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**Harrie Massey Medal:** Recognises contributions to physics made either by an Australian physicist or by work carried out in Australia.

**General Conditions:** The prize is awarded biennially for contributions to physics or its applications made by an Australian physicist working anywhere in the world, or by a non-Australian resident in, and for work carried out in, Australia. The recipient must be a member of the Australian Institute of Physics or the Institute of Physics.

**Alan Walsh Medal:** Recognises significant contributions by a practising physicist to industry in Australia.

**General Conditions:** The prize is awarded biennially for physics research and/or development that has led to patents, processes or inventions which, in the opinion of the judging panel, have led to significant industrial and/or commercial outcomes, such as devices that are being manufactured or have influenced a major industrial process.

**Walter Boas Medal:** Recognises excellence in research in Physics in Australia and to perpetuate the name of Walter Boas.

**General Conditions:** The prize is awarded annually to a member of the AIP by the Victorian Branch for physics research carried out in the five years prior to the date of the award, as demonstrated by both published papers and unpublished papers prepared for publication.

**Education Medal:** Recognises the importance of all aspects of physics education in Australia.

**General Conditions:** The prize is awarded biennially to a member of the AIP who is judged to have made a significant contribution to university physics education in Australia. In determining the recipient of the award, the quality of the work, the significance to physics education, and the creativity displayed will be taken into account.

**Bragg Gold Medal:** To recognise the work done by a Ph.D. student in Australia that is considered to be of outstanding quality.

**General Conditions:** The medal is awarded annually to the student who is judged to have completed the most outstanding PhD thesis in Physics under the auspices of an Australian university, whose degree has been approved but not necessarily conferred in the previous thirteen months. No candidate may be nominated more than once.

**Outstanding Service to Physics:** Recognises an exceptional contribution on the part of an individual.

**General Conditions:** The AIP Award for Outstanding Service to Physics will recognise an exceptional contribution on the part of an individual who give great amounts of time and effort to the furtherance of physics as a discipline. Nominations may be made by a Branch Committee or by three members of the AIP. There will be no more than three awards nationwide in any one year.

**Presentation of the Awards:** All the above awards will be presented at the biennial Congress by the President of the AIP. The next presentation will be made at the 2014 Congress in Canberra. Each recipient is expected to present a talk at Congress on her/his work, and in the case of the Harrie Massey, Alan Walsh and Walter Boas medals, write an article based on the talk for Australian Physics.

**Nominations:** Nominations for all awards (except the Bragg Gold Medal) should be sent to Olivia Samardzic, Special Project Officer AIP, by the 31st May 2014. Details for the Bragg Gold Medal nomination process can be found on the web site listed below.

Further information about these awards can be found at [http://www.aip.org.au/content/medals](http://www.aip.org.au/content/medals) or obtained by email from the AIP Special Projects Officer at olivia.samardzic@defence.gov.au. Applications and nominations (except for the Bragg Gold Medal) should be sent by email attachment to the above email.
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Lightning over Sydney. See article by Richard Morrow on page 11. Credit for image: Cameron Richardson / Newspix

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Promoting the role of physics in research, education, industry and the community

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An image for the cover?

Cover images for Australian Physics are usually related to one of the items in the issue. This, however, does not need to be the case. If you have an image that you would like to put forward for consideration as a cover image, send it to the editor at brian.james@sydney.edu.au, with a caption of up to 100 words. Image files should be in a standard format and be of sufficient resolution for reproduction on the cover (1 MB is a good rule of thumb).
EDITORIAL

A new year – new ideas?

Welcome to the first issue for 2014, the first issue of our 51st volume. As a result of various professional memberships I read copies of Physics World (Institute of Physics) and Physics Today (American Institute of Physics). In both there is a lively correspondence from readers, often, but not always, in response to articles. It is an understatement to say that Australian Physics does not achieve a comparable lively correspondence! In fact, in my experience, letters to the editor are rare.

In an attempt to generate some member participation I would like to set aside one page in each issue for an opinion piece by a member on any topic with a connection to physics. It could be whimsical, a reminiscence, an interesting observation, a point of view you have been aching to put down. So let’s see if we have any takers. More details are given in the box on p31.

We are always looking for interesting images for the cover. Usually the image relates to one of the articles in the issue, but this does not need to be the case. So if you have an interesting, presumably physics related image, you would like to put forward as a cover image, I would be happy to consider it for a future issue of Australian Physics. For more details see box on p6.

In the present issue the first article, The Cause of Fatal Lightning Strikes and Non-Fatal Shocks by Richard Morrow, describes his investigation of a lightning strike in Geelong that caused two deaths. Some of his conclusion may surprise you, but also provide useful advice if caught outdoors in a thunderstorm. The second article, The Sparkling World of Nanoparticles by Asma Khalid et al. describes an example of interdisciplinary research; in this case, laser induced fluorescence from nanoparticles is shown to have many applications, particularly in biotechnology and medicine.

I suspect many members will not be familiar with the National Committee of Physics (NCP), one of a number of national committees of the Australian Academy of Science. In this issue, NCP chair, Hans Bachor, describes its role and, in particular, its part in following up on the Decadal Plan for Physics: Building on excellence in physics – underpinning Australia’s future, which was released in late 2012.

Brian James
Best wishes to all of our members for 2014, which is sure to be interesting, both in terms of the new discoveries that will be made or announced, but also in terms of the political and funding environment in which we operate.

Anyway, I would like now to discuss a couple of initiatives the AIP is taking. Specifically, we are looking to revitalise both our Women in Physics Group and Committee (see http://www.aip.org.au/info/?q=content/women-physics-wip). The group's stated aim is “to support women in physics, to advocate on their behalf, and to work towards removing impediments to their career advancement through cultural change within the discipline and via the advancement of policies.” So we are actively soliciting volunteers or nominations to become involved. If you are interested, please e-mail me with your name, contact details and a short biographical statement.

The second regards the 5th IU-PAP International Conference on Women in Physics being held near Niagara Falls in Waterloo, Canada, 5-8 August 2014. Historically, Cathy Foley has represented Australia at previous meetings, with travel funding via her employer. This time, while the Australian Institute of Physics generally does not have very deep pockets, there are some funds available for partial or full support. We (Australia) are allowed to send up to three delegates, so if you are interested, please let me know, along with the level of support that you may be able to get from your own institution. Note that our delegates to the international meeting in Canada need not be the same as those serving on the domestic committee.

As a man, I feel that I may now be getting into dangerous territory, but issues of gender equity and diversity affect all of us, our colleagues, family members and friends. So I will reflect upon a couple of the things I have seen or experienced in my life so far. I grew up in England, as one of three children: myself and two sisters. Our father was the first person in our family to get a university education, the hard way by night school, soon after the end of the Second World War. I think this was partly due to the vision and ambition of my grandmother, a wonderful clever lady, who had to leave school at the age of 14, at the outbreak of the First World War – in those days, ordinary people (especially girls) didn't get much of an education. Our father studied Physics at the University of London, and then subsequently worked at the boundary between physics and engineering successively for various industrial companies. All three of us were very good at mathematics, and I drifted into physics because of that.

After getting my BA, I taught high school in the North of England for a few years, partly because I didn’t really know what I wanted to do next, but also because I thought that “modern physics” was such a wonderful thing, and that its ideas should be spread out as broadly as possible in society. Amongst much else, I had pastoral responsibility for a group of 13-year olds, and the girls were far more mature in all ways than the boys. Half seemed more interested in older boys, while the other half were more academically inclined. I actively tried to get all of the pupils interested, especially in science. The best student was one of these girls. Anyway, the week before I left to return to study for a PhD in physics, there was a parent-teacher evening and most of the parents were very grateful for my efforts. The parents of this most talented girl said to me “Thank you Mr. Robinson for all that you’ve done for our daughter, and we’re really pleased that …… is so enthusiastic about science - but do you think it’s really appropriate for a girl?” I was only 23 at the time and was “gob-smacked” – completely lost for words. These were nice middle-class parents, in a nice middle-class community and this was completely alien to what I had grown up with. I realised then that issues of gender balance in the workforce are much more deeply rooted in our society, and its attitudes, than we will be able to fix solely through the adult workforce or tertiary education, or even within schools. Not that we shouldn’t try.
**NEWS & COMMENT**

**New President of the Australian Academy of Science**

Professor Andrew Holmes, a pioneer of research in organic electronics, has been elected as the next President of the Australian Academy of Science. He takes over from current President, Professor Suzanne Cory, after the Academy’s next Annual General Meeting in May 2014. The presidency alternates between the physical and biological sciences and the term lasts for 4 years.

