THE UNIVERSITY OF MELBOURNE
School of Physics
Issue 8, Jul 2008

Alumni & Friends Newsletter

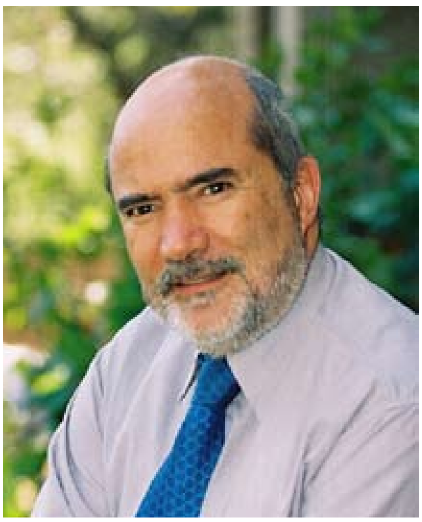
Message from the Head of School

If there is a theme emerging in 2008 – it is the year of change and renewal. The School of Physics is preparing new courses, developing new curriculum, tilling new research ground…all under a new Head. To paraphrase Robert Hughes, "the shock of the new" can be daunting at times but I am excited by the achievements to date.

Academic staff, under the leadership of Professor Ray Volkas and his team, have responded magnificently to the challenges of Melbourne Model by developing a first rate Masters of Science (MSc) degree as an alternative for Honours, starting in 2009 (with Honours to be eventually phased out). We feel the time is right for our students, to receive the best global education experience; for our staff, who can now deliver intellectually challenging material over a two year period instead of one and, of course, for the University, which has taken the brave step to lead the education debate within this country. It will not surprise me to see the other Australian universities follow suit over the course of the next few years.

Additionally, we will have on offer for the first time next year, another new Masters of Science degree, designed for professional employment outcomes, while the 'old' Masters degree, based purely on research thesis, will be renamed Master of Philosophy (MPhil). We encourage you to peruse our website over the next few months (http://graduate.science.unimelb.edu.au/graduate/new).

I am particularly indebted to all staff in the School who have been working tirelessly in order to their deliver on these new challenges - I recognise that demanding teaching loads and curriculum re-design are difficult, especially while maintaining quality research output. In line with the University's "2008 - Year of Research" , this edition of the newsletter will be devoted to our staff's ground-breaking research publications in journals such as ***Nature*** and the media generally.



Finally, I would like to to take the opportunity to thank the out-going Head, Professor Geoffrey Taylor, for his leadership, dedication and outstanding service to the School.

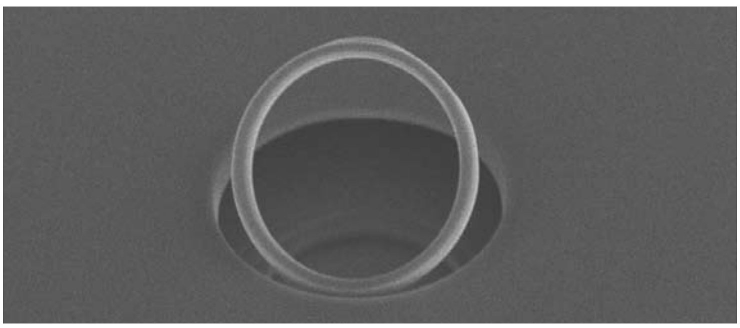
Professor David Jamieson

World's smallest diamond ring!

In March 2008, Professor Steven Prawer and his team presented to the American Physical Society images of the world's smallest diamond ring, carved from a slither of diamond using FIB (focussed ion beam) milling techniques. Measuring just 5 micrometers across and 300 nanometers thick, the tiny loop may help let scientists manipulate single photons, a role potentially important in the quest for quantum information processing.

"Scientists know in theory how quantum computers could take advantage of the rules of quantum physics to carry out enormous numbers of processes simultaneously but in reality, building such a computer has been an enormous challenge. Diamonds could overcome some of the obstacles", Prawer says. The ring offers an ideal way to produce 'qubits', the quantum equivalent of 'bits' that store information on standard computers except that the values of '0' and '1' normally associated with 'bits' can also exist in a 'superposition' of both states at once.

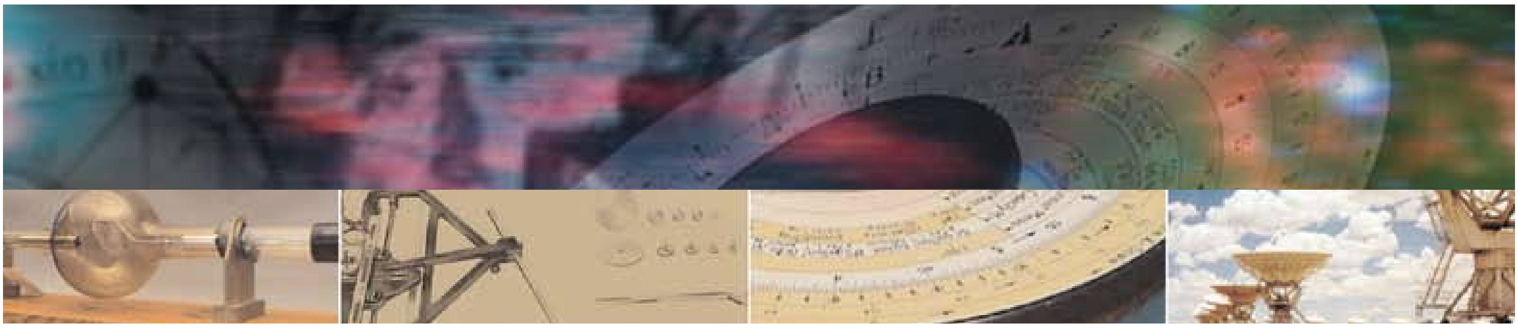
Professor Prawer says the key to diamond's success in this role is the impurities found in diamond – single nitrogen atoms (nitrogen-vacancy centres) trapped with the carbon structure have the ability to affect the electronic band gap and act as a semi-conductor. When a laser light is shone into the centre, single photons of red light are produced in ways that are easy to manipulate and measure. What distinguishes this system is its ability to perform at room temperature, something most other quantum systems can't do.



