JULY 2013

Physics Matters

Spark the Gap – the Forum by Students for Students

The four speakers at the inaugural session ⇨

⇦ The enthusiastic audience

Inside this issue :

Spark the Gap—the forum for physics students—was initiated by the NUS Physics Society (PhySoc) with the motivation to engage physics freshmen via a platform that could address their interests and concerns from research to job prospects.

Adrian Nugraha Utama, the Honorary Event Master of the PhySoc Committee and one of the proponents of the forum, shared with *Physics Matters* the rationale behind the forum: "Often, in the midst of their research or learning experience, students discovered something they want to share with their community. However, they don't have the chance and this mind-kindling discovery just has to be kept within them or maybe shared with very close friends or professors. But what they have observed could actually spark the mind of others and escalate the interest in discovering physics.

"Learning among physics students has also been quite individualized. Having good grades, research and study skills seem to be all that matter. But we feel it is more important that students be given the opportunity to learn to convey their thoughts in layman terms to the non-physicist world."

So comes Spark the Gap! The aim is to promote the sharing of interesting research or physics learning among students. Here students could practise sharing their ideas with peers in a friendly atmosphere. Through the forum, young physicists could also build their own social circles and enhance the physics learning environment in the department.

The planning for the first forum was quite a challenge to the PhySoc Committee. After much deliberation, a framework was put in place. They were happy to have four students to speak at the inaugural session held on the 4th of April.

Each speaker was allocated 10 to 15 minutes with a Q&A at the end. Speakers could engage in an academic talk—a sharing of ideas and concepts behind their current research (UROPS or FYP) or any interesting physical phenomenon—or a free talk which is a sharing of their physics learning experience whether personally or in a special programme.

Despite the forum being held close to the exam period, there were still about 20 enthusiastic physics staff and students who attended the talk. Audience got to vote for their most favourite speaker who was awarded with a small prize as a token of appreciation by the Physics Society. The feedback received thereafter has been positive. The Physics Society believes that in future, with greater publicity and more speakers, there will be an increase in student participation. They have also decided to host this event every semester.

The Physics Society welcomes the attendance and feedback from academic staff and hopes that this forum may even spark off some research projects!

⇦ The PhySoc Committee with staff advisor, Dr Cindy Ng (left)

Department of Physics

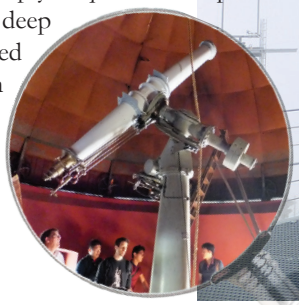
NUS National University of Singapore

Germany Immersion Trip 2013

The Germany Immersion Trip from 9–30 June attracted a total of 18 physics undergraduates. The students spent the majority of their time in Munich and Göttingen.

In Munich, they visited the Ludwig-Maximilians-Universität (LMU) including the Wendelstein Observatory. They also attended a number of talks and colloquiums and had a chance to visit the Garching nuclear reactor. Another highlight was a visit to one of the world's best science museums—the Deutsches Museum.

Also in Munich, they indulged in the local traditional Bavarian breakfast at Atzinger, toured the Allianz Arena (Bayern Munich Stadium) and had a lovely touch of nature in an animal wild park called Poing. They also patronised many Beer Gardens mainly unique to Bavaria, where you could dine with your own food as long as you purchased the beer—simply exquisite. A trip to the concentration camp in Dachau left deep impressions on students too as they relived the Nazi regime with the aid of an excellent tour guide.



At the Wendelstein Observatory ⇨

In Göttingen, they were brought around the science-history-rich town, listened to a talk from a professor from the Higgs Boson discovery team and visited Trinos, a huge vacuum chamber manufacturing company, among other engagements. A trip to the awesome Plesse castle was also part of their excursion which rewarded them with a breath-taking view. The architecture and sights in Europe were a pleasure to visit firsthand.

Through all the eye-opening trips and informative talks, students learned about Germany and the European culture as they mingled with students from the local universities they visited. They also experienced how physics was taught and held with great respect in Germany which helped to broaden their own perspectives. Overall, the students found that the trip exceeded their expectations and was enriching both academically and culturally.

⇩ Participants of GIT2013

Physics Enrichment Camp 2013

⇧ Listening to an interesting talk

Nearly 500 students from secondary schools and junior colleges all over Singapore attended the 17th Physics Enrichment Camp from 10–13 Jun.

From aerodynamics to wave-particle duality, students had an interesting time listening to talks by physics professors. They also visited the labs and participated spontaneously in the quizzes.

This year, more time was allocated for secondary school students to try hands-on activities. They got to construct a cheap mini-catapult using wooden pegs, craft sticks, rubber band, binder clips and a plastic spoon. They also got to explore crater formation on planets using a tray of flour with a layer of cocoa powder on top. This is truly physics in action for students!

⇧ Hands-on activities

Awards

Congratulations to our fellow colleagues for being the proud recipients of the following awards:

Annual Teaching Excellence Award 2013
A/Prof Chung Keng Yeow
Dr Yeo Ye

Young Researcher Award 2013
Dr Barbaros Özyilmaz

Mentor of winning project at the Intel International Science and Engineering Fair (ISEF) 2013:
Dr M V Venkatashamy Reddy

Mentor of winning projects at the Singapore Science and Engineering Fair (SSEF) 2013:
Gold: A/P Sow Chorng Haur & Student Mentor Sharon Lim Xiaodai; A/Prof Phil Chan; Dr M V Venkatashamy Reddy & Prof B V R Chowdari
Silver: A/Prof Peter Ho & Dr Png Rui Qi; Dr M V Venkatashamy Reddy & Prof B V R Chowdari
Bronze: Dr Yeo Ye; Dr M V Venkatashamy Reddy & Prof B V R Chowdari
Merit: Dr M V Venkatashamy Reddy & Prof B V R Chowdari

NUS High School Inspiring Research Mentor Award 2013
Dr M V Venkatashamy Reddy
A/P Sow Chorng Haur

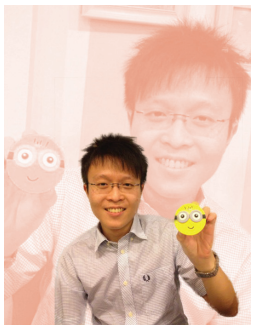
The Physics Department was awarded the "Commitment to Safety and Health Excellence" in the Annual Safety & Health Performance Award (ASHPA) 2013.

What I learn about Physics...

Each academic year, a large number of non-physics majors enrol for the GEM and GEK modules the department offers. *Physics Matters* approached a few students to find out about their learning experience (below is the first of this two-part series).

Before taking this module, I thought that arts and physics were two subject matters with little in common. However, the *Art of Science, Science of Art* module allowed me to appreciate how scientific theory could be used to enhance the aesthetic beauty of art. Although the theory is easy to grasp, applying it to real life situation could be difficult.

Marilyn Chew, School of Design & Environment



The Introduction to the Nanoworld module is certainly one of most interesting and relevant GEMs I have taken thus far. It focuses heavily on Quantum Physics, a personal favourite subject of mine, as well as the applications of nanotechnology in the 21st century. The various experiments conducted during the lectures were enjoyable and helped to reinforce the theories taught. This truly enriched the overall learning experience of students as we could participate in the experiments. The visit to the Singapore Synchrotron Light Source (SSLS) was an eye-opening experience for many of us. I thank the staff for always being so enthusiastic in their teaching and would recommend this module to any student.

Liew Wai Kit, Faculty of Arts and Social Sciences (Economics)

Although I am a computing student, I realize the knowledge of Physics is important in order to understand the concepts of how things work and interact with one another in the universe. I took *Understanding the Universe* as my unrestricted elective because previously I had great interest in taking photos of the sky and stars at night. It is so far the most memorable module I have taken in NUS as I could gain many interesting facts and concepts about the star systems and the universe that we live in. One immediate benefit for me is getting a clear understanding of the stars and constellations, their movements and ways to identify them which helps me greatly in my night photography.

Phyo Myat Thu, School of Computing

Concepts taught in class and the lab experiments done constantly challenged me to be more imaginative and analytical as many of the components are linked to each other. This experience complemented my studies in the Business School and offered me a scientific approach in looking at a problem. The *How the Ocean Works* module is one of the most interesting and enjoyable modules I have taken in NUS. As a result, I have also gained more understanding about the world around me.

Siswanto Tang, School of Business

I was interested in taking the *Science of Music* module as I wanted to learn more about music from a different point of view—a more objective and scientific point of view. Despite being a member of a Chinese orchestra for nine years and dabbling in instruments such as the guitar, piano and electric organ, this module was an eye-opening experience for me. I got to learn more about sound frequencies, harmonics, how the musical scale was derived and how sound is digitised. These are things not taught in conventional music lessons. The lessons were conducted in such a way that concepts were easy to grasp.