Professor Holmes is a Laureate Professor of Chemistry at the University of Melbourne’s Bio21 Institute, a CSIRO Fellow and Distinguished Research Fellow in the Department of Chemistry at Imperial College London.

In the 1990s, Professor Holmes achieved international prominence when, in collaboration with Cambridge physicists, the team developed a new class of light-emitting polymers. These polymers transformed digital display technology with lightweight, super-thin, flexible video screens bright enough to be viewed even in direct sunlight.

Professor Holmes returned to Melbourne in 2004 as a Federation Fellow to establish a laboratory at the then newly established Bio21 Institute. He was instrumental in forming the Victorian Organic Solar Cell Consortium.

**Academy celebrates 60th anniversary in 2014**

Registrations are now open for *Science at the Shine Dome*, 27-29 May 2014. As well as acknowledging the outstanding work of awardees and new Fellows, this annual meeting will acknowledge the 60th anniversary of the Academy’s founding with a one-day symposium celebrating Australian science and exploring the shape of Australia’s science future. For more information see http://www.science.org.au/events/sats/sats2014/Symposium-DayThree.html.

**ANSTO releases apps and an e-book**

In 2013 ANSTO celebrated its 60 years of delivering research and nuclear medicines to the Australian public. To commemorate this milestone, ANSTO has developed an e-book and tablet app that provide a summary of ANSTO’s history, present day achievements and important infrastructure including the OPAL Research Reactor, Centre for Accelerator Science and the Australian Synchrotron.

ANSTO has also produced an interactive app for students called *Elementals*. Suitable for all levels, there are five games that will familiarise students with the various elements, their atomic numbers and their groups. The app can be downloaded from either the Apple App store or Google Play—just type “ANSTO Elementals” into the search field.

**Possible futures for our electricity grid**

Australia’s electricity landscape could change significantly in the future and consumers will be deciding just what that future will look like.

A new report from the Future Grid Forum, *Change and choice: The Future Grid Forum’s analysis of Australia’s potential electricity pathways to 2050*, looks at a range of opportunities and presents four scenarios, not predictions, through which we can view potential futures for our national electricity system.

CSIRO Energy Flagship Chief Economist, Paul Graham, said recent declining demand, higher electricity prices and strong adoption of roof-top solar panels have changed the industry’s view of what is plausible in the future and trained a focus on affordability challenges.

“All of the choices in the Future Grid Forum scenarios have consequences for the price of electricity, something that has significantly impacted consumers in recent years,”
Mr Graham said.

“Electricity will not get cheaper in the coming decades, but bills can be reduced through the adoption of energy efficiency, peak demand management and on-site generation.

Electricity has traditionally been a service with which consumers have not proactively engaged, but the Forum’s scenarios present a number of ways for people to take greater control of how they consume and produce electricity.

“This proactive shift could potentially influence the business model for the electricity sector, encouraging the emergence of new services to supply an individually tailored product – not dissimilar to the telecommunications industry shift from a one-size-fits-all landline telephone system to a wide variety of mobile and associated data and entertainment services,” Mr Graham said.

“One of the Forum’s scenarios looks at the option for around a third of consumers to disconnect from the electricity grid through the use of on-site generation using technologies like rooftop solar panels and battery storage; and this is projected to be economically viable from around 2030 to 2040.

“Under the full range of scenarios Australia could see on-site generation grow from the current figure of 8 per cent to reach between 18 and 45 per cent of total generation by 2050, but mostly while staying connected and using the grid as an electricity trading platform,” Mr Graham said.

The Forum also projected that technology will allow more sophisticated ways of managing household demand during peak times through the introduction of devices such as smart air conditioners and in-home storage systems.

“Better strategies for peak demand management could save two cents per kilowatt hour or $1.4 billion per annum on distribution costs for households,” Mr Graham said.


DSTO release app

DSTO’s role is to ensure the expert, impartial and innovative application of science and technology to the defence of Australia and its national interests.

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Cosmic neutrinos named Physics World 2013 Breakthrough of the Year

The Physics World award for the 2013 Breakthrough of the Year went to the IceCube South Pole Neutrino Observatory for making the first observations of high-energy cosmic neutrinos. Nine other achievements are highly commended and cover topics ranging from nuclear physics to nanotechnology (see physicsworld.com/cws/article/news/2013/dec/13/).

In December 2013, an international team of scientists that includes University of Adelaide researchers announced the first solid evidence for astrophysical neutrinos - very high-energy neutrinos coming from distant regions of our galaxy or further - which will lead to new ways of exploring the Universe.

Published in the journal Science, the scientists reported the observation of 28 very high-energy ‘particle events’ and estimate about half of these to have come from distant, as yet unidentified, highly energetic sources.

“This has opened a new window on the Universe,” says Dr Gary Hill, ARC Future Fellow at the University of

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Adelaide’s School of Chemistry and Physics. “This discovery makes way for a new type of astronomy that we can use to probe the far reaches of the galaxy and beyond.”

The neutrinos were observed between May 2010 and May 2012 at the IceCube Neutrino Observatory, a particle detector buried in the Antarctic ice at the South Pole. It is operated by the IceCube Collaboration which consists of 250 physicists and engineers from the US, Germany, Sweden, Belgium, Switzerland, Japan, Canada, UK, Korea, New Zealand and Australia, and is led by the University of Wisconsin-Madison. The University of Adelaide is the only Australian university involved.

“This is the first indication of high-energy neutrinos coming from outside our solar system,” says Professor Francis Halzen, IceCube principal investigator and Professor of Physics at the University of Wisconsin-Madison. “It is gratifying to finally see what we have been looking for.”

Neutrinos are nearly massless subatomic particles. Because they rarely interact with matter, they can carry information about the workings of the highest-energy and most distant phenomena in the Universe.

Billions of neutrinos pass through every square centimetre of the Earth every second, but the vast majority originate either in the Sun or in the Earth’s atmosphere. Astrophysical neutrinos are far rarer and have long been theorised to provide insights into potential sources of cosmic rays, the highest energy particles ever observed.

Dr Hill spent seven summers in Antarctica overseeing the deployment of strings of optical detectors embedded in a cubic kilometre of ice beneath the South Pole. He was the original analysis coordinator for the IceCube Collaboration and spends significant time at UW-Madison, collaborating on analysis of the data.

University of Adelaide research students Mark Aartsen and Sally Robertson, and postdoctoral researcher Dr Ben Whelan, are focusing their efforts on improved ways of analysing the data.

**ARC Centre of Excellence for Naonoscale Biophotonics**

The ARC Centre of Excellence for Naonoscale Biophotonics, based at the University of Adelaide, is one of 12 new centers of excellence for which funding will begin in 2014. The new Centre, which brings together researchers from the University of Adelaide, Macquarie and RMIT Universities with international, national and industry partners, will cross the boundaries of biology, lasers and nanoscience, using light-based sensors to probe molecular processes within living systems.

“Our understanding of the processes of life is limited by constraints imposed by studying cells and biological systems outside the body. Much more can be learnt if we can work within,” says Professor Tanya Monro, the Director of the new Centre of Excellence. “We will use nanomaterials and photons to serve as an interface between organisms and artificially engineered systems. By bringing these fields together we will transform our understanding of nanoscale events in living systems.”

**Dr Gary Hill**

Dr Hill spent seven summers in Antarctica overseeing the deployment of strings of optical detectors embedded in a cubic kilometre of ice beneath the South Pole. He was the original analysis coordinator for the IceCube Collaboration and spends significant time at UW-Madison, collaborating on analysis of the data.

University of Adelaide research students Mark Aartsen and Sally Robertson, and postdoctoral researcher Dr Ben Whelan, are focusing their efforts on improved ways of analysing the data.

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The Cause of Fatal Lightning Strikes and Non-Fatal Shocks

Richard Morrow

Applied and Plasma Physics, School of Physics, The University of Sydney, Sydney, NSW, Australia, 2006.

Lightning seems to strike objects and people in very unexpected and apparently inexplicable ways. However, using recent theoretical results, coupled with a close examination of the circumstances surrounding a fatal lightning strike in Geelong, some clear explanations have been developed. Essentially, lightning does not “choose” where to strike; rather the object struck has sent up a positive streamer, drawing the lightning strike to that object. Using this theory, many fatal lightning strikes can be explained; for example for people standing under metal verandah roofs, and workers carrying metal implements. Given this understanding, strategies can be developed to avoid such events. In the case of non-fatal shocks from lightning it is proposed that it is a rapidly changing vertical electric field that induces currents in people’s bodies causing the shock.

1. Introduction

Lightning generally originates from a negatively-charged cloud when a highly-conducting negative leader channel is formed and moves in steps towards the ground [1, 2]; this effectively brings the high voltage of the cloud close to the ground very quickly, generating high electric fields at the earth. Positive streamers are initiated on sharp metal objects and propagate out towards the negative leader following the electric field lines towards the negative leader head. As the electric field rises the streamer is steadily driven towards the leader head, as shown in detail for a streamer propagating 50 cm by Morrow and Backburn [3]. Such a streamer propagating several metres is visible in Figure 1 [4]: the streamer is propagating from a telegraph pole to the left of the main strike.

In a Geelong park a rotunda was struck by lightning and two people were killed with many people suffering minor injuries. The lightning approached the rotunda at an angle of 45° to the ground. The event is analyzed in the light of the positive streamer theory above. One puzzling aspect was that the metal roof of the rotunda was not obviously connected to the earth. The lightning appeared to burn only part of the way down the rotunda support and then stop.

“…. a rotunda was struck by lightning and two people were killed with many people suffering minor injuries”.

It is a common occurrence in Africa for people to be killed by lightning while sheltering under a metal verandah roof; perhaps these cases are related to the rotunda case.

In Zambia [5] an incident occurred involving the death of prisoners carrying farming implements such as hoes, axes and rakes when struck by lightning. The metal implements probably led to the fatal lightning strike by the same mechanism described here. Similarly, golfers carrying golf clubs can be vulnerable in the same way and this will also discussed.

Finally, there are many reports of people being struck by lightning but surviving. These people are said to be affected by ground currents, but this is not a satisfactory explanation and some better explanation of these shock events is required. In the light of an experience during a
bushwalk an explanation in terms of the displacement current due to rapidly changing electric fields is proposed.

### 3. Positive Corona Generated in a Rising Electric Field

My theoretical results [3] help us to understand the rotunda case and the cause of many fatal lightning strikes, particularly lightning events involving relatively sharp metal objects. The results show that a sharp metal point in a steadily-rising electric field directed upwards will give rise to a streamer that steadily propagates in the direction of the electric field towards an oncoming negative leader as the electric field increases. In this way the positive streamer is guided towards the negative leader head by the leader’s electric field. The calculation follows the streamer for 0.5 m, and clearly the streamer could propagate much further limited ultimately by the available voltage, $V$, as discussed below.

Some representative results from the calculations by Morrow and Blackburn [3] are shown in Figure 2. In a long streamer channel conductivity must be maintained by keeping the electric field above $E_c \sim 30$ kV/cm, where the ionization rate balances the attachment rate for electrons attaching to air molecules to form negative ions. Thus, for a given voltage, $V$, a streamer can only propagate a distance $D \sim V/E_c$; this principle defines the length of the positive streamer, and probably the length of the steps taken by the negative leader as it approaches the earth [1].

The rapidly-changing electric field constitutes an electric current defined as Maxwell’s displacement current density given by $J = \varepsilon_0 \frac{\partial E}{\partial t}$ [6], and this current is induced in all conducting objects, including people. As the electric field rises, positive electrical corona is triggered on any sharp metal object where the electric field is intensified.

“The rapidly-changing electric field constitutes... displacement current...and this current is induced in all conducting objects, including people”.

### 4. The Fatal Lightning Strike in Geelong

In January 1997 two people were killed by lightning while sheltering in a rotunda in Eastern Park, Geelong, Australia. I was alerted to investigate the lightning strike because television reports showed many tall trees nearby, and I wanted to know why the rotunda was struck, and not the trees. On further inquiry, I found that one of the trees was actually touching the roof of the rotunda, and I wanted to know if this fact contributed to the tragedy.

Figure 3: Sydney Harbour, with a positive (blue-green) streamer going nowhere in the centre [7].
The following is a record of my observations of the site made about a week after the tragedy:

- A close inspection of the tree close to the rotunda, and the tree branches touching the rotunda showed no signs of a discharge or lightning strike; therefore the tree was not directly involved. (When trees are struck by lightning there is often a clear track burned on the trunk.)

- According to Mr. Rogers, the Director of the Geelong Botanic Gardens, and his wife (who were witnesses, and the first helpers at the scene), the day was dry and there was no thunderstorm activity locally, although there was a storm further down the coast. Because of the relatively dry conditions the trees may not have produced positive steamers that would attract the lightning.

- The lightning was observed by one of the park workers (as reported by Mr. Rogers) to pass over the ranger’s house at an angle of at least 45° to the ground, and go towards the rotunda. This observation suggests that the rotunda acted as the source of a positive streamer which rose at a 45° angle to intercept the leader. (For an example of such an oblique streamer channel, see Figure 1).

- The metal edge of the corrugated iron roof, which was not obviously earthed, would have acted as a “streamer launcher” in the intense electric field caused by the advancing leader.

- From the police photograph (Figure 4) [9] burn marks are clearly visible at the top of one of the wooden posts; from the photographs, and from the statements of Mr. & Mrs. Rogers, there were no burn marks on the lower two-thirds of the post. The lightning clearly took another path to ground, probably through the body of the woman standing in the rotunda who died instantly.

- Mr. Rogers observed the people in the rotunda from his kitchen window at the time of the lightning strike and said that they all “jumped into the air”, then “fell to the ground”; “people were thrown everywhere”. Inspector Tim Attwil of Geelong police, who was on the scene soon after the tragedy, said many of the people were limping. These two observations suggest that as the rotunda roof was struck it was raised to a high voltage creating a high electric field which would affect everyone in the rotunda. The sudden increase in the electric field would have induced electric currents in the legs of all those present, causing them to involuntarily jump in the air and fall down, due to the contraction of their muscles. This involuntary movement may have caused muscle strain; hence all the limping people.

“**The sudden increase in the electric field would have induced electric currents in the legs of all those present, causing them to involuntarily jump in the air….”**

- The other people affected by the strike, including the man who died, and a woman who was severely injured, but survived, could have been affected by such an induced shock, or by a branch of the main discharge.

It is probable that a positive streamer was launched from the sharp metal edge of the rotunda roof at an angle of about 45 degrees; it would have then intercepted the main negative leader from the cloud bringing the full lightning discharge to the rotunda. Even though the roof did not appear to be earthed there must have been a conduction path to earth sufficient to carry enough current for the streamer to progress. The woman who died was probably touching the post at the time of the strike and was unknowingly providing a slightly lower conduction path for the streamer current. The full lightning current from the negative leader would have followed the streamer path; then it would have followed the streamer current path down the post until it reached the relatively low resistance of the woman, then on to earth. The full force of the lightning discharge current would have gone through the woman causing horrific injuries and instant death.
5. Risk Evaluation According to the Australian Standard Applicable at the Time of the Lightning Strike

The following risk assessment was made with strict reference to the Australian Standard for Lightning Protection AS 1768 – 1991 [8] (This was the Australian Standard for Lightning Protection applicable at the time):

- When the "Risk index" for the rotunda structure is evaluated according to the Australian Standard (p.7, AS 1768 - 1991), a risk index of 8 is obtained, and consequently the risk of a lightning strike would (at the time) be evaluated as negligible.

