

Institute of Advanced Studies @ Nanyang
Technological University – Institute of Physics UK
Joint Workshop on Physics Education

Envisioning Physics Education for the 21st Century

5 to 6 September 2016
Nanyang Executive Centre, NTU



Supporting Organisations



Institute of Physics, Singapore



Ministry of Education
SINGAPORE



School of Physical and Mathematical Sciences



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FOREWORD

Welcome to the physics education workshop, Envisioning Physics Education for the 21st Century, jointly organised by the Institute of Advanced Studies (IAS) at NTU and the Institute of Physics (UK).

A career in physics can open doors to almost any profession. Employers regularly state that there is a global need for more physics graduates and an even greater need for people with sub-degree technical skills. In order to meet this increasing demand for science-based and technical skills, developed and developing countries both are in need of educational systems that are attractive, dynamic and able to equip students with knowledge and experience to not only further their careers but to make invaluable contributions to society.

In an effort to enthuse the interest in physics in high schools and to improve the teaching of physics, the workshop will discuss modern approaches to teaching physics with a particular focus on tools and techniques so as to inspire students in physics through informal science learning. These include implementing a school-based physics curriculum that balances the aims of developing science capital for all citizens whilst providing a strong foundation for aspiring scientists; equipping teachers to promote awareness and interest in physics-related careers to students in their lessons, and the effective use of practical work to enhance physics instruction.

We hope that you will engage actively in the workshop and benefit greatly from the discussions and practical demonstrations. With dedicated and passionate educators like all of you, the discipline of physics will continue to be attractive and relevant for the demands of society now and in the future.

Professor Kok Khoo Phua (*Co-Chair*)
Director, Institute of Advanced Studies
Nanyang Technological University (NTU)

Professor Paul Hardaker (*Co-Chair*)
Chief Executive, Institute of Physics UK

ORGANISING COMMITTEE

Co-Chairs

<u>Name</u>	<u>Institution</u>
Kok Khoo Phua	Institute of Advanced Studies, NTU
Paul Hardaker	Institute of Physics, UK

Members

<u>Name</u>	<u>Institution</u>
Hongjin Fan	School of Physical and Mathematical Sciences, NTU
Choy Sin Hew	Institute of Advanced Studies, NTU
Shen Yong Ho	School of Physical and Mathematical Sciences, NTU
Leong Chuan Kwek	Institute of Advanced Studies, NTU and NUS
Paul Lee	National Institute of Education
Seow Boon Loh	National Institute of Education
Hwee Boon Low	Institute of Advanced Studies, NTU
Choo Hiap Oh	Institute of Advanced Studies, NTU and NUS
Zexiang Shen	School of Physical and Mathematical Sciences, NTU
Chorng Haur Sow	Institute of Physics, Singapore and NUS
Joy Tan	Ministry of Education
Darren Wong	Ministry of Education
Jennifer Yeo	National Institute of Education

SUPPORTING ORGANISATIONS



Institute of Physics, Singapore



Ministry of Education
SINGAPORE



NANYANG
TECHNOLOGICAL
UNIVERSITY

School of Physical and Mathematical Sciences

PROGRAMME

5 September 2016 (Monday)

8:00 am - 9:00 am Registration

Opening Ceremony

9:00 am - 9:05 am Welcome address by
Kok Khoo Phua (Director, IAS NTU)
9:05 am - 9:15 am Paul Hardaker (Chief Executive, Institute of Physics, UK)

Chair: **Kok Khoo Phua** (IAS NTU)

9:15 am - 10:00 am **Paul Hardaker** (Institute of Physics, UK)
Delivering a STEM Education System that's Fit for Purpose

10:00 am - 10:30 am **Pao Chuen Lui**
(National Research Foundation, Prime Minister's Office, Singapore)
Physics Teachers Needed to Grow the Future of Economy and Society of Singapore