Tham Juncheng, Yong Loo Lin School of Medicine (Nursing)

In memory of Mr Tan Choon Wah

The Department is deeply saddened by the departure of workshop manager Mr Tan Choon Wah on 17 April 2013.

Mr Tan had always played a primary and significant role in supporting the works of the workshop right from its inception. From colleagues in the department to vendors, all would acknowledge Mr Tan's diligence and dedication to his work. He willingly assisted any staff or student who needed his service in designing and fabricating equipment parts for research or teaching purpose. His demise has been a great loss to the department.

A caring family man, Mr Tan left behind his wife, three children and two grandchildren.

Physics in Action!

Where Physics meets Chemistry at the Organic Nano Device Laboratory

A/Prof Peter Ho, Director at the Organic Nano Device Laboratory (ONDL), Science Faculty, NUS, shares his thoughts about research at ONDL. A/Prof Ho, whose work is in the field of Organic Electronics, is also joint holder of the Dean's Chair Professorship.

How ONDL started

Together with a team of students and Asst/P Lay-Lay Chua, I started the Organic Nano Device Laboratory (http://www.physics.nus.edu.sg/~ondl/) in the Physics Department in 2005. This was the first device cleanroom facility in our Faculty and was funded by start-up grants awarded by the Faculty and NUS. The ONDL now has a suite of class 1,000 and class 10,000 cleanrooms on level 3 of Block S7 and a synthetic facility in Block S9. These together house our materials and device research and development programmes.

Organic Electronics

The mission of ONDL is to conduct fundamental research to advance the science and technology of Organic Electronics. Organic electronics are based on organic semiconductors which are molecular or polymeric carbon-containing materials with delocalised pi electron densities. They can be tailored by synthetic chemistry to show excellent (opto)electronic, transport and other properties for a variety of interesting applications, such as in energy-efficient thin-film lightings and displays, flexible electronic paper and plastic solar cell foils. The solubility of these materials in common solvents enables their low-cost processing through additive printing or coating techniques. This allows electronic devices to be fabricated over large, flexible and/or unconventional substrates, which could potentially revolutionalise electronics.

There is a lot of emerging interest in Organic Electronics worldwide, and also in Singapore where several multinational chemical and electronics companies have R&D facilities in this field. Nevertheless, a number of pressing fundamental scientific questions remain open, such as the nature and control of charge carriers, and their injection, dissociation, transport, and recombination in these organic semiconductor materials. The answers to these and related questions will reveal cornerstone insights for new advanced generations of devices with higher performances and energy efficiencies. To tackle these questions effectively, however, one needs to work beyond the traditional boundaries of semiconductor physics and materials chemistry to build teams which can understand and contribute simultaneously to both of these aspects.

Fusion of physics and chemistry

Thus each of the four research groups in ONDL is integrated with materials chemistry and semiconductor physics capabilities, including characterisation and modeling. The four groups are the organic light-emitting diode and solar cell groups, led by Dr Rui-Qi (Rachael) Png and myself, and the transistor and graphene–organic hybrid groups, led by Asst/P Chua. The students and post-doctoral research fellows in each of these groups come from both the Physics and Chemistry Departments. While the groups are substantially independent, they are strongly coordinated to tackle overarching issues together as an "ideas factory".

Recent achievements

This is the reason why we think ONDL has achieved a strong reputation worldwide for its research. ONDL scientists are regularly invited to give lectures in large international conferences overseas. We also work in deep collaboration with our partners. One recent example of a success is our first demonstration of advanced heterostructure devices, reported in *Nature Materials* in 2010, which improves the prospect for sophistication in polymer organic electronic devices. Another one is the "taming" of the nanomorphology in polymer: fullerene organic solar cells using doped polymer networks, reported in *Nature Communications* in 2012, which removes a key bottleneck to commercial production. Other examples include a new world record in nonlinear optical limiting materials using graphene hybrids, reported in *Nature Photonics* in 2011; and a potentially game-changing graphene transfer methodology for device applications, reported in *Nature Nanotechnology* in 2013. ONDL has a programme which is widely acknowledged to investigate and advance the physics of ohmic contacts in Organic Electronics.

⇧ **ONDL scientist at work**

In addition, ONDL has also succeeded to attract industry support for her works through both research collaboration agreements and intellectual property licensing agreements. This year, the total value of industry-funded commitments per annum to ONDL reaches one million dollars. This underlines the confidence and value which the international community places on our work.

Looking beyond

ONDL has just completed its Phase I plans for core competency building. Over the next five years, ONDL will embark on its Phase II plans for value creation together with its partners. We intend to achieve this by broadening our collaborations with university groups worldwide to develop global synergisms, and with both local and international industry partners to help translate fundamental scientific breakthroughs to industry-compatible processes. These two aspects should provide interesting new dimensions to the experience and training of our students and research fellows. We are confident that ONDL will reach new heights. The success of ONDL depends on the many very brilliant graduate students and research fellows who have joined us over the years. It is to them that the credit ultimately belongs.

Contributed by A/Prof Peter Ho

Discovering Physics: How Physics helps in discovering new DNA structures

Double-stranded DNA has often been described as a right-handed helical structure, known as B-DNA. However, to perform its multiple functions, DNA must exist in multiple structures depending on the conditions. Here I describe an interesting story of how physics helps in discovering a novel mysterious DNA structure induced by mechanical stretching.

A long-lasting debate on the DNA overstretching transition

In 1996, two back-to-back papers published in the same issue of the scientific journal Science reported a surprising finding that the DNA became elongated by ~ 1.7 fold when a tensile force of ~ 65 pN was applied to the two ends of the DNA [1,2]. This finding led to an 18-year debate on the nature of the transition. Three possible transitions that may lead to different elongated DNA structures have been proposed, namely, a single-stranded DNA (ssDNA) under tension, DNA bubbles consisting of two parallel, separated single-stranded DNA (2ssDNA) under tension, and a hypothesized new form of base-paired double-stranded DNA named the S-DNA. The focus of the debate is whether the mysterious S-DNA exists.

Multiple transitions distinct in kinetics revealed

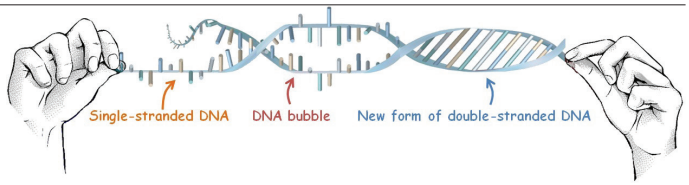
This highly risky project began in my lab in 2009 by my former research fellow, Dr Fu Hongxia, who is now a postdoctoral fellow in the Harvard Medical School. After overcoming many frustrating technical challenges, in 2010, we reported that DNA overstretching involves two transitions that are distinct in kinetics, namely, a slower hysteretic transition likely involving DNA melting and a faster non-hysteretic transition to an unknown DNA structure [3]. In 2011, we showed that the slower hysteretic transition is a DNA melting transition involving peeling apart a single-stranded DNA from the other [4]. The remaining questions are what the nature of the non-hysteretic transition is and what DNA structures it may lead to.

Anomalous entropy change during the non-hysteretic transition

After Dr Fu Hongxia moved to the Harvard Medical School, a new research fellow, Dr Zhang Xinghua in the Singapore-MIT Alliance for Research and Technology (SMART), continued with the exploration. In 2012, we realized that we could answer the questions if we can measure the entropy change associated with the respective transitions. Due to the gained freedom from the dissociated DNA bases, a melting transition must associate with a large positive entropy change. We developed a powerful method that allowed us to measure the entropy change at a single-molecule level when DNA was stretched. We confirmed that the hysteric transition is indeed associated with a DNA melting entropy. In sharp contrast, we found that the non-hysteretic transition was associated with a small negative entropy change. This result strongly suggests that DNA re-arranges into a highly ordered, non-melted state during the non-hysteretic transition. We also demonstrated that the selection between the two transitions was dependent on DNA base-pair stability and could be represented in a multi-dimensional phase diagram [5].

Three distinct transitions identified

In our most recent study, using a topologically closed DNA that does not have open ends or nicks in the DNA, we identified the third possible transition, which is a melting transition involving two separated single-stranded DNA (2ssDNA) under tension, formed at low salt concentration or high temperature [6].



⇧ **Three overstretched DNA structures in mechanically stretched DNA**

This new result, together with the results from the previous four years of studies, means that we have finally identified all the three proposed structures and fully characterized their respective thermo-mechanical properties. These findings complete the picture about the structures of torsion-unconstrained DNA under tension and prove the existence of the S-DNA, providing a conclusion to the 18-year-old debate.

References:

[1] Cluzel P, et al, "DNA: An extensible molecule", *Science* **271**(5250), 792-794 (1996).

[2] Smith S B, Cui Y, Bustamante C, "Overstretching B-DNA: The elastic response of individual double-stranded and single-stranded DNA molecules", *Science* **271**(5250), 795–799 (1996).

[3] Fu, H X, et al, "Two distinct overstretched DNA states", *Nucleic Acids Research* **38**, 5594-5600 (2010) (featured article).

[4] Fu, H X, et al, "Transition dynamics and selection of the distinct S-DNA and strand unpeeling modes of double helix overstretching", *Nucleic Acids Research* **39**, 3473-3481 (2011).

[5] Zhang X, et al, "Two distinct overstretched DNA structures revealed by single-molecule thermodynamics measurements", *Proceedings of the National Academy of Sciences* **109**, 8103-8108 (2012). News release: http://www.sciencedaily.com/releases/2012/08/120803082913.htm

[6] Zhang, X et al, "Revealing the competition between peeled-ssDNA, melting bubbles and S-DNA during DNA overstretching by single-molecule calorimetry", *Proceedings of the National Academy of Sciences* **110**, 3859-3864 (2013). News release: http://www.sciencedaily.com/releases/2013/02/130228080240.htm

Yan Jie received his first PhD in theoretical physics from the Institute of Theoretical Physics of the Chinese Academy of Sciences (1998) and a second PhD in experimental biophysics from the University of Illinois at Chicago (2005). He joined NUS as an Assistant Professor in 2005. He is currently an Associate Professor in the Department of Physics and a Principal Investigator of Mechanobiology Institute. He also holds various other positions including Principal Investigator, NUS Centre for Bioimaging Sciences, and Faculty Fellow, Singapore–MIT Alliance for Research & Technology (SMART). His research areas involve investigating the micromechanics of DNA, protein and their interactions, at a single-molecule level.

ICMAT 2013, 30 Jun–5 Jul, Suntec Singapore

2500 international delegates at the 7th International Conference on Materials for Advanced Technologies had plenty to keep them busy. With nine plenary lectures, four theme lectures and 30 symposia covering a diverse range of latest scientific developments in the field of materials science, participants were in for a great time. Nobel Laureates Profs Lee Yuan-Tseh and Alan Heeger also gave two public lectures at the University Cultural Centre well attended by students and members of the public.

⇦ Prof Lee Yuan–Tseh opening the ceremony with Prof B V R Chowdari and Provost Prof Tan Eng Chye looking on

⇧ Posters on display

⇧ ICMAT 2013 at Suntec City

⇧ Public lecture at UCC

⇧ Plenary lecture

A Day in the Life of...

⇦ Bee Hwee holidaying in picturesque Venice

"Information technology has been evolving rapidly so has my work over the past 30 years. I welcome the opportunity to learn about changing technology. With a positive frame of mind, I could continue to take on new challenges." Mdm Tay Bee Hwee shared readily with *Physics Matters* concerning her work in the department.

A day for Bee Hwee could start out recovering data from a faulty hard disk, setting up an IT equipment, troubleshooting software in the two computer labs used extensively for teaching or testing the personal response system in the LT for department events. As an IT lab manager, she has to lead her team of lab technologists besides supporting staff, students and researchers as well as dealing with vendors.

"All requests could seem urgent but once I manage to resolve a problem, I liken myself to a doctor prescribing a 'cure' to colleagues' anxiety and burden. This is where I derive my greatest job satisfaction!"

Bee Hwee enjoys every gathering with colleagues on special occasions like a birthday celebration. As a member of the Department Staff Welfare Committee, she often assists in the organisation of staff outings and tea sessions. She also initiated a weekly exercise programme for colleagues during lunchtime which has been running for over four years.

Anyone who knows Bee Hwee would attest to her passion for singing. A karaoke champion, Bee Hwee thinks singing is fun, relaxing and helps her to stay healthy and youthful. "Singing increases the lung capacity and boosts my mental alertness. I perform regularly in community centers for our residents especially the senior citizens, something meaningful for me to do." Bee Hwee also loves DIY jewellery making, a creative hobby that trains her patience and concentration and also allows her to craft handmade gifts for friends.

Born into a big family, Bee Hwee learned from early life to be self-supporting. Through sheer hard work, her nine years of night classes finally paid off as she was awarded a Gold Medal for Outstanding Performance in SIM where she received her Master's degree eight years ago. A recipient of multiple Outstanding Service Awards and Wellness Supportive Supervisor Award, Bee Hwee believes in being proactive and bringing happiness to others. She has this to say, "Have concern for others, repay society, be grateful for what you have and cherish your loved ones."

An Interview with Prof Belal Baaquie

Prof Belal Baaquie shares with *Physics Matters* his passion and insight on the subject of quantum theory and physics in general.

Your new book *The Theoretical Foundations of Quantum Mechanics* was published by Springer this February. Share with us your motivation behind this writing.

In the standard Copenhagen interpretation of Quantum Mechanics the foundation of the quantum entity is the degree of freedom; all experiments carried out on the quantum entity yield only the expectation value of projection operators that mathematically represent the experimental apparatus. Interestingly and strangely enough, the degree of freedom itself can never be experimentally observed: the degree of freedom is intrinsically indeterminate and 'exists' only as a theoretical construct. It is this enigmatic aspect of Quantum Mechanics—and of the degree of freedom in particular—that is explored in my book.

It is interesting to note that the subject of quantum theory can be applied to fields as diverse as finance and human psyche. In layman terms, why do you think this is probable?

Calculus was discovered by Newton for describing mechanics, but is now applied to almost all branches of science. The mathematics of quantum mechanics, namely quantum mathematics, is similarly a vast theoretical structure that goes far beyond merely quantum mechanics. In particular, it is my view that the description of randomness and uncertainty in all branches of science as well as beyond it—in finance, the human psyche, the social sciences and so on—is most effectively modeled using quantum mathematics.

If there is one thing you wish could change in the world, what would that be and why?

The world needs a more equitable and just global social system, with the wealth of the earth benefitting all of mankind. People need to be more empowered so as to ensure justice and equity for all.

What is one important message you like to share with our Physics graduates today?

The study of Physics provides one of the finest training in quantitative and mathematical thinking as well as introducing one to the vast universe that we live in. Physics prepares you for solving complex problems in your professional life as well as imparts a world view that is at the foundation of modern society.

What are some of the most satisfying moments in your academic life with the Physics Department?

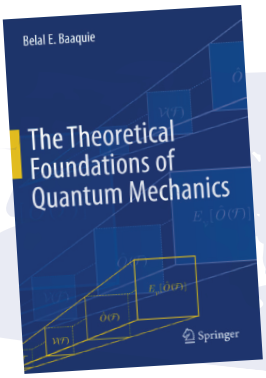
The most satisfying aspect of my academic life in the Department has been to chart out my own field of research by applying quantum mathematics to finance and other subjects.

Share with us your hobbies or interests.

I like reading books on diverse subjects, traveling, sight-seeing, doing yoga and I enjoy watching science fiction and other movies.

If you have a chance to start all over, would you still like to pursue the field of physics or perhaps some other field?

Yes, I would still like to pursue physics and if given a second chance would like to pay more attention to the application of physics to other disciplines.



The Theoretical Foundations of Quantum Mechanics

By Belal E. Baaquie
Springer (2013, XII, 268 p. ISBN 978-1-4614-6224-8)

Addressing fundamental issues not discussed in most books on quantum mechanics, this book focuses on analyzing the underlying principles of quantum mechanics and explaining its conceptual and theoretical underpinning. In particular, the concepts of quantum indeterminacy, quantum measurement and quantum superposition are analyzed to clarify the concepts that are implicit in the formulation of quantum mechanics. The new concept of the interplay of empirical and trans-empirical constructs in quantum mechanics is introduced to clarify the foundations of quantum mechanics and to explain the counter-intuitive construction of nature in quantum mechanics.

Announcements

5th International Conference on Recent Progress in Graphene Research
9 – 13 Sep, 2013,
Tokyo Tech Front,
Tokyo Institute of Technology, Japan
More details at:
http://lt.px.tsukuba.ac.jp/RPGR2013/

14th Frontier Science Symposium
21 – 25 Oct 2013,
Nanjing University, China
Contact: Teo Hwee Sim
(phyteohs@nus.edu.sg)

2nd Global Young Scientists Summit
19 – 24 Jan, 2014,
One North, Singapore
Contact: Teo Hwee Cheng
(phyteohc@nus.edu.sg)

India-Singapore Joint Physics Symposium
24 – 26 Feb, 2014
Indian Institute of Technology (IIT), Bombay, India
Contact: Teo Hwee Sim
(phyteohs@nus.edu.sg)

Congratulations Class of 2013!

Bachelor of Science

Abdul Halim B Rashid
Ang Rui Xiang
Chan Jian Hui Jonathan
Chan Tsz Kin
Glenn Cheong Zhi An
Goh Jun Hon Alvin
Goh Ming-Chung David
Hu Yang
Ignatius Lim Jingren
Kyi Kyi Wai Lynn
Liesel Tjin
Lin Feng Jackie
Lisha Mohandas Raghani
Muhammad Hamdan bin Rahmat
Reuben Ho Chee Wui
Ruth Soh Hui Ling
Seah Zuo Sheng
Shium Yanxu
Song Lu
Tan Zhi Yang
Wu Chien Wei
Zhang Jindun

Bachelor of Science with Honours

Ang Ther Wey Jeysthur (*Lee Kuan Yew Gold Medal, IPS Medal, Jurong Shipyard Prizes, Outstanding Undergraduate Researcher Prize, Sugar Industry of Singapore Book Prize*)
Aw Chixiong
Deng Jiawen (*Tan Siak Kew Gold Medal, Jurong Shipyard Prizes, Lim Soo Peng Book Prize*)
Do Thi Xuan Hung
Elizabeth Marcellina
Foo Fang Fang
Gan Huat Chai Jaren
Ganeshan s/o Jayaraja
Goh Wei Yang Leonard (*USP Scholar*)
Issac Raedwald Hans Garfield Schroeder I
Jani Hariom Kirit
Kevin Siswandi
Koh Su Yong
Kong Pei Shan
Lee Kang Hao
Liew Ji Shen
Lim Wei Jun
Liu Tao
Looi Khai Chern
Mak Foo Wai
Musawwadah Mukhtar (*Outstanding Undergraduate Researcher Prize*)
Navneeth Ramakrishnan
Ng Soon Peng, Joseph
Ong Zongjin
Phuah Kia Tan Benjamin
Raghavendra Srinivas (*USP Scholar*)
Saw Thuan Beng (*Outstanding Undergraduate Researcher Prize*)
Seah Wei Ling
Shi Yicheng
Soo Kah Wai Kelvin
Tan Boon Hon
Tan Hong Qi
Tan Shao Xun
Tan Wei Hou
Tang Zhen Yang Nicholas
Tay Jian Hao Jeremy
Teo Shi Hua
Tham Wei Khang
Vimal s/o Hergobind Goklani
Vindhiya Prakash
Vishnu Vardhan Sridhar (*USP Scholar*)
Wen Di
Wilson Chin Yue Sum
Wong Wei Hon Harry
Wong Wei Juan (*Lijen Industrial Development Medal*)
Yeo Li Hsia (*USP Scholar*)
Zheng Kaiyuan

Master of Science

Boredin Saengtuksin
Chang Guoqing
Goh Jing Qiang
Indra Yudhistira
Kan Cheng Mun
Li Yanan
Long Zhicheng
Meer Ashwinkumar Muhyidin bin Meer Ahmad
Teh Run Yan
Teng Po-Wen Ivan
Wang Qian
Wang Yibo
Wong Ten It
Yang Yiwen
Zhang Kaiwen

Double Degree Programme

Phuah Kia Chai
Xiao Wen

Doctor of Philosophy

Arpan Roy
Bijay Kumar Agarwalla (*Materials Research Society of Singapore Medal*)
Cao Yang
Chen Xiao
Chiam Sher-Yi
Christie Thomas Cherian
Diao Yingying
Hou Ruizheng
Leek Meng Lee
Lin Cheng Sheng
Lin Jie
Lin Tingting
Liu Bo (*World Future Foundation PhD Prize in Environmental and Sustainability Research*)
Lu Xin
Ma Fusheng
Mallikarjuna Rao Motapothula
Ng Siow Yee
Ni Guangxin
Pan Huihui
Phua Li Xian
Ram Sevak Singh
Sara Azimi
Sun Jingya
Thingna Juzar Yahya
Vandrangi Suresh Kumar
Venkatesh Mamidala
Vo Trong Nghia
Wang Xiao
Xu Gangqin
Yang Hongzhi
Yang Zhen
Yao Donglai
Yao Guanggeng
Zhou Miao

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