- Even when the tree and rotunda complex is considered as one unit, the risk is evaluated as negligible.

Note that the problem of small structures with un-earthed metal roofs, such as rotundas, has now been recognized in the latest Australian Standard [9] where a down-connection to an earthed stake is recommended.

6. Relevance to other Fatal Lightning Strikes

The relevance of the Geelong experience to the many fatal lightning strikes that occur in Africa where people are killed on their verandahs in a lightning storm is clear: in a poor district a house would probably have a corrugated iron roof supported by wooden posts, with no gutters or down pipe. In the same fashion as for the rotunda in Geelong, the metal roof would initiate a positive connecting streamer from its sharp edge and lightning would travel down the wooden supports and divert through anyone standing nearby as they are a better conductor than the wooden post.

Any metallic connection to earth, even by relatively thin copper wire, would be effective in diverting the lightning current to earth. Because of the low probability of the structure being hit by lightning the lightning protection need only work once in a lifetime. Many lives could be saved this way. The protective wire could be replaced like an old-fashioned fuse wire.

In Zambia [5] the farming implements the prisoners were carrying, such as hoes, axes and rakes, would have acted as points from which positive connecting streamers could be launched. The Geelong experience indicates that a metal object does not have to be solidly connected to earth in order to be able to launch a connecting streamer and bring the full lightning current to the metal object;"
my son and I felt nothing. I was led to think that the lightning strike had affected them from a considerable distance, probably because they were well earthed in the river water. The only possibility was the changing electric field due to the lightning strike inducing sufficient electric current (Maxwell’s displacement current) in them to give a slight shock sensation.

Clearly, a person standing near a lightning strike will be a conducting body in a changing electric field, and a transient current will be generated in their bodies. They will be affected in the same way as the people who were not critically injured in the rotunda; they may even have streamers coming from their heads and clothing.

8. Conclusions
From the detailed analysis of the lightning strike at the rotunda in Geelong, and in the light of positive streamer theory and lightning photographs, it is clear that many objects struck by lightning of the most common form, with a negative cloud overhead, are struck because they initiate positive streamers which intercept the negative leader from the cloud. The surprising result is that the object (usually metal) does not have to be well connected to earth, but must be capable of supporting the current required to propagate the streamer. Thus it is essential to be aware that any sharp metal object can initiate a positive streamer and cause a serious risk. The objects should be placed on the ground and the person should move away. People who are mildly shocked by lightning strikes are most likely affected by currents induced by the rapidly changing electric fields.

9. References

6. Acknowledgements
The author wishes to thank Dr Vivienne Morrow for editing, Zoe Woodridge and Guy Morrow for giving such a clear account of their experience on that day with a lightning strike in the mountains, and Peter Andrews for his encyclopedic knowledge and infinite patience.
The Sparkling World of Nanoparticles
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Fluorescent nanoparticles (NPs) have become versatile tools in a wide range of applications, from industrial to bio-medical applications. For some of them it is essential to detect and track such fluorescent NPs without additional tags. In this paper we present two examples of combining these NPs with optical materials: silken nanodiamonds and zinc oxide nanoparticle in silica. Our results indicate that both materials are having great potential for future bio-sensing and bio-medical applications.

INTRODUCTION
Understanding the underlying processes at the cellular and sub-cellular levels is one of the most important tasks in modern biology. One of the crucial steps in this understanding has been the cross-disciplinary approach of combining physical and biological techniques that has led to direct and functional biological imaging. The importance of biocompatible and environmentally friendly biomarkers for biotechnology and medicine cannot be underestimated. The most important applications include: biomarking, cellular imaging, tumour targeting, single particle tracking and long-term in-vivo monitoring.

Laser-induced fluorescence, a spectroscopic method that uses optical emission excited by absorption of laser light, is one of the key avenues to understand cellular processes. In the last few years, study into fluorescent nanoparticles (NPs) has become a distinctive subject of research. Studies are undertaken into both physical implementations of these structures and their applications. This increase in interest is driven by the numerous applications of fluorescent materials in industry, medicine, information technology, energy storage, sensing and elsewhere [1-3].

“Important applications include: biomarking, cellular imaging, tumour targeting, single particle tracking and long-term in-vivo monitoring”

There are a large number of applications where it is essential to detect and track such fluorescent NPs without additional tags. Current methods for detection and tracking NPs in living cells, food, and environment use either clinical methods like blood and urine sample collections or imaging via additional fluorescent markers. Fluorescent biosensors should satisfy three main criteria: biocompatibility, photostability and suitable wavelengths of absorbance and fluorescence. In a biological cell, the presence of components such as collagens and flavins produce fluorescent background signals. These particles typically absorb light in the range 300-500 nm and fluoresce at 400-550 nm. Therefore it is essential for the probe to absorb light at wavelengths longer than 500 nm and to emit light at wavelengths longer than 600 nm [4].

Organic dyes and fluorescent proteins meet those requirements but they suffer from photobleaching and blinking (random switching between ON-bright and OFF-dark states of the emitter under continuous excitation), precluding their usage in long-term monitoring [5]. Quantum dots (QDs) have been investigated extensively due to their brightness and reasonable stability. However, the major obstacle in the clinical use of QDs is their toxicity [6]. There is, therefore, an urgent need to develop new biocompatible and environmentally friendly nanodevices for bio-sensing and biomedical applications.

In this paper we present two examples of fluorescent nanoparticles combined with photonic materials. First, we present the results on a new compound material consisting of nanodiamonds (NDs) and silk. Second, we report on zinc oxide (ZnO) fluorescence, with ZnO nanoparticles obtained by Zn-ion implantation in silica. The availability of optical defects (centres) in nanoparticle form that can be introduced into biological environments allows for many new sensing mechanisms. For example, diamond optical defects may include foreign impurity atoms (typically nitrogen) or some other defect in the lattice. Some of these lattice imperfections can create spectroscopic features by allowing the diamond to absorb particular energies of incident light or radiation. These two projects bridge two remarkable fields, physics and biology, involving an international and multi-university collaboration. It also offers outstanding opportunities for postgraduate students to embark in interdisciplinary research and experience multi-university internationally competitive environments. Capacity, synergy and expertise are
matched in perfect partnership between the University of Melbourne, University of Sydney, Hong Kong University, National Institute for Materials Science in Tsukuba and Tufts University in Boston.

**SILKEN NANODIAMONDS**

The photostability of the optical centres in diamond, such as the negatively charged nitrogen vacancy centre (NV-), combined with the biocompatibility of diamond makes NDs highly suitable for long-term imaging and monitoring in cellular environments [1]. Due to these characteristics, NDs have been investigated in nanomedicine in the areas of drug delivery (for cancer therapy, protein and gene delivery), targeted bioimaging (fluorescence monitoring) and biosensing [1,3]. On the other hand, silk, a natural protein fibre has been used in biomedicine for centuries [7] due to its non-inflammatory response. Silk fibroin derived films are highly flexible, biodegradable and biocompatible in-vitro and in-vivo [7,8].

Our team at the University of Melbourne is actively involved in the research on diamond including use in bio-applications. Research is simultaneously under way at the University of Sydney and Tufts University to develop biocompatible silk-based bio-chips for health monitoring in-vivo. So far, the studies on both NDs and silk stand alone but combining these two materials immensely magnifies the functionalities of each of them. NDs benefit from a silk-based coating in terms of a versatile functionalization chemistry, elimination of blinking and increased mobility. On the other hand, silk benefits from NDs in terms of improved bio-sensing functionality.

First the optical transmission of silk was examined with and without NDs. Then, the change in the emission properties of NDs embedded in silk relative to air was studied using a customized confocal microscope. Confocal microscopy is an optical imaging technique used to increase optical resolution and contrast of a micrograph by using point illumination. Here we use green light illumination and we collect red emission. A schematic of the hybrid film including the method of optical characterization is shown in Fig. 1 (a) and an example of a scanning confocal map is shown in Fig. 1 (b). A theoretical model was used to explain the experimentally observed enhanced emission from NDs. Lastly, the non-toxicity of the ND-doped silk films was evaluated through an in-vivo model, see Fig. 1 (c).