10:30 am - 11:00 am **Group Photo and Coffee Break**

Chair: **Chih-Ta Chia** (National Taiwan Normal University)

11:00 am - 11:45 am **Charles Tracy** (Institute of Physics, UK)
A Physics Curriculum Based on Big Ideas

11:45 am - 12:30 pm **Nicola Wilkin** (University of Birmingham)
*Embedding Skills in the Curriculum in Partnership with Employers:
Two Distinctive Case Studies*

12:30 pm - 1:30 pm **Lunch**



Chair: **Leong Chuan Kwek** (IAS NTU & NUS)

1:30 pm - 2:15 pm

Lay Nam Chang (Virginia Tech)

An Integrative Approach to Science Pedagogy

2:15 pm - 3:00 pm

Bernard Taylor (Stockton Riverside College)

Effective Use of Practical Work to Enhance Physics Instruction

3:00 pm - 3:45 pm

Tajamal Bhutta (Institute of Physics, UK)

A UK Perspective: Young People's Physics and Career Aspirations

3:45 pm - 4:05 pm

Coffee Break

4:05 pm - 5:45 pm

**Panel Discussion on Implementing Physics Education
for the 21st Century: Vision & Tools**

Moderator: Darren Wong

(Ministry of Education, Singapore)

Panel speakers:

- **Lay Nam Chang** (Virginia Tech)
- **Paul Hardaker** (Institute of Physics, UK)
- **Yuxin Liu** (Peking University)
- **Pao Chuen Lui** (National Research Foundation, Singapore)
- **David Pritchard** (Massachusetts Institute of Technology)
- **Charles Tracy** (Institute of Physics, UK)
- **Nicola Wilkin** (University of Birmingham)

7:00 pm - 9:00 pm

****Dinner Banquet at Chui Huay Lim Club (by invitation only)**

****Dinner Banquet at Chui Huay Lim Club**

Two-way transport will be provided. Please gather at the NEC Guest Wing Lobby (Level 1) by **6.10pm**.



**6 September 2016 (Tuesday)**

Chair: **Hock Lim** (National University of Singapore)

9:00 am - 9:45 am **David Pritchard** (Massachusetts Institute of Technology)
Physics Education Research on Learning in Online and Blended Environments and the Future

9:45 am - 10:30 am **Mary Whitehouse** (University of York)
The Role of Assessment in Developing a 21st Century Physics Curriculum

10:30 am - 10:50 am **Coffee Break**

Cluster session on Physics Education in Asia Today

Moderator: Chornng Haur Sow
(Institute of Physics, Singapore and NUS)

10:50 am - 11:10 am **Yuxin Liu** (Peking University)
11:10 am - 11:30 am **Ravi Bhattacharjee** (Delhi University)
11:30 am - 11:50 am **Proty Wu** (National Taiwan University)
11:50 am - 12:10 pm **Tai Kai Ng** (Hong Kong Academy for Gifted Education & HKUST)
12:10 pm - 12:30 pm **Leong Chuan Kwek** (IAS NTU and NUS)
12:30 pm - 1:00 pm Discussion

1:00 pm - 2:00 pm **Lunch**

Chair: **Paul Lee** (National Institute of Education)

2:00 pm - 2:30 pm **Chornng Haur Sow** (Institute of Physics, Singapore and NUS)
Minds-On Science Demonstration

2:30 pm - 4:00 pm **Hands-on Activities and Demonstration**

4:00 pm - 4:20 pm **Coffee Break**





4:20 pm - 5:45 pm

Roundtable Discussion on Physics Education in ASEAN

Moderator: Choy Heng Lai

(National University of Singapore)

Panel speakers:

- **Phichet Kittara** (Mahidol University, Thailand)
- **Monika Raharti** (Center for Young Scientists, Indonesia)
- **Yann Rem** (Royal University of Phnom Penh, Cambodia)
- **Hajah Hardimah Haji Mohd Said** (Universiti Brunei Darussalam)
- **Chorng Haur Sow** (Institute of Physics, Singapore and NUS)
- **Sin Zang Sua** (Chung Hua High School, Malaysia)



ABSTRACTS OF SPEAKERS

Author: Tajamal Bhutta

Affiliation(s): Institute of Physics, UK

Email of Presenter: taj.bhutta@iop.org

Title: A UK Perspective: Young People's Physics and Career Aspirations

Abstract:

In the UK, there has been considerable research into the low uptake of physics amongst girls and other underrepresented groups. This talk explores the latest findings and approaches that the Institute of Physics has taken to increase the uptake of physics post-16 through its careers resources and activities.

Author: Lay Nam Chang

Affiliation(s): Virginia Tech

Email of Presenter: laynam@vt.edu

Title: An Integrative Approach to Science Pedagogy

Abstract:

Conventional division of science into various disciplines is motivated by organizational convenience, and can frequently obscure the unity inherent in the subject. An integrative pedagogy is proposed, which emphasizes this unity from the beginning. At Virginia Tech, students interested in majoring in science are offered the option of signing up for a two-year sequence following an Integrated Science Curriculum (ISC). I will describe some details of this curriculum, the performance of the students who undertook the challenge, and the role that the classroom and laboratory settings play in this approach.



Author: Paul Hardaker

Affiliation(s): Institute of Physics, UK

Email of Presenter: Paul.Hardaker@iop.org

Title: Delivering A STEM Education System That's Fit for Purpose

Abstract:

Education delivers cultural enrichment, instils social values and enables people to make an active contribution to society. These are all important and valued parts of education systems the world over. However the route of our modern education systems is founded principally on preparing people for a professional career. Some 200 years ago, that was a factory-based model where learning was much more linear and skills-based. We still see some of that history in our education systems today although we have now moved to a more outcomes and competency-based model. It still remains a challenge, however, to move to a form of teaching and assessment that recognises learning and attainment as a very personal journey. For many, our educational experience has become much narrower and we have yet to find effective ways that allow our young people the benefits of a mix of vocational and academic learning. More recent developments are beginning to address this and to understand the value of classroom experiences and assessments based more on curiosity, creativity, and critical thinking as drivers for learning. These are fundamentally important because they help students spend more time on deeper reflection, experimenting in a way that allows them to learn from mistakes, and give them confidence to ask challenging and fundamental questions. If we want to continue this, then we need stronger support for and recognition of professional development for teachers, more radical changes to our curricula and assessment, more availability of data and an evidence base. We should place greater value on pedagogic research where innovation is driven by applying the same values that we are looking for from our students in the classroom and less on politically motivated outcomes.





Author: Pao Chuen Lui

Affiliation(s): National Research Foundation, Prime Minister's Office, Singapore

Email of Presenter: paochuenlui@gmail.com

Title: Physics Teachers Needed to Grow the Future of Economy and Society of Singapore

Abstract:

With a small population and no natural resources, Singapore has chosen the path of growth through innovation. Science, Technology, Engineering and Mathematics, STEM is fundamental to innovation. The creation, accumulation and exploitation of knowledge are necessary but not sufficient. We need imagination. We need teachers to excite our youth to reach out into the unknown, to teach them a sound foundation to take flight into the unknown. Our future depends on our teachers.

Author: David Pritchard

Affiliation(s): Massachusetts Institute of Technology,
Founder of MasteringPhysics.com

Email of Presenter: dpritch@mit.edu

Title: Physics Education Research on Learning in Online and Blended Environments and the Future

Abstract:

Physics education is increasingly important in a knowledge-based economy, and will continue to be done mostly in schools and colleges. Online education should blend with this: help students learn, monitor their knowledge state and remediate poor procedural skills, and prepare them for a more interactive (flipped) classroom. It should also enable the teacher to transfer his effort from preparation of materials to interacting with students, and to improve the materials by research and development. We compare student learning in blended environments with purely online learning, and indicate where we think research can contribute to future learning.



Author: Chorng Haur Sow

Affiliation(s): Institute of Physics, Singapore and National University of Singapore

Email of Presenter: physowch@nus.edu.sg

Title: Minds-on Science Demonstration

Abstract:

Interactive demonstration is an important tool in teaching and learning of physics. It helps educators illustrate ideas and principles, and helps students visualize abstract concepts. More importantly, the strategy adopted during the science demonstration plays a critical role in actively engaging the minds of the students. With proper design of the learning process, the students can develop even greater understanding and insights into the physical phenomenon. In this presentation, we aim to share our experience in the development of the Science Demonstration Laboratory (SDL) at the Faculty of Science at National University of Singapore. SDL was developed initially as a platform for outreach to attract students and show interesting phenomenon to the visiting students. Soon, we realize that it can be an effective platform for teachers and professors to tap on to enhance the quality of their teaching. In addition, we have developed a Young Educator in Science Program where undergraduate students contribute as a science demonstrator in promoting science to the general public and junior students. This program is very well received as the undergraduate students get to develop good science communication skills and at the same time, develop deep knowledge about the subject matter. During the course of the development of SDL, we have also learnt that the demonstration items are just some hardware. The key factor in an effective science demonstration is to develop engaging approach where the students go through a journey of scientific discovery and develop their own model to account for the interesting phenomenon shown. In this presentation, we hope to share our experience in the development of SDL.

Author: Bernard Taylor

Affiliation(s): Stockton Riverside College

Email of Presenter: bernard.taylor67@gmail.com

Title: Effective Use of Practical Work to Enhance Physics Instruction

Abstract:

I will focus on a number of exciting demonstrations and move on to suggest a variety of practicals that can be used in physics classes. There will be some practical activities and some paper-based activities.

I will also suggest some useful equipment suppliers, some ideas for practical projects and share some of my favourite physics websites.

In addition, I will mention some of the recent changes to practical work in A level physics courses in the UK.



Author: Charles Tracy

Affiliation(s): Institute of Physics, UK

Email of Presenter: Charles.tracy@iop.org

Title: A Physics Curriculum Based on Big Ideas

Abstract:

The Institute's curriculum committee has been looking at the possibility of developing a curriculum based on the big ideas of physics. The aim has been to look at both the big ideas about physics (the attitudes, competencies and ways of thinking) as well as the big ideas from physics (the recognizable content around which school physics has been traditionally built). In this presentation, I will discuss what constitutes a 'big idea', why they might be helpful for structuring a curriculum and, above all, how we engender the notion that studying physics is much more than simply learning the traditional content – it develops ways of thinking that are valued and valuable in many domains. Our hope is that by making these ways of thinking explicit, they are more likely to be developed through the curriculum and that curriculum may gain broader appeal.

Author: Mary Whitehouse

Affiliation(s): University of York Science Education Group

Email of Presenter: mary.whitehouse@york.ac.uk

Title: The Role of Assessment in Developing a 21st Century Physics Curriculum

Abstract:

When thinking about developing a new curriculum, the assessment of that curriculum should be at the front of the developers' minds. There are important reasons for this:

- writing assessment items at the same time as writing the intended outcomes helps to clarify those outcomes for the developer
- the assessment of the curriculum will signal to teachers what they need to teach.

In this talk, I will use examples from work at the University of York to show how the development of assessment alongside the curriculum content can be used to support the teaching and learning of physics for citizens in the twenty first century.



Author: Nicola Wilkin

Affiliation(s): College of Engineering and Physical Sciences, University of Birmingham

Email of Presenter: N.K.WILKIN@bham.ac.uk

Title: Embedding Skills in the Curriculum in Partnership with Employers: Two Distinctive Case Studies

Abstract:

The higher education landscape within the UK is increasingly metric driven: across the entire undergraduate journey from recruitment, to employment in a graduate level position upon successful completion of the degree. This is reported in a number of ways that are accessible to applicants including newspaper league tables, the National Student Survey, the Destination of Leavers' Survey – and in preparation of an overarching Teaching Excellence Framework that is scheduled to begin shortly.

I will illustrate via two case studies, how we are increasingly working with employers to enhance the skill set of our graduates. The company involved is Forresters, a local intellectual property company which increasingly frequently recruits physics graduates. Through alumni connections, we now have a number of activities – embedded in the curriculum, which enable the students to

- develop an understanding of intellectual property and its relevance to them
- develop their ability to explain complex scientific ideas to the informed general audience

The second case study originates from a commercial collaborative partnership with Maplesoft. This includes a joint development officer (a physics PhD) to enhance our STEM based educational technology solutions using Maple T.A. Content for the breadth of Engineering and Physical Sciences is being generated in partnership with summer undergraduate student interns. This is enabling students to build their entrepreneurial skills, whilst working with an external company.

CLUSTER SESSION ON PHYSICS EDUCATION IN ASIA TODAY – DISCUSSANTS

Ravi Bhattacharjee

Delhi University

Email:

ravi_bhattacharjee@yahoo.co.in

Prof Ravi Bhattacharjee is an Associate Professor in the Department of Physics at Sri Guru Tegh Bahadur Khalsa College, University of Delhi, with 35 years of teaching experience.

At present, he is the coordinator of the IAPT - APhO Cell, which looks after the organisation, training and participation of the Indian team at the Asian Physics Olympiad (APhO). He is a life member of the Indian Association of Physics Teachers (IAPT) and he was the Secretary of the Regional Council of IAPT. He is also a senior member of the core team for the Indian Physics Olympiad, which prepares students for IPhO.

Tai Kai Ng

Hong Kong Academy for Gifted Education and Hong Kong University of Science and Technology

Email:

phtai@ust.hk

Prof Tai Kai Ng is the Executive Director of the Hong Kong Academy for Gifted Education. He was appointed as the Associate Dean of Science at the Hong Kong University of Science and Technology (HKUST) in 2004. In 1993, he was conferred an Honorable Mention at the Achievement in Asia Award by the Overseas Chinese Physics Association (OCPA), for his contribution to the understanding of the non-equilibrium mesoscopic Kondo effect.

Prof Ng also participates actively in Hong Kong's secondary and primary school science education. He was a (Hong Kong) representative in the joint Hong Kong-Mainland expert working groups on Science Education and is a Member of CDC Committee on Science Education, Curriculum Development Council. His main research interests include theoretical condensed matter physics and statistical physics. He is a member of the (Hong Kong) training team for the International Physics Olympiad competition and is interested in developing active science learning activities for primary and secondary-school students.

Leong Chuan Kwek

Institute of Advanced Studies,
Nanyang Technological
University and National
University of Singapore

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kwekleongchuan@nus.edu.sg

Prof Leong Chuan Kwek is a Principal Investigator at the Centre for Quantum Technologies, National University of Singapore and the Deputy Director of Institute of Advanced Studies, Nanyang Technological University. He is also the Deputy Secretary General for the International Union of Pure and Applied Physics and a council member of IUPAP Working Group 5 on Women in Physics. He is an elected Fellow of the American Association for the Advancement of Science (AAAS), a Fellow of the Institute of Physics, UK and a council member of the Association of Asia Pacific Physical Societies (AAPPS).

Yuxin Liu

Peking University

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yxliu@pku.edu.cn

Prof Yuxin Liu received his BSc in Physics from Henan Normal University. He was awarded his MSc and PhD in Physics by Tsinghua University. After having worked as a Postdoctoral Fellow in the Institute of Theoretical Physics, Chinese Academy of Sciences, he became an Associate Professor in 1994. He was promoted to full professor in 1999 in the Department of Physics, Peking University. He has accomplished pioneering work on quantum chromodynamics phase transition with sophisticated non-perturbative quantum chromodynamics approaches. His research focuses on the structure of exotic nuclei, phase transitions of strong interaction systems of nucleus, quantum chromodynamics and strong interaction matter, and nuclear astrophysics.

Jiun-Huei Protty Wu

National Taiwan University

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jhpw@phys.ntu.edu.tw

Prof Protty Wu is the Deputy Vice President of International Affairs at National Taiwan University. He has been conducting cosmological experiments at Hawaii and Antarctica. He received his PhD in cosmology from Prof Stephen Hawking's Group at the University of Cambridge and then became a KDI Fellow at UC Berkeley, jointly appointed by NASA as a Long-Term Space Astronomer.

He joined the faculty of National Taiwan University in 2001. He is currently also a Joint Researcher at the Institute of Astronomy and Astrophysics, Academia Sinica, and an Adjunct Professor at National Cheng-Chi University. He owns a few patents related to optics and image processing, with applications commercialized on mobile phones. For years, he has been serving at the Ministry of Science and Technology, Ministry of Education, and College Entrance Examination Center. He has been an editor and author for high-school textbooks since 2004. He has also been conducting national camps for telescope DIY since 2003, producing more than six thousand hand-made telescopes. He was awarded the Excellence Award for Social Service in 2012 and the Silver Medal of the first World Chinese Award for Popular Science in 2013.

ROUNDTABLE DISCUSSION ON PHYSICS EDUCATION IN ASEAN – DISCUSSANTS

Phichet Kittara

Mahidol University, Thailand

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phichet.kit@mahidol.ac.th

Dr Phichet Kittara is the leader of Thailand team in the International Physics Olympiad (IPhO) and International Astrophysics and Astronomy Olympiad (IOAA). He obtained his PhD in Astrophysics from Cambridge University, England, in 2002. He founded a Thai education website <http://www.vcharkarn.com> with approximate 50,000 daily visitors. He is currently a lecturer at Mahidol University, and a STEM educator of the Institute for the Promotion of Teaching Science and Technology (IPST), Thailand.

Monika Raharti

Center for Young Scientists,
Indonesia

Email:

monika.raharti@gmail.com

Dr Monika Raharti is an Assistant Professor in the Physics Department of several universities in Indonesia: Parahyangan Catholic University, Telecom University, National Institute of Technology, and Surya University. She graduated from the Bandung Institute of Technology with a Master's Degree. She has been working in science education within Indonesia and also internationally for the last 10 years. Her passion in fostering young scientists brought her to focus on developing the environment of research at the secondary school level. Together with the Ministry of Education Indonesia, she has been organising seminars, conferences and workshops within Indonesia and overseas. She is the Founder of the Center for Young Scientists and the Association of Science Mentor Teacher in Indonesia. She is also the Co-Founder and the President of the Asia Pacific Conference of Young Scientists.

Yann Rem

Royal University of Phnom
Penh, Cambodia

Email:
rem_yann@yahoo.com

Dr Yann Rem has been a lecturer of Physics at the Royal University of Phnom Penh (RUPP) since the beginning of 2012. He received his Bachelor and Master Degrees of Science in Physics from RUPP. He was awarded the Certificate of Teacher Higher Education Degree in Physics-Mathematics from the National Institute of Education, Phnom Penh capital, Cambodia. He worked as a Teacher Trainer at Takeo Regional Teacher Training Center, Takeo province, Cambodia before lecturing at RUPP.

The Royal University of Phnom Penh (RUPP) is Cambodia's oldest and one of the largest public universities. It is unique in Cambodia for offering specialist degrees in fields including the sciences, humanities and social sciences, as well as professional degrees in fields such as information technology, electronics, psychology, social work, and tourism.

**Hajah Hardimah Haji
Mohd Said**

Universiti Brunei Darussalam

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Dr Hardimah Said is a MA graduate in Science Education from the University of Leeds, UK. She is awaiting her PhