract Submission Opening – 2 Jan 2016
- Registration Opening – 2 Jan 2016
- Abstract Submission Closes – 30 April 2016
- Abstract Acceptance Notification – 06 May 2016
- Registration Closes – 10 June 2016
- Payment Deadline, - 17 June 2016

More Details to Follow Soon


Accurate Materials Measurements and Analysis
Semiconductor Device Characterisation
High Speed Digitisers and Data Acquisition
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Physics Comment Editorial Policy

Deadline for submissions for the March 2016 issue of Physics Comment is 28. February 2016

Physics Comment is an electronic magazine for the Physics community of South Africa, providing objective coverage of the activities of people and associations active in the physics arena. It also covers physics-related ideas, issues, developments and controversies, serving as a forum for discussion. It is not a peer review journal.
Physics Comment publishes innovative reports, features, news, reviews, and other material, which explore and promote the many facets of physics. Physics Comment endeavours to:
support and inform the physics community
promote membership of the South African Institute of Physics
promote the understanding of physics to interested parties and the general public
represent the readers' point of view
focus on issues and topics of importance and of interest to the physics community
We accept submissions on any physics-related subject, which endeavours to inform readers and to encourage writers in their own researches. We aim to be politically, socially and geographically inclusive in the articles, which we commission and receive. Therefore we shall not discriminate according to political or religious views. Physics Comment does not support or endorse any individual politician or political party. However, contributions, which are being published, may contain personal opinions of the authors.
It is our desire to present unfettered the opinions and research of our readers and contributors. All articles submitted for publication are subject to editorial revision. Such revisions, if necessary, will be made in cooperation with the author.
The views expressed in published articles are those of the authors and are not attributed to the Editorial
The Editor will make the final determination of the suitability of the articles for publication.

Declaration by Author

When an author submits material for publication, this means:
The author(s) assures the material is original, his/her own work and is not under any legal restriction for publication online (e.g., previous copyright ownership).
The author allows PC to edit the work for clarity, presentation, including making appropriate hypermedia links within the work.
The author gives PC permission to publish the work and make it accessible in the Magazine's archives indefinitely after publication. The author may retain all other rights by requesting a copyright statement be placed on the work.
Authors should respect intellectual integrity by accrediting the author of any published work, which is being quoted.

Publication Deadlines

Physics Comment is published four times a year.

Issue	Closing Date	Publication Date
Issue 1	28 February	15 March
Issue 2	31 May	15 June
Issue 3	31 August	15 September
Issue 4	30 November	15 December

Specification and Submission of Content

Editorial Tone. As the voice of the physics community, the magazine will create a provocative, stimulating, and thoughtful dialogue with the readers; and provide a variety of perspectives that reflects the dynamism of the physics community.
Article types. The magazine is devoted to articles, reports, interesting facts, announcements and recent developments in several areas related to physics:
Manuscripts. Solicited manuscripts will be judged first for reader interest, accuracy and writing quality. The editor reserves the right to request rewrite, reject, and/or edit for length, organization, sense, grammar, and punctuation.
Re-use. The publisher reserves the right to reuse the printed piece in full or in part in other publications.
Submission and Format. Manuscripts must be submitted to the editor on or before the designated due date Manuscripts must be submitted electronically, on the prescribed Microsoft Word template available for download from http://www.saip.org.za/PhysicsComment/. Manuscripts are to be submitted directly to the editor:
PhysicsComment@saip.org.za.
Style. AP style is followed for punctuation, capitalization, italics and quotations.
Photography and Illustration. All solicited photography and illustration should be part of an article and will be judged first for technical quality and editorial appropriateness. The editor and art director reserve the right to request revision or reject any material that does not meet their criteria. The publisher reserves full rights to all solicited photography and illustration, including the right to reprint or reuse graphic material in other publications.

Categories of Content Contributions

Technical articles and reports: These are generic articles of about 1 500 words plus diagrams and pictures. A technical article covers a relevant feature topic. Articles are authored by the writer and publishing a 40-word resume of the author could enhance its credibility. By submitting an article that has been previously published the author confirms that he/she has the right to do so, and that all the necessary permissions have been received. Acknowledgement must be made within the article.
News: These are short editorial items usually not more than 250 words. Full colour pictures must be clearly referenced on the editorial submission and on the picture or picture file.
Advertorials: Advertorials could be published when supplied by the client. We recommend a maximum of 500 words plus one or two pictures for maximum impact. A PDF file of the laid out advertorial should be emailed by the client along with an MS Word file of the text and separate image files of the pictures. It is the client's responsibility to ensure that the advertorial is correct as it is in fact a paid for advert page.
Letters to the Editor: Letters to the Editor are encouraged. The Editor reserves the right to edit for length and format. The Editor will not change the political position of the initial letter. Physics Comment does not publish anonymous letters.
Advertising Policy: The Editorial Board will determine advertising prices for Physics Comment, subject to approval by SAIP Council. The objective will be to obtain revenue to maintain and develop the magazine. Physics Comment offers classified advertising to subscribers of the magazine for free. The advertisements must be a maximum of 60 words including the telephone number, and there is a limit of three free classifieds per subscriber, per issue. Advertisements may include a photo, which may be reduced in size or resolution by the editor to optimize loading time. All items or opportunities, which are being advertised for free, should be physics-related. The Editor reserves the right to refuse any advertising, which does not conform to the objectives of the magazine.

Submission of Articles

All articles must be submitted on the prescribed template available for download from http://www.saip.org.za/PhysicsComment/