JANUARY 2017

Physics Matters

Topology opens new doors for physics

The 2016 Nobel Prize in Physics was awarded to Prof David J Thouless (University of Washington), Prof F Duncan M Haldane (Princeton University) and Prof J Michael Kosterlitz (Brown University) "for theoretical discoveries of topological phase transitions and topological phases of matter".

In our department, a number of faculty members have been working on topological phases of matter, including Prof Feng Yuan Ping, Prof Gong Jiangbin and Asst/P Lin Hsin. In particular, Prof Gong Jiangbin is recently awarded a competitive National Research Foundation investigatorship grant for his project on "quantum control approach to new topological phases of matter".

Prof Gong explained, "In a nutshell, topological properties refer to certain robust properties of an object that do not change upon continuous deformations until a transition point. Take the shape of a donut as an example. If you continuously deform the donut, the number of holes will not change, unless you introduce singular points, in this case, dig new holes, on the donut surface. Hence, the number of holes in this donut example is identified as a topological invariant distinguishing between different topological phases."

In the early 1970s, the then current theory that superconductivity or suprafluidity could not occur in thin layers was overturned by Prof Kosterlitz and Prof Thouless. They showed superconductivity occurring at low temperatures and also offered an explanation of its disappearance at higher temperatures using phase transition.

After more than a decade, Prof Thouless went on to explain an earlier experiment with very thin electrically conducting layers in which conductance was precisely measured as integer steps. He demonstrated the topological nature of these integers. Prof Haldane also, at about the same time, applied topological concepts in understanding the properties of chains of small magnets found in some materials.

The laureates' discoveries have certainly opened the door for the search of new and exotic phases of matter and has pushed frontline research in condensed matter physics further. Though yet to be materialised, future applications in materials science and electronics hold great promises.

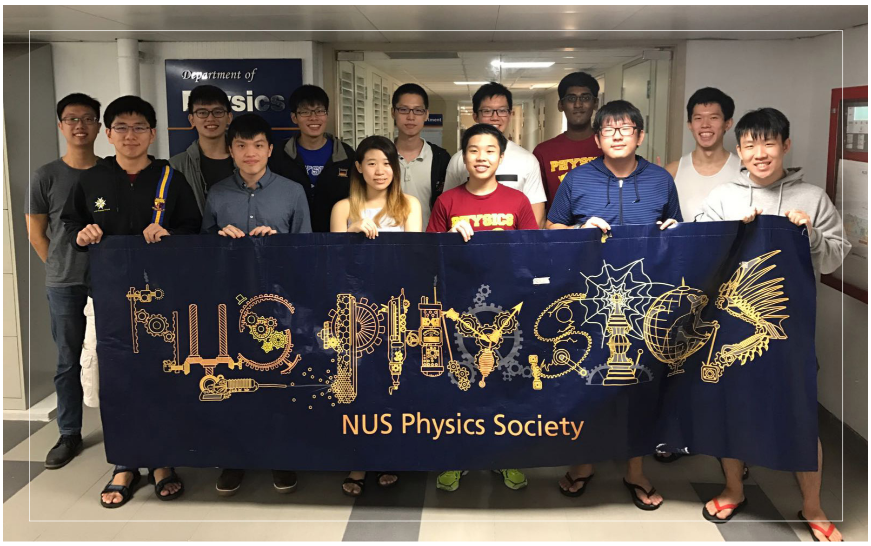
Inside this issue :

An appreciation to the NUS Physics Society

The NUS Physics Society launched the Senior-Freshmen Briefing on 11 Aug 2016 following feedback from the Physics Induction Workshop held previously. Solely organised by seniors for new undergraduates, the event served to make new students feel more at home by inducting them to the department and connecting them with their seniors.

For the past years, the Physics Society has been actively initiating and supporting departmental events such as the Physics Orientation Camp, Spark the Gap and the Physics Enrichment Camp. It has also been collaborating with the Science Club for the various carnivals held on campus. Festive gatherings organised for all physics majors such as the Mid-Autumn Celebration and Chinese New Year Dinner have also been very well received.

The department appreciates and thanks the Physics Society for all their efforts and also congratulates the newly elected 30th Physics Society Management Committee.



⇨ The 30th Physics Society Management Committee

Department of Physics

NUS National University of Singapore

Bringing the sky closer

The digital planetarium system is the latest large-scale teaching tool in the department's arsenal of education and outreach resources. The system could project a high resolution 180 degree full sky view onto a 6 m (diameter) and 3 m high dome inflated by a fan. The maximum seating capacity is about 25 persons.

A 3D projection of the sky has been found to be more effective in enhancing students' understanding of the subject matter as compared to a conventional 2D projection as students get to immerse themselves in a more realistic setting.

More than 100 GEK1520 students had their first tutorials in the planetarium last semester. Dr Cindy Ng, together with other colleagues, showed students how the positions of the stars, Moon and Sun change with time as she explained the celestial motion. Students also viewed a video on light pollution which is common in Singapore and hindered stargazing activities. So the planetarium has the added advantage of providing a visualisation of the sky without light pollution.

The digital planetarium system promises to excite and engage students beyond their imagination. Feedback from students has been positive so far. Indeed astronomy teaching will never be quite the same again.

⇨ Students enjoying a more realistic sky view inside the planetarium

⇩ Inflated dome housed the planetarium

Champions emerged at the International Natural Sciences Tournament

Second-year physics major Mr Kam Mao Quan, Gabriel, shared about his experience at the VII International Natural Sciences Tournament 2016. His team won first place and Gabriel was also one of the best speakers at the tournament.

⇧ Celebrating the victorious moment when the first place was clinched (Gabriel is third from the left)

The intramural round of the VII International Natural Sciences Tournament (INST) 2016 was held on 12–16 Oct at Novosibirsk, Russia. INST teaches students to apply their knowledge to solve current practical scientific and industrial problems. Six local and international teams were selected based on their performance from the extramural rounds open to all universities. Our team comprised of four second-year science undergraduates coached by Dr Robert Lieu from the Special Programme in Science (SPS) and Department of Biological Sciences.

Participants were given broad unsolved realistic scientific problems or situations posed by Russian manufacturing or technology companies. Teams had to offer solutions in the form of presentation, debates and had to defend their standpoints during the scientific discussion. Only the top three teams got promoted to the final stage.

We had much research to do to tackle the 12 out of 15 problems we had chosen. Due to the interdisciplinary nature of the tournament, certain questions required expertise from the various disciplines. So we found ourselves having to teach one another concepts from across our individual majors in order to achieve effective brainstorming sessions. We also held mock presentations and Q&A sessions to brace ourselves for the actual presentation and polemics.

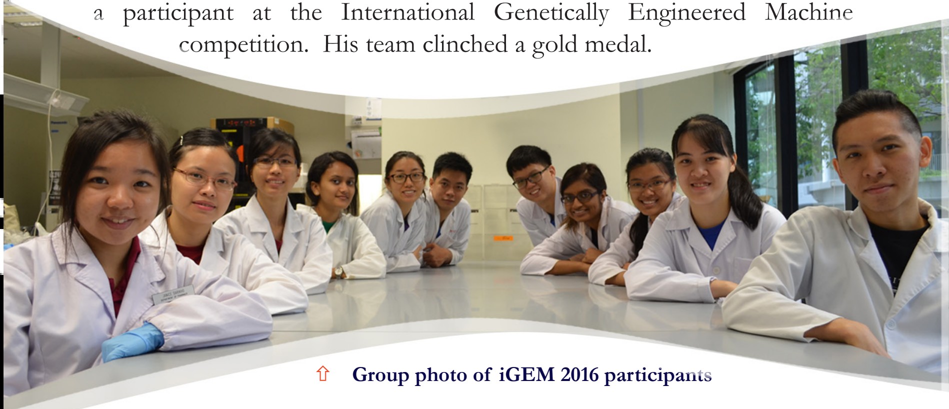
I believe our team scored a few winning points right from the start. All of us were trained in scientific communication and presentation skills throughout our course of study as science and SPS students. Compared to a few other teams, our team was multi-disciplinary with chemistry, life science and physics majors who also have some experience and basic knowledge on other disciplines thanks to SPS. This widens our capacity to handle the problems on hand.

Each team had three roles to fulfill—speaker, opponent and reviewer—and I had the opportunity to play all three. My background in physics helped me tackled the problems on lightning (EM) and solar heating (thermodynamics) in completing the theoretical calculations required to establish the soundness of the solution. It also enabled me to contribute to the other interdisciplinary questions from a physics standpoint. In the final round, a few physics problems were brought out, and I was honoured to have given my team an edge over the other two teams that lacked physics majors.

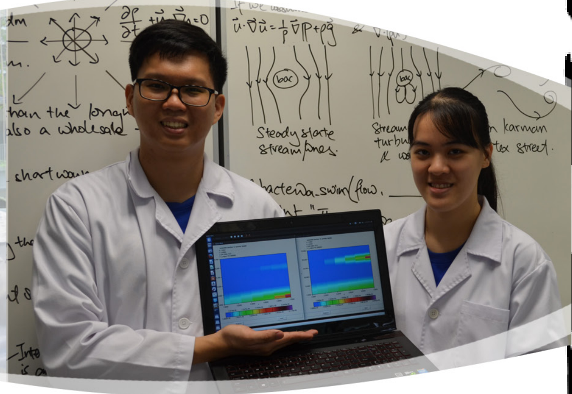
During the tournament, I picked up new scientific knowledge (especially from the other disciplines) while reviewing my own. INST has boosted my interest in interdisciplinary science and helped me appreciate its usefulness. We also got to experience other cultures—there was a cultural exchange time where the different teams shared about their country and culture. A visit to a planetarium and Russian opera topped up my overall INST experience.

Gold for team NUS at the International Genetically Engineered Machine competition

Final-year student Mr Chan Man Yau, Joseph, shared about his experience as a participant at the International Genetically Engineered Machine competition. His team clinched a gold medal.



⇧ Group photo of iGEM 2016 participants



⇩ Joseph working hard with his group mate for iGEM 2016

Artificial life, genetic engineering, micro-organisms, microscopes and zealous biologists in their lab coats are what come to mind whenever the term "synthetic biology" is mentioned. So it was rather strange to find a physics major joining life science, chemistry and pharmacy majors in the International Genetically Engineered Machine (iGEM) competition. iGEM is a premier international synthetic biology competition for students held annually in Boston, USA. There were 5600 participants from 42 countries last year. The goal was to create novel and applicable biological systems through the use of standardized DNA parts (BioBricks) and synthesizing new ones. The teams made their submissions and then gathered to present their works.

For the past two years, the Special Programme in Science (SPS) have organised teams to represent NUS in the undergraduate category of the competition. My team comprised of third- and final-year students. We aimed to develop a bacterial 'radar system' that could diagnose, locate and invade a broad range of human cancers. Our system is 'persuaded' to move towards the high lactate concentrations of cancer tumours. Cancer cell markers were then used to target and invade the cancer cells with the bacteria literally forcing its way in. Compared to chemotherapy and radiotherapy, this approach is more specific and does not require specialised equipment for administration. Considering the short nine months given for project preparation, we had been remarkably successful in generating new BioBricks for this system, as well as understanding its behavior.

Back to the oddity of having yours truly in this clearly biological undertaking, especially since my research focus is on meteorology (something different). As it turns out, synthetic biology is a huge playground for physicists. Many processes inside and outside of bacteria can be modelled using diffusion-reaction and diffusion-advection dynamics as first approximations, respectively. My role was to model these dynamics using a C-based approach. What I learned from A/P Paul Lim's module on *Computational Methods in Physics* became useful. It is surprisingly difficult to model intra-bacteria dynamics by conventional methods due to the tiny size of the bacteria (solving for diffusion by forward-time central-space method requires time steps of the order of 10^{-7} s).

Perhaps the biggest 'physics' challenge is to work out the constants or parametrisations of the processes in the bacteria. Processes within bacteria are typically understood qualitatively, but to figure out the mathematical and numerical details of bacterial processes from the literature requires great effort. Physics majors have an advantage in this field. We intuitively know if the model is generating sensible data, and have a firm foundation in the mathematics involved in modelling. Knowledge in numerical techniques (I strongly recommend Prof Wang Jiansheng's module on *Numerical Recipes with Applications*) helps: we can search for the best parameters for the modelled processes (eg, conjugate gradient, variational Monte Carlo).

I enjoyed myself during the iGEM competition. Boston trip aside, we often met and collaborated with teams from other countries. Furthermore, it was fascinating to witness the model I constructed taking shape, and to know how my other team-mates worked. I strongly recommend physics majors to join iGEM.

New modules launched this semester

GET1024 Radiation — Scientific Understanding and Public Perception

This module aims to equip students with the essential knowledge to make intelligent assessments on the potential risks and uses of radiation in our modern society. After introducing the physics behind various forms of radiation, we will look at how these radiations are used in medical diagnosis and treatment and other applications. Some controversial issues in these applications will be raised and debated. The health effects of high and low levels of radiation will be presented based on scientific evidence thus dispelling some of the negative misconceptions of radiation and irrational fear of it. The social and political dynamics in electricity generation through nuclear power plants in various countries will also be discussed.

PC3246 Astrophysics I

Astrophysics I is the first of two astrophysics modules. The first part of the module introduces astronomical observations and the telescopes. The second part of the module covers celestial mechanics, which is the application of classical mechanics to astronomy. The third part of the module provides an introduction to stellar physics. The module prepares students to study stellar evolution and galaxy in Astrophysics II.

"Edvocating" Physics

Senior Lecturer Dr Nidhi Sharma and Teaching Assistant Mr Raditya Weda Bomantara shared about what teaching physics meant to them.

I fell in love with the Physics Department from day one when I joined as a graduate student in the year 2002. I was impressed with the research facilities and independent learning environment the department offered. I was required to fulfill my teaching duties then and I had my first interaction with the teaching labs, undergraduate students and modus operandi at the undergraduate level. After three years, it was without struggle for me to take up a teaching assistant position while continuing my graduate candidature.

My first introduction to physics teaching really began with the engineering classes. It took a lot of hard work as I tried explaining everything to students, with immense use of calculus and trigonometry. Then came students' feedback which I analysed carefully. Students were not impressed with the heavy content and found it hard to absorb. I learnt my first lesson—physics teaching is not about deriving equations or solving problems only.

I decided to change my teaching strategy subsequently. This time I provided more background to the tutorial questions for students and tried extracting some problem solving strategy from the class. Once I was satisfied that the students had interpreted the physics rightly, I left to them to finish the mathematical task. This student-centred approach became useful for small classes and has greatly enhanced my teaching. From the students' point of view, I was an excellent tutor.

Things became more demanding when I began lecturing. Motivating a class of more than 100 students and keeping the lessons interesting for them with the desired learning outcomes was another great challenge. Knowing physics and teaching physics are surely two different things. But I was fortunate to learn from fellow colleagues who offered me valuable suggestions.

I learned to tell students the what and why of learning and helped them connect the physics principles learnt with real life applications. I gave illustrations with live demonstrations and incorporated conceptual questions which served to reinforce what had been taught. The focus was on the students instead of teacher. I also tapped into technology such us using annotations in my slides, visualizers for problem solving, videos and interactive online assessment tool. As a result, students became more engaged and even found lessons enjoyable. Though there is still much to learn, teaching physics has never been so delightful to me.

Dr Nidhi Sharma

"You cannot teach a man anything, you can only help him find it within himself.

Galileo Galilei

Teaching physics has been my passion since my high school days when I often helped my classmates solved their physics problems and in university when I provided my course mates with additional notes and problems.

In my opinion, physics education entails methods and strategies employed to teach physics effectively. Teaching physics is an art. Being knowledgeable alone is not sufficient. In a large class setting, students come from different backgrounds. Pacing lesson too fast or slow will affect weak and strong students respectively. Even with the right teaching pace students may still not be motivated or forget what is taught. Far from being an expert on this matter, I will share my experience of teaching with the aim of making the lesson interesting and memorable for students.

Students in the two engineering physics modules I taught used to attend tutorial classes either on the odd or even weeks. Last semester, I implemented a new system: all the students had to attend tutorials in the same week followed by another week of supplementary lesson where I went through some past year test or exam questions while clarifying any misconceptions. I believe students had benefitted from these extra sessions as they gained a deeper level of understanding and better retention of knowledge.

I also distributed a worksheet to students that consisted of three non-gradable questions (with different difficulty levels in order to reach all levels of students). Unlike tutorial questions, no solutions were provided. I invited students to send me their solutions and I will publish the best solutions regularly. I was delighted to learn that students actually contributed their solutions and would seek clarification with me when they had difficulties. In my opinion, this worksheet system is effective in motivating students as they tried hard to get their solutions published.

There have been several challenges I encountered in the past while teaching. When I first started teaching large classes, I became nervous when speaking and was not able to deliver my lessons effectively. With more experience now I have managed to overcome this fear by treating my students like my undergraduate friends.

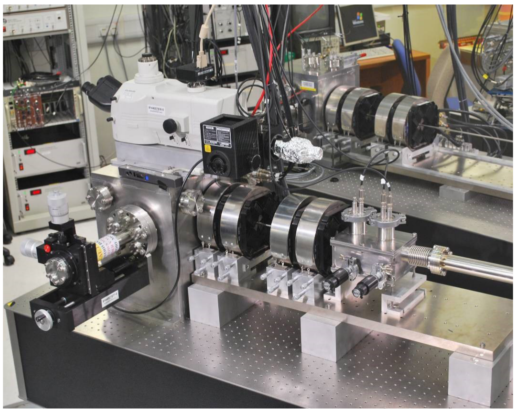
A last advice I like to share concerning teaching is the practice of patience. Not all students are motivated to study our modules. Some do not read emails or announcements and may ask something we have told them before. Taking things personally and being aggressive will only make matters worse. For me, I will send absent-minded and indifferent students an email about some life lessons to spur them on. Indeed teaching physics has trained me unconsciously to be a more mindful person.

Raditya

Discovering Physics: Super-resolution imaging using MeV ion beams

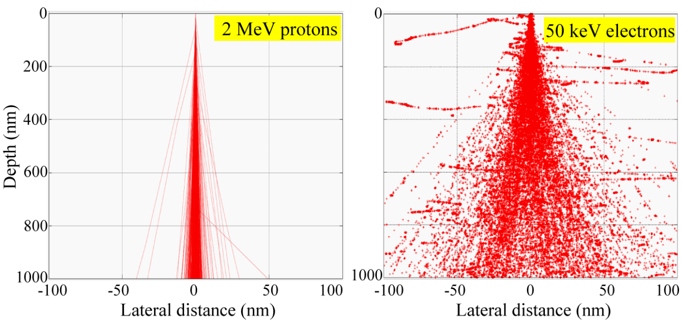
In 1873, Ernst Abbe formulated the famous diffraction limit of an optical microscope: the best resolution achievable for a specimen illuminated with visible light is approximately half the wavelength of light or roughly 250 nm assuming green illumination. This stood for more than 100 years for wide field microscopy until overturned by super-resolution optical imaging techniques. Betzig, Hell and Moerner won the 2014 Nobel Prize in Chemistry for the "development of super-resolved fluorescence microscopy." Super-resolution is important for many fields of science, including cell biology where many of the sub-cellular structures of interest are of the order of 1 µm or less.

The Centre for Ion Beam Applications (CIBA) in the Physics Department has been developing several alternative high-resolution imaging techniques using mega-electron volt (MeV) ion beams. As the energetic particles have a small de Broglie wavelength, diffraction effects are absent at resolutions in the nanometre range (10-100nm). The single cell microscopy beamline for imaging whole cells (Fig. 1) integrates a fluorescence microscope with a vacuum target chamber where frozen dried cells can be imaged with highly focused beams of protons and alpha particles.



⇧ **Fig. 1: The CIBA cell imaging beamline and target chamber**

MeV ions have some unique properties that make them well suited for high resolution imaging. MeV ions interact mainly with atomic electrons in the target and due to their large mismatch of momenta, primary ion scattering is minimal and hence the trajectories of MeV ions are not altered as they pass through the sample. This could be seen in the result of the Monte Carlo simulations (Fig. 2) we have obtained.

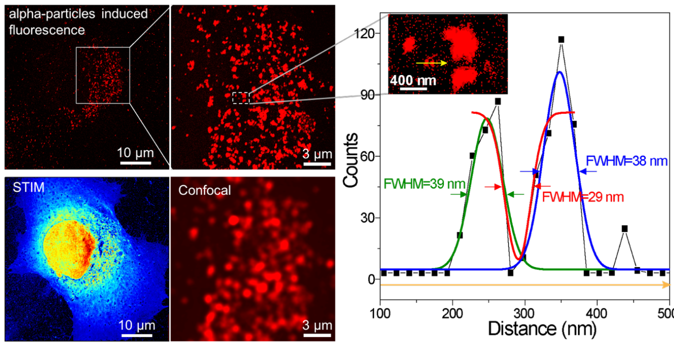


⇧ **Fig. 2: Monte Carlo simulations of 2 MeV protons and 50 keV electrons impinging on a 1 µm biological sample using the DEEP software [1]. The 50 keV electrons rapidly spread out as they penetrated a thick sample, so high resolution was only maintained at the surface.**

MeV ion beam imaging techniques generally fall into two categories: high current techniques and low current or single ion techniques. The spatial resolution produced by the former is usually limited to 500 nm or more. Low beam current techniques such as Scanning Transmission Ion Microscopy (STIM) and Proton Induced Fluorescence (PIF) imaging are performed using single ions at 10000 – 20000 ions per second. Since a single ion generates enough usable signal for imaging, focused spots as small as 20 nm have been achieved by reducing the size of objects slits and beam colimation [2]. At these resolutions, single nanoparticles can be imaged which make quantitative measurements possible.

In STIM, the energy and location of a single ion transmitted through a sample is measured. The energy lost by the ion in traversing the sample is a measure of the areal density of the sample. The transmitted ion energies, which depend on the localised electron density in the sample, can be measured and a 2D areal density map can then be constructed [3].

In CIBA we have generated fluorescence images by impinging cells with Mev ions. Complimentary information was obtained using both STIM and PIF imaging (Fig. 3). The STIM image showed density information and could distinguish cell nucleus and cytoplasm. Some increase in density due to the presence of fluorescent nanodiamond particles around the nucleus was evident. The alpha-induced fluorescence image also showed the nanodiamond particles. The confocal microscope image is included for comparison. It showed that nanodiamonds (<100 nm) cannot be resolved using conventional wide field optical imaging.



⇧ **Fig. 3: Image of a cell that has been infused with fluorescent nanodiamonds. A STIM image is compared with alpha particle-induced fluorescence and confocal microscope images. Line scans showed that the resolution was well below 100 nm.**

References

[1] C Udalagama et al, *Phys Rev B* **80**, 224107 (2009)

[2] Mi ZH et al, *Nature Comm* **6**, 8832 (2015)

[3] A Bettiol et al, *Appl Phys Rev* **3** (4) 041102 (2016) (invited)

A/Prof Andrew A Bettiol obtained his PhD at the University of Melbourne, Australia, in 1999 working on ion beam induced luminescence. He joined NUS in 1999 as an NSTB fellow and is currently an associate professor. He has published over 160 papers in international refereed journals. His current research interests include the ion beam modification of materials, applications of ion beams in photonics and optics, and super-resolution imaging using nuclear microscopy.

For students and by students

Physics Graduate Symposium

Physoc CNY Dinner

Freshmen-Seniors Briefing

Research Evening

Spark the Gap

A Day in the Life of...

When the core facility lab was relocated during the recent departmental upgrading, Mr Chen Gin Seng was happy to assist in its setting up. The lab houses mostly thin film machines and tube furnaces which are important for the synthesis and characterization of nanomaterials such as nano wires and nano tubes. Mr Chen overseas and manages the operations and routine maintenance of the vacuum systems too.

"We now have bigger lab space and better safety measures in place. The most number of vacuum pumps could be found here, old and new, not less than 20. So some people call me the 'pumping man'," remarked Mr Chen delightfully. He is now also involved in the setting up of a pulsed laser ablation lab.

Mr Chen still held fond memories of the humble beginnings of the department where labs had no air-conditioning and facilities were scare. Gone were the days when he tried assembling Apple computers and IBM machines with colleagues after getting the necessary parts from Sim Lim tower. Mr Chen also remembered having to develop black and white negatives in the darkroom for scanning electron microscope processed photography. Indeed with more than 30 years of work experience as a lab technologist, he has witnessed drastic developments from IT to vacuum technologies.

Mr Chen was encouraged by the dedication of some retired faculty such as Prof K K Phua (now Chairman of World Scientific Publishing) who used to lecture direct honours students one at a time in a small room. He too enjoyed interacting with undergraduates when he was working in the first and third year teaching labs. Now he provides guidance and demonstrations in the core facility lab to new students or researchers. He admires in particular the good analytical minds and experimental skills possessed by international students.

No task is too mundane for Mr Chen. Besides setting up, testing, servicing and upgrading the lab equipment, Mr Chen is directly involved in the purchase of new machine or equipment part which he makes sure is done with caution and prudence. Besides work, he enjoys communicating with colleagues and participating in any departmental outing for a time of bonding. To Mr Chen, work becomes more meaningful when there exists good working relationship among colleagues.

An Interview with Prof Lai Choy Heng

Deputy Director of the Centre for Quantum Technologies, Prof Lai Choy Heng, shared his views and thoughts on physics and education. Prof Lai was also formerly Dean of Science, Vice Provost (Academic Personnel) and Executive Vice President (Academic Affairs), Yale-NUS College.

You have been conferred the Singapore National Academy of Science (SNAS) Fellowship not long ago for your many outstanding contributions to science in Singapore. Share with us what this conferment means to you.

This came as a surprise, and is of course an honour, for which I am deeply grateful. I have done many things during my career—largely following my conviction—which I thought would make my scientific life (and those of others) more meaningful and fulfilling. Looking back, I would consider a number of these a bit idealistic, but I must also confess that I drew great gratification from them all. I never thought that they would be "recognised" as my "contributions to science in Singapore". I am grateful and humbled by this recognition.

One of your current research interests is social cohesion in communities mediated through common pool resource exploitation. How does physics play a role in this?

My research interests evolved significantly over the years. My latest fascination focuses on dynamical processes on complex networks. In a sense, interaction models based on networks are similar to the familiar lattice models in physics, except that spatial distance and regularity are often absent in networks. We deal with a different kind of topological structure (and symmetry), and we find coherence and collective behaviour, and even (phase) transitions in these network interaction models. Statistical physics techniques and mean field methods are useful in the simulation studies, and our vast physics experience and intuition often guide us in our investigations, in identifying the relevant questions and solvable problems, formulating models, as well as in assessing whether the simulation results make general sense.

As a former Dean of Science, you had the experience of overseeing the university science curriculum. What do you think are the challenges facing the university science education currently?

If the focus is on the word "education", then it has become very complex and challenging. Education has more to it than just curricula, teachers and teaching methodologies, information and communication technology infrastructure, etc. It is also about nurturing the optimal (I hesitate to say "correct") learning attitude and mind-set in the students—particularly relevant if we subscribe to the life-long learning educational philosophy. And this is where the challenges are most obvious. In an era when you can find any "information" at any instant of time on the Internet, the tendency is to adopt a "just-in-time" learning attitude towards the "relevant", and to ignore what would be considered as an essential foundation of knowledge. The thing is, without this foundation, there is no useable "filter" that will help us to differentiate the correct from the wrong, the true from the false, or to adapt a piece of information for application in a drastically different condition, or to have an understanding of the whole—the essence of "knowledge". Maybe artificial or machine intelligence can be advanced to take away the need for such "critical analyses" from us, but I am apprehensive about such an eventuality: it is to me totally counter to our humanity and stands in the way of our creativity and innovativeness.

I believed when I was young, and I still believe today, that physics brings together the tenets of modern science in a majestic way: the characteristic experimental observation and verification, and the theoretical and logical construction of the tapestry of our understanding of the physical world.

What defines an educated person in your opinion?

I am of the old school, perhaps a little complicated by my exposure to the Western culture in the US during my formative years. My thoughts on this question are not very coherent, and I will simply articulate them as they come to mind. To me, an educated person is not just one who is knowledgeable, but also someone who has compassion, empathy and a sense of righteousness; someone who is constantly hunger for appreciation, if not understanding, of events, people, cultures around us. Humility should emerge naturally, and respect for others an automatic mode.

What are some things you like to instruct our physics undergraduates today?

I believed when I was young, and I still believe today, that physics brings together the tenets of modern science in a majestic way: the characteristic experimental observation and verification, and the theoretical and logical construction of the tapestry of our understanding of the physical world. Perhaps because of its early development in human history, physics also shares some common traits with philosophy. A full appreciation of all these facets of physics will take a lifetime—you will need to prepare yourself with the fundamentals, and sharpen your intuition and heighten your imagination as you progress in the journey. But in the end it will be worth it, as we get to enjoy (in the words of Robert Oppenheimer) "physics and the many excellences of the life it brings".

⇦ **Prof Lai receiving an award from Prof Shen, Dean of Science, at the recent Science Faculty Award Ceremony**

Awards

Congratulations to colleagues in the department for being the proud recipients of various awards in the year 2016!

Faculty Teaching Excellence Award AY2015/2016

Dr Chan Taw Kuei
Dr Wang Qinghai

Faculty Honour Roll AY2015/2016

A/P Chan Aik Hui, Phil
A/P Tay Seng Chuan

Faculty Teaching Assistant (Full-time) Award AY2015/2016

Ms Angeline Shu Sze Yi
Mr Leong Qixiang
Mr Raditya Weda Bomantara

Faculty Young Scientist Award

Asst/P Utkur Mirziyodovich Mirsaidov

Faculty Outstanding Scientist Award & IPS World Scientific Award

Prof Gong Jiangbin

IPS Nanotechnology Award

Asst/P Quek Su Ying
Asst/P Utkur Mirziyodovich Mirsaidov

IPS CADI Scientific Award for Public Awareness of Physics

Dr Yeo Ye

IPS Crescendas Award for Outstanding ITE Engineering Physics Lecturer

Ms Lee Lai Bay

Outstanding Mentor Award for SMP 2016

Dr M V Venkatashamy Reddy

National Day Award

Prof Ji Wei
Mr Kang Nguang Heng
Mr Lim Hwa Ngee
Ms Ng Soo Ngo
Mr Ong Pang Ming

Welcome On Board!

The department welcomes adjunct A/P Koh Wee Shing.

⇨ A/P Koh Wee Shing

⇧ Mr Ali Bin Haji Omar

Farewell and Best Wishes!

The department thanks adjunct A/P Teo Kien Boon and Mr Ali Bin Haji Omar for all their contributions to the department and wishes them all the best!

⇨ A/P Teo Kien Boon

Departmental Outing, 4 Jan 2017