The ND-silk film was found to be highly transparent in the visible and infrared with small scattering losses induced by NDs. Our results of silk coated NDs showed a significant rise in counts that was 1.6 - 3.8 times higher as compared to the original counts of the ND single emitters without silk coating. This rate of enhancement was found to be in good agreement with the theoretical model. The toxicity test of the ND-silk films in-vivo revealed a non-inflammatory response. Our vision of this remarkable new “material” is of much larger scope than presented here. We expect numerous biotechnical and medical applications to emerge as these two extraordinary materials perfectly complement each other.

Future work includes integrating biochemistry into silk and testing the change of emission in ND-silk system upon a binding event with the biological component (may be with a gene or protein). Investigation of more integrated pump and probing sources will be performed so that the device will, eventually, be one integrated chip [9].

**ZINC OXIDE NANOPARTICLES**

Fluorescent metal oxide NPs have attracted intensive interest during the past decade because their outstanding optical properties make them suitable for various fields such as biological analysis, lighting and photovoltaic applications [2]. The origin of defects responsible for different visible emissions in metal-oxide has been controversial for decades [10].

Recently, we have observed bright single photon emission (> 650 nm) from ZnO when pumped with a laser at 532 nm [11]: all ideal properties for detection and tracking in living cells. We have discovered that ZnO nanoparticles themselves can act as bright, single photon sources, and can therefore be used as fluorescent biomarkers in their own right [11]. This discovery enables the possibility

Figure 1: (a) Schematic representation of a silk-coated ND (on silicon substrate) fluorescing in red (a characteristic of NV-centre), when pumped with a green laser (532 nm). (b) Scanning confocal fluorescence map of a 5 µm × 5 µm region of the sample after coating with silk. The cross hair specifies the defect centre. (c) Animal toxicity test of ND-silk films: non-inflammatory response of the NDs-silk films after two weeks of implantation [9].
of using highly-sensitive scanning confocal fluorescence techniques to track nanoparticle propagation through biological tissue at the single nanoparticle level, see Fig. 2(a). However, our first results showed blinking behaviour between bright and gray states [11].

![Figure 2: (a) Wide field confocal imaging of skin cells with ZnO nanoparticles (NPs) inside the skin cells [courtesy of D. Simpson and P. Tran]. (b) A 5×5 µm² confocal image of the ZnO NPs silica sample, with the cursor placed on a single photon emitter [12]. The colour bar on the right shows the number of counts s⁻¹ on one avalanche photodiode (APD) detector. (c) Fluorescence spectra of four individual single photon emitters found on the sample. The legend shows the maximum count rate for each of the different emitters [12].](image)

We have already obtained encouraging preliminary results that have been presented at CLEO Pacific Rim 2013 [12] and as a post-deadline paper at AIP Congress 2012 [13]. Stability of ZnO NPs has been significantly improved. ZnO NPs are formed by ion implantation combined with thermal oxidation in a silica substrate [14]. Fig. 2(b) and (c) shows a representative confocal image and fluorescence spectrum of four individual emitters on the samples provided by Hiro Amekura from NIMS in Tsukuba. All spectra show broad emission in the visible regime from 580 nm to 850 nm. The exact origin of defects responsible for different visible emissions in ZnO is yet to be conclusively determined.

**Application: Detection of food additives**

Our research will have a large impact on the safety and quality of every-day life and here we give one example of these future applications. In the food industry various additives, including metal oxides, are used to optimize colour, taste and freshness of food. Confocal microscopy has been used in some of the pilot studies to detect these additives [15] but ensemble measurements have always been performed. We are using a methodology that can trace the presence of the additives down to single molecule level. This will greatly improve quality control and safety of food products.

We have tested our methodology on a product purchased from supermarket: a bag of lollies. We dissolved their sugar coating in water; one example is shown in Fig 3 (a) for red lollies which contained fluorescent red dye (E129), indicated at the back of the bag by the manufacturer. The confocal maps of those diluted products are shown in Fig. 3 (b), in which bright red fluorescence is collected. Our results indicate that commercially available lollies appear to be extremely bright, with overall counts per second recorded as high as a few millions with a small power, of the order of 50 µW used: see Fig. 3 (b). For comparison, the NDs excited with the same power would have around 100 times smaller counts. However, this bright fluorescence bleaches away within seconds.

The manufacturer reported these food additives used in their product: dyes (E102, E110, E129, E133) and TiO₂ (E171). There are a large number of food additives that are forbidden in Australia, such as silver (E174) and gold (E175) that we can detect and track (unpublished results). At the moment we cannot detect them unambiguously. Therefore, in future we will have a powerful tool for control of food with the ability to non-destructively detect compounds down to single molecule level.

**CONCLUSIONS**

In conclusion, we have demonstrated successful coating of nanodiamonds with silk and observed a single-photon emission with significantly increased collection efficiency after the silk coating. This unique combination of silken nanodiamonds has the potential to give rise to a new class of very bright, bio-compatible and environment friendly bio-sensors. Also, we have observed single photon emission from optical emitters in zinc-oxide nanoparti-
cles. Our ability to address and identify individual defects will allow further insight into their nature and opens new applications of these fluorescent NPs.

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REFERENCES


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We are now working on an active website which will enable us to share and discuss developments in physics, alert our community to opportunities for lobbying and new developments that all physicists should be aware of. This website will be linked with the AIP webpages. In this way we can get information to you more effectively.

“With a political system focussed on economical outcomes it will be important for more people to see the positive role physics plays in the development of our country and its economic basis.”

With a political system focussed on economical outcomes it will be important for more people to see the positive role physics plays in the development of our country and its economic basis. You will have your own good news story about this, and the decadal plan includes some impressive case stories. Spread the word, be positive and active.

At the national level the chief scientist has argued the case for science, based on the importance which STEM research already has in Europe, Asia and the US. Other countries, in particular in the UK [2] and Europe [3], have carried out economic studies by respected economic consulting firms. Should we be doing the same for Australia? The Committee is giving consideration to organising such a study - complementing the positive lobbying all of us individually can do as a diverse group of physicists.

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Burning soil fuels ball lightning

Researchers in China are the first to study ball lightning using high-resolution spectroscopy. Their results lend support to an idea first advanced in 2000 that ball lightning is fuelled by burning minerals from soil.

Ball lightning is one of the strangest phenomena in atmospheric physics, with reports of glowing spheres or ellipsoids chasing cows, flying through windows or appearing in aeroplanes. While a growing amount of evidence points to its existence, ball lightning has never been properly explained. This is because its rarity and unpredictability make systematic field study impossible.

In 2000 John Abrahamson and James Dinniss of the University of Canterbury in New Zealand suggested that ball lightning is caused by lightning striking silicon-rich soil. If the earth gets hot enough to be vaporized, carbon from the soil reduces silicon from silica to its elemental form. In the oxygen-rich environment of the air, however, it rapidly oxidizes once more, emitting black-body radiation that we perceive as ball lightning.

Then in 2012, Jianyong Cen, Ping Yuan and Simin Xue from Northwest Normal University in China had a stroke of luck. The team was recording thunderstorms in the country’s Qinghai Plateau with high-speed cameras with high spectral resolution in an attempt to determine the spectral characteristics of ordinary lightning. By pure chance, one of the lightning strikes that the researchers recorded was followed by the appearance of a glowing sphere about 5 m in size, moving at about 8.6 m s⁻¹ and lasting just beyond 1.5 s. It started out a bright purple-white colour before gradually turning orange, white and finally red.

The entire event was captured on a digital video camera. Analysing the pictures taken, the researchers found clear emission lines from silicon, iron and calcium – the main components of soil. The researchers say this supports the idea that the energy source for ball lightning is a burning core of soil. Curiously, however, there was also an intensity fluctuation at about 100 Hz. The event occurred near some high-voltage power lines with a frequency of 50 Hz, and the authors suggest this intensity modulation could be related to this proximity. [To be published in Phys. Rev. Lett.]

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CERN gears up for new experiments

This year will be a fallow one for the Large Hadron Collider (LHC). The accelerator and its experiments are still being upgraded and the 27 km circumference collider is not due to restart until 2015. However, all is not quiet at the CERN particle physics lab near Geneva: the accelerators that feed protons into the LHC – the Proton Synchrotron (PS) and the Super Proton Synchrotron (SPS) – will both be fired up in the second half of 2014, which means that lots of experiments at CERN should be taking data this year, including some that are entirely new.

One new experiment firing up is the rather prosaically named NA62, and physicists working on it are now in the final stages of installing their 270 m long experiment on the SPS. The SPS itself has a circumference of 7 km and its experiments are in CERN’s “North Area”, from which NA62 takes part of its name (62 being simply an incremental experiment number). The NA62 collaboration is small by CERN standards but it still comprises about 150 physicists at 20 institutes worldwide. Their primary aim is to make an extremely precise measurement of the probability that a positively charged kaon will decay to a positively charged pion plus a neutrino/antineutrino pair.

The decay probability might seem an arcane value to measure, but as collaboration member John Fry of the University of Liverpool in the UK explains, the decay itself is “one of the few ways open to us to actually challenge the Standard Model of particle physics”.

NA62 is looking for evidence of tiny quantum fluctuations in a specific decay process. A kaon comprises an up quark and an anti-strange quark. The up quark is a “spectator” that does not take part in the decay, while the anti-strange quark is transformed into an anti-down quark. According to the Standard Model, this occurs via a quantum loop and the probability of the transition has
been calculated to a high degree of precision.

However, hitherto unknown particles not predicted by the Standard Model could also contribute to the quantum loop. These particles could, for example, be "sparticles" that are predicted to exist by supersymmetric models of particle physics. Rather than revealing themselves in the final products of the decay, these particles would appear as quantum fluctuations and then contribute to the quantum loop before vanishing. These fluctuations could cause a significant deviation from the Standard Model decay rate – and measuring that discrepancy is the primary goal of NA62.

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Infrared light could create hydrogen from water

Infrared light could help split water into hydrogen and oxygen, despite the fact that infrared photons have less energy than is needed to drive the reaction. That is the claim of physicists in China, who have calculated that the reaction could proceed with the help of a bilayer catalyst that has a strong internal electric dipole.

In the 1970s some scientists envisaged that electricity generated by nuclear power stations could be used to create large quantities of hydrogen via the electrolysis of water. An alternative method for making hydrogen is photochemical splitting, which was proposed in 1972 by the Japanese chemists Akira Fujishima and Kenichi Honda. Their scheme is usually realized in a suspension of catalyst particles in water. A particle absorbs a solar photon, which generates an electron–hole pair that stimulates the decomposition of water and liberates the hydrogen. In order to succeed, the band-gap energy associated with the creation of the electron–hole pair must be greater than 1.23 eV. This corresponds to a near-infrared photon, so in theory photons with at least this energy (about 57% of photons from the Sun) can split water molecules.

In the intervening years, researchers have tried to develop catalysts with band gaps hovering just above 1.23 eV but with little success. Now, Jinlong Yang and colleagues at the University of Science and Technology of China in Hefei have set their sights on an even more ambitious goal: to make use of much more of the solar spectrum by developing a catalyst that works with infrared light well below the 1.23 eV threshold. While this might sound impossible from an energy point of view, catalysts often work by dividing a chemical process into several steps, each of which requires less energy than the overall process.

Using advanced computational algorithms based on density functional theory, the team designed an ultrathin catalyst comprising a bilayer of boron nitride functionalized with hydrogen atoms on the upper surface and fluorine atoms on the lower one. Fluorine has a very large electronegativity, which means that valence electrons would migrate to the lower surface of the bilayer to cause a potential difference of about 10 V between the top and bottom of the device.

The team calculates that the material has a band gap of just 0.85 eV, thereby allowing it to absorb infrared photons. The research suggests that when an electron–hole pair is created, the electron migrates to the top surface and the hole to the bottom surface, with the electron–hole pair thereby gaining 10 eV of energy. This is more than enough energy to split water and the researchers predict that hydrogen from water molecules would be reduced to hydrogen gas by the free electrons at the top surface, whereas oxygen from other water molecules would be oxidized to oxygen gas by the holes at the bottom. [To be published in Phys. Rev. Lett.]

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**Pulsar and companions will put general relativity to the test**

Astronomers have discovered the first pulsar with two stars circling it. By watching the three objects orbit one another, observers will soon be able to perform the best-ever test of the “strong equivalence principle”, which is a key prediction of Albert Einstein’s general theory of relativity.

Like the Newtonian theory of gravity that came before it, Einstein’s general theory of relativity says that gravity does not discriminate: it accelerates all objects equally, no matter what their size, shape or composition. Apollo 15 astronaut Dave Scott demonstrated this so-called equivalence principle on the Moon in 1971 by dropping a hammer and a falcon’s feather, which hit the lunar surface simultaneously.

The strong equivalence principle of general relativity goes further, saying that gravity should accelerate all objects in the same way even if the objects hold themselves together with their own gravity. In other words, the gravitational self-energy that binds a planet or star together should have no effect on how it is accelerated. This is unlike theories that seek to topple general relativity and predict a small deviation related to gravitational self-energy called the Nordtvedt effect.

The most exacting test of the strong equivalence principle performed so far involves tracking the Earth and the Moon. As they orbit the Sun, both are continually falling through the solar gravitational field. Einstein’s theory says that the Earth and the Moon should behave the same, even though the Earth has greater self-gravity. Precise laser-ranging measurements of the distance between the two bodies back this up by revealing no evidence of the Nordtvedt effect.

“The problem with tests of the strong equivalence principle here in the solar system is that none of the objects is strongly self-gravitating,” says Scott Ransom of the National Radio Astronomy Observatory in Charlottesville, Virginia. In contrast, a pulsar is ideal. It arises when a massive star explodes and collapses; it is typically just 20 km across but about 50% more massive than the Sun, so its gravity strongly binds it together.

Now, Ransom and colleagues have discovered a pulsar, named PSR J0337+1715, that will put Einstein to the test, thanks to the two stars that circle it. All pulsars spin fast, but this one, located 4200 light-years away in the constellation Taurus, spins especially quickly. It is a millisecond pulsar and each second it spins 365.953363096 times. Knowing its period to this incredible precision makes the pulsar an outstanding clock that astronomers can exploit.

By recording when the pulsar’s pulses reach Earth, Ransom’s team discovered small delays caused by the gravitational tugs of two companion stars. Many millisecond pulsars have one stellar companion, which has dumped material onto the pulsar and spun it up to high speed. But astronomers have never before found a pulsar with two stellar companions. “It’s really in a pretty extraordinary and very rare system,” says Ransom.

Both companions are white dwarfs, which have weaker self-gravity than the pulsar. Both are larger than the Earth but less massive than the Sun. One white dwarf is much closer to the pulsar than Mercury is to the Sun and orbits it every 1.629401788 days. The other white dwarf is about as far out as the Earth is from the Sun, circling the pulsar and the inner white dwarf every 327.257541 days.

The pulsar and the inner white dwarf can be thought of as Scott’s hammer and the feather: both are falling through the gravitational field of the outer white dwarf. Although the pulsar has much greater self-gravity, Einstein says both it and the inner white dwarf should respond in exactly the same way.

By carefully monitoring delays in the pulsar’s pulses, Ransom and colleagues are currently tracking the exact positions of all three objects. “Very, very soon we are going to be able to make tests of the strong equivalence principle that are orders of magnitude better than anyone’s been able to do before,” says Ransom, who expects a verdict within a year.

So far, Einstein’s theory has passed every test. “But general relativity is probably not the final word in gravity, since it doesn’t mesh well with quantum mechanics,” Ransom says. “So eventually, in some deep dark corner of parameter space, it’s probably going to fail. This could be it; we just don’t know yet.”
Clifford Will, a physicist at the University of Florida in Gainesville and author of the book *Was Einstein Right?*, calls the new pulsar the greatest test the strong equivalence principle has ever faced. “I hope Einstein prevails,” he says. “General relativity is so unbelievably simple by comparison [with alternative theories] that to me it just has the feeling that it has to be right, down to the quantum level.” Einstein formulated general relativity in 1915, and Will says a confirmation in 2015 “would be a great 100th birthday present for Einstein’s theory.” [S.M. Ransom et al, *Nature* (2014), doi:10.1038/nature12917]

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**Nanotubes give Raman spectroscopy a boost**

Tiny “tags” made of dye molecules stuffed into carbon nanotubes have been used to develop a high-resolution imaging technique based on Raman scattering. Created by researchers in Canada, the tags boost the weak Raman signal of molecules about one million times.

“One can imagine Raman scattering as the process by which photons shake a molecule,” explains Thomas Szkopek of McGill University, who is part of the research team. The vibration of each type of molecule is unique and so is the amount of energy exchanged with photons. By measuring the energy spectrum of the scattered photons, it is possible to determine what molecules are present in the sample.

Raman spectroscopy is widely used in medicine, chemistry and drug development. A major limitation, however, is that the scattered light is very weak. This makes the technique impractical for many applications, especially those involving high-resolution imaging of biological samples, because it takes so much time to collect the weak signal from each pixel.

Increasing the strength of the interaction between the light and the molecules does not help much, as it leads to the Raman light being hidden by much brighter fluorescence. “To be practical in high-resolution imaging, there is a need to boost the Raman signal by about a million times or more,” says Richard Martel of the University of Montreal, who led the research team.

The researchers begin by using nitric acid to purify the nanotubes, cleaning them and opening their ends. They then dissolve dye molecules in a solvent, mix in the nanotubes and heat the solution for a few hours. The dye molecules fill the tiny nanotubes and align along the tube axis. The resulting “nanoprobes” are about 1 nm in diameter, 500 nm long and contain about 500 dye molecules.

The next step involves adding a nanoprobe to the sample to be examined. The nanoprobes can be chemically grafted onto any object, even bacteria or proteins, therefore becoming a sort of “Raman tag”, says Martel. “Attaching the nanoprobes to a target is like printing a barcode into the object, allowing it to be identified even if it’s not Raman active or visible,” he says.

A measurement then proceeds like a normal Raman spectroscopy procedure. A laser beam inserted in the microscope objective shines onto the sample and its scattering is probed with a spectrometer. The only difference is a huge increase in the intensity of the Raman signal. [E. Gaufres, *Nature Photonics* 8, 72–78 (2014), doi:10.1038/nphoton.2013.309]

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**Raman hot spots**

**First noble-gas molecules found in space**

An international team of astronomers has accidentally spotted the first space molecules bearing a noble gas, argon. The surprising discovery, in the debris of an exploded star, reveals the element’s isotopic composition, confirming long-standing predictions that argon is forged in such doomed stars.

Once called inert gases, the elements in the final column of the periodic table have closed outer shells of electrons that normally prevent them from exchanging electrons with other atoms to form molecules. In 1962, however, chemists discovered molecules containing xenon and now call these elements noble gases instead. But no one had ever seen a molecule in space harbouring a noble gas, even though one such gas – helium – is the universe’s
second most abundant element.

Mike Barlow, an astronomer at University College London, and his colleagues were using the Herschel Space Observatory to study supernova remnants, including the well known Crab Nebula. It resulted when a massive star 6500 light-years from Earth in the constellation Taurus ran out of fuel, sparking a brilliant explosion that our ancestors witnessed in 1054.

Barlow and his colleagues wanted to observe the Crab Nebula’s dust, which radiates its heat at the far-infrared wavelengths that Herschel detects. They also searched the Herschel spectra for lines from common molecules such as carbon monoxide. The scientists never found those molecules. Instead, they saw two mysterious emission lines – one at a wavelength of 243 microns, the other at 486 microns, exactly twice as long. “That was a giveaway that it was a simple diatomic molecule – two atoms rotating about each other,” says Barlow. After failing to find a match with common diatomic molecules, the scientists realized that they had spotted the argon hydride molecular ion, the chemical formula of which is ArH+.

The peculiar molecule probably forms when singly ionized argon – an argon atom with one of its electrons missing – meets molecular hydrogen (H2) and grabs a hydrogen atom.

Argon (atomic number 18) is the eleventh most abundant element in the universe and the third most common gas in the atmospheres of Venus, Earth and Mars. Most terrestrial argon is argon-40, which comes from the decay of radioactive potassium-40 in rocks. But theorists have long predicted that massive stars should manufacture large quantities of a lighter argon isotope, argon-36, which has equal numbers of protons and neutrons. Other astronomers had already detected argon atoms in the Crab Nebula. “But there was no direct proof that it was argon-36,” Barlow says, because atomic spectral lines from different argon isotopes have nearly the same wavelengths, making it difficult to distinguish them.

For molecules, however, the task is easy, because molecules containing different argon isotopes emit radiation at noticeably different wavelengths. Therefore, the argon-hydride molecules revealed the element’s isotopic composition: it is argon-36, just as the theory predicts. [M.J. Barlow et al, Science 13 Dec 2013: 342, 1343-1345 doi: 10.1126/science.1243582].

Extracted with permission from an item by Ken Croswell at physicsworld.com
**Physicists and Physicians: A History of Medical Physics from the Renaissance to Röntgen**

by Francis Duck.

Institute of Physics and Engineering in Medicine (2013), paperback, 310 pages

ISBN 9781903613559

Reviewed by: Gilbert Vella, Honorary Associate, The University of Sydney.

When one thinks of medical physics today, it is customary to think its foundations commenced with the discovery of x-rays by Wilhelm Röntgen in 1895 and Henri Becquerel's discovery of radioactivity in 1896. This book clearly shows a much richer and longer history which dates back to the Renaissance era.

This is a fascinating story of the origins of medical physics over 300 years. As the subtitle states, it commences in the early 17th century with Giovanni Borelli in Italy and traces the significant contributions by early pioneers of this discipline in France, Germany, England, Scotland and eventually the USA. The story concludes with the revolutionary discovery of x rays and radioactivity, which ushered in the hospital-based discipline as we know it today.

It is very interesting to read that many of those involved in the development of medical physics were doctors with a strong interest in physics and mathematics. Indeed, what united them all was the belief that physics principles were essential to medicine. Two of the greatest contributors, both medically trained, are well known physicists in their own right. These are Thomas Young and Hermann von Helmholtz. In addition to describing their insightful work, Francis Duck presents some lesser known contributors such as Pierre Pellatan, Thomas Griffiths, Neil Arnott, Jules Gavarret and John Draper.

Professor Duck is a wonderful storyteller as he weaves the stories of these contributors, with an eye on the historical context, and describes how they developed the specialities of biomechanics, bioelectricity, haemodynamics, physiological measurement, ophthalmology and bioenergetics. Furthermore, these achievements were made against a backdrop of sometimes very difficult social, religious and political climates of the day. While placing the contributions into their historical setting is a great strength of this book, the unfortunate consequence is that some of the chapters do not follow seamlessly as the developments in medical physics in the various countries are described as separate stories. Throughout the book, what is clearly evident is the desire of these doctors and scientists to apply the current scientific knowledge of their time to understand the human body. In this way they were able to raise clinical medicine from its historical state of ignorance, guesswork and custom. It was truly inspiring to read how much these extraordinary people were able to achieve with so little at their disposal.

The book includes many wonderful figures of instruments of a bygone age, some of which are worthy of being called a Heath Robinson contraption! It is very well referenced with over 400 historical references. It is an excellent and approachable work for any scientist or doctor interested in medical physics or any person wishing to know how physics has advanced the practice of modern medicine.

**The Physics Book**

by Clifford A. Pickover

Sterling (2011), hardback, 528 pages

ISBN 9781402778612

Reviewed by Jason Dicker, Launceston College

As on the front cover, 250 Milestones in the History of Physics! This general reference cum coffee table book is from a prolific author with a PhD in molecular biophysics and biochemistry, who attempts to summarise the history of significant physics events whether theory, experimental or technical.

The book uses a format of a page for an article and the opposing page for an impressive graphic or photo. Articles are of the form, "1924 De Broglie Relation", or "1798 Cavendish Weighs the Earth" and they attempt to give a précis of the heading topic that includes leading names, physics and significance. As such they are necessarily limited in depth and content but often still surprising in richness. A lot of research has gone into the content as shown by the thoroughness of each article and the extra reading list at the end.

Necessarily, any reader will have cavils over the selection of some events and wonder at the direct relevance to physics. The Cannon of 1132 is one such item as are the Superball of 1965 and the Lavalamp of 1963. These sit next to Bell’s Theorem 1964 and Quasicrystals 1982. But the reasons for inclusion are interesting in their own right and any one writer will come to a different set of events.

I also have noticed a slight bias towards American events over some others, the Cyclotron is included but...
the Walton-Cockcroft Accelerator is not! The Baseball Curveball is an article about aerodynamics, as one would assume, but why not simply call it the Magnus Effect, why link it to the American baseball in the heading when this is not done for similar articles?

There are also some slight oversights, a “mediaeval cannon” picture is clearly late eighteenth century. Of greater concern, The Dark Energy article fails to emphasize the basic physics, that the expansion of the Universe is accelerating (and those who made this discovery, Perlmutter, Schmidt and Riess are not mentioned, something that Pickover was scrupulous about elsewhere), instead focusing on the hypothetical Dark Energy as if it has been absolutely corroborated and not a model mechanism. Indeed, it is in the articles of the most recent times that I found most disquiet. They change from being quite authoritative to speculative, and they are biased to largely US theories. (On the other hand, he may be right and I completely wrong!)

However, this is quite a good book, very well presented and excellent for those who wish to become aware of the development of physics over time but do not wish to spend a huge amount of time so doing. It is a very good book for school libraries or teachers who are happy to lend books to their students.

Einstein and the Quantum: The Quest of the Valiant Swabian

by A. Douglas Stone
Princeton University Press (2013), hardback, 344 pages
ISBN 9780691139685

Reviewed by Emeritus Professor Paul Edwards, University of Canberra.

Professor Douglas Stone has written an engaging book about Einstein’s contributions to early quantum theory. He makes a convincing case that these contributions, most of which were made in the 20 year period between 1905 and 1925, have been historically undervalued and that it was Einstein himself, not Planck or Bohr, who deserves most credit for the initial development of quantum theory. Stone believes that Einstein would be widely recognised as the father of quantum physics were it not for his eventual rejection of quantum epistemology and indeterminacy, the latter typified by the often quoted comment from a 1926 letter to Max Born: “I...am convinced that He [God] does not throw dice”.

Early in the book, Stone quotes another Einstein’s comment, this time to Otto Stern: “I have thought a hundred times as much about the quantum problems as I have about Relativity Theory”. He then proceeds to document the evidence for this preoccupation from recent biographies and from primary sources such as the 12 volume Collected Papers of Albert Einstein.

This book will interest working scientists, teachers and students as well as science historians. The science, the historiography, and the descriptions of the personalities and lives of the early quantum physicists are well interwoven. The relevant classical and quantum concepts and the conflicts between them are presented at the level of an introductory modern physics course. However some physicists may find this treatment rather repetitive: I counted more than 30 mentions of the equipartition principle and the equation \( E = kT \) in the first half of the book.

Stone was apparently led to his reappraisal of Einstein’s early work in the course of his own research on quantum systems by the discovery that the solution to a particular problem, on which he and a PhD student were working, had been found by Einstein a century earlier, well before the advent of modern quantum theory. Further research evidently convinced him “that it was Einstein who had introduced almost all the revolutionary ideas underlying quantum theory”, usually well in advance of their eventual acceptance by a conservative European physics community.

Stone identifies these ideas as energy quantisation; the concept of the photon; wave-particle duality; intrinsic quantum stochasticity; the indistinguishability of quantum particles; and the concept of wave field intensities as probability densities. He enthusiastically suggests that these achievements were worth four Nobel prizes, not just the one “grudgingly” presented in 1922 for the 1905 paper on the photo-electric effect!

He points out that following the experiments of Geiger and Bothe in 1925 which finally vindicated the concept of the photon as a force-carrying particle (contrary to Bohr’s belief), Einstein became increasingly disenchanted with the “new” quantum theory of Heisenberg, Born and Schrödinger promulgated in the summer of that year. Indeed, he became a quantum theory sceptic and an advocate of “hidden variables”. He believed these could account for the “spooky action at a distance” of quantum entanglement, now of course central to quantum information science and its applications. Since his death, EPR thought experiments of the type which he proposed in his 1935 paper with Podolsky and Rosen in an attempt
to draw attention to the “untenable” non-local correlations predicted by the new theory, have since been realised many times, and their reality confirmed.

In the final chapter of this excellent book, Douglas Stone attributes Einstein’s early role as an innovative quantum science leader, and his later role as a conservative critic of quantum theory, to his iconoclastic personality; to his experience as a scientific maverick of eventually having been proven right; and to his unshaken belief in a “…huge world, which stands independently of us human beings and which stands before us like a great eternal riddle…”.

**PRODUCT NEWS**

**COHERENT**

**New Nd:YAG laser with automated phase-matching**

Quantel has released the new Q-Smart 850, a high-energy Nd:YAG laser delivering 850 mJ pulses at 1064 nm and 10 Hz repetition rate. A full range of harmonic options is available including 532 nm, 355 nm, 266 nm and 213 nm.

Q-Smart builds on the success of the earlier Brilliant B laser which featured compact design, modular harmonics and excellent beam properties. The new laser is even easier to use as a result of the new Q-touch interface and completely automated optimisation of harmonics phase-matching. Changing wavelengths and tuning of harmonics is straightforward and can be completed in a matter of minutes.

Q-Smart is compact and highly portable, with easy disconnect of the laser head from the electronics when required. The laser includes a comprehensive 2-year warranty and flashlamp lifetime of 100 million shots.

**2013-2014 Semrock Catalogue Released**

This comprehensive catalogue contains the latest products introduced over the last six months including over 40 new or improved thin-film filters for fluorescence microscopy and measurements, Raman spectroscopy, and other laser analytical instrumentation applications.

Among the standouts is the expansion of the industry-leading high performance RazorEdge® “E” grade product line. These ultra-steep long-pass edge filters are designed to provide deep blocking at the laser wavelength, then quickly transition to high transmission in less than 0.5% of the laser wavelength (e.g. <2.7 nm for a 532 nm laser). Nine new wavelengths have been added to this series. All Semrock filters are covered by a five-year warranty.

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corporated diode and the systems have a typical mode-hop free tuning range of 20-50 GHz.

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Horiba H20-UVL, Vacuum UV Monochromator

The H20-UVL is a monochromator especially designed for analysing 100-400 nm (3 to 12.4 eV) Vacuum Ultra-violet (VUV) range under vacuum, or 190-400 nm at atmospheric pressure. Its micrometric slits and its worm drive make its scans precise and fast. This short focal length vacuum monochromator is ideal for lighting samples if coupled with a VUV light source or for VUV low resolution analysis when equipped with single channel detection.

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The first ever USB 3.0 Beam Profiling Camera from Gentec-EO

Gentec Electro-Optics and Lastek, are proud to launch the Beamage 3.0, the very first USB 3.0 camera dedicated to Laser Beam Profiling. This new CMOS-based camera comes with a completely redesigned software that features both a highly intuitive user interface and powerful data analysis tools. The USB 3.0 interface of the new Beamage 3.0 camera features a data transfer rate up to 10X faster than any USB 2.0 system. This incredible speed allows for much faster data transfer rates, up to 10 fps at 1 MPixels. USB 3.0 also features an improved communication architecture that reduces both data transmission latency and power consumption.

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