Diamond ring (diameter of 5 micrometers), prepared by Dr Paolo Olivero and PhD student Babs Fairchild

New website for the School

Well overdue we know, the School of Physics has a new website – ***http://physics.unimelb.edu.au***
Our 'Alumni' section will have back issues of newsletters for you to peruse while our 'Newsroom' with RSS feeds will keep you informed of latest colloquia, seminars, public lectures, news and other events. Help us boost the Google Page Rank by viewing it. We hope you enjoy the new look!



Why matter matters in the Universe

"Difference in direct charge-parity violation between charged and neutral B meson decays" **Nature**, 452, March 2008 – Belle Collaboration (including University of Melbourne's A/Prof Martin Sevior, Dr Elisabetta Barberio, Prof Geoffrey Taylor, Philip Urquijo),

This paper reveals that investigation into the process of B-meson decays has given insight into why there is more matter than antimatter in the universe. "B-mesons are a new frontier of investigation for us and have proved very exciting in the formation of new thought in the field of particle physics." said A/Professor Martin Sevior. Sevior says that B-mesons contain heavy quarks that can only be created in very high energy particle accelerators. Their decays provide a powerful means of probing the exotic conditions that occurred in the first fraction of a second after the Big Bang created the Universe.

"Our universe is made up almost completely of matter. While we're entirely used to this idea, this does not agree with our ideas of how mass and energy interact. According to these theories there should not be enough mass to enable the formation of stars and hence life."

"In our standard model of particle physics, matter and antimatter are almost identical. Accordingly, as they mix in the early universe they annihilate one another leaving very little to form stars and galaxies. The model does not come close to explaining the difference between matter and antimatter we see in the nature. The imbalance is a trillion times bigger than the model predicts."

Sevior says that this inconsistency between the model and the universe implies there is a new principle of physics that we haven't yet discovered. "Together with our colleagues in the Belle experiment, based at KEK in Japan, we have produced vast numbers of B mesons with the world's most intense particle collider."

"We then looked at how the B-mesons decay as opposed to how the anti-B-mesons decay. What we find is that there are small differences in these processes. While most of our measurements confirm predictions of the Standard Model of Particle Physics, this new result appears to be in disagreement. It is a very exciting discovery because our paper provides a hint as to what the new principle of physics is that led to our Universe being able to support life."

Quantum all the way

News feature, **Nature**, 453, May 2008 (quoting University of Melbourne's Dr Max Schlosshauer) - article by Phillip Ball, presented as edited extract by Joanne Kuluveovski

'One of the great puzzles of modern physics is the quantum–classical transition: where the strange quantum world somehow gives way to the solid, definite certainties of the everyday 'classical' world as we go up the scale from atoms to apples. Early quantum theorists treated the quantum–classical transition almost as a kind of sleight of hand, something that had to be imposed on quantum mechanics to recover the familiar world. Now, however, there are strong signs that the transition can be understood as something that emerges quite naturally and inevitably from quantum theory. If that's so, it implies that 'classicality' is at root simply another quantum phenomenon.

"There's good reason to believe that we are just as much part of the quantum world as are the tiny atoms and electrons that sparked quantum theory in the first place," says quantum theorist Dr Maximilian Schlosshauer. One of the most favoured one involves a phenomenon know as 'decoherence', the idea of quantum behaviour leaking away when a particle interacts with its surroundings. For example, when an atom or molecule collides with those around it, or when light bounces off it. All we are left with is a partial picture of the system — a picture in which only a well-defined subset of macroscopic properties, such as position, are apparent.

Decoherence also predicts that the quantum–classical transition isn't really a matter of size, but of time. The stronger a quantum object's interactions are with its surroundings, the faster decoherence kicks in. So larger objects, which generally have more ways of interacting, decohere almost instantaneously, transforming their quantum character into classical behaviour just as quickly.

The decoherence description of the quantum–classical transition is not necessarily the end of the matter — it leaves unresolved some more fundamental questions about the interpretation of quantum theory. But at present, it seems a fair bet that what we think of as the classical world is really only the quantum world viewed through the lens of decohered states. "The conceptual leap would then be to conclude from this that quantum mechanics is truly universal," says Schlosshauer, "in the sense that everything, including us, is described by entangled quantum states." '

If you would like to drop us a line, please email us at alumni@ph.unimelb.edu.au. The information in this publication was correct at the time of printing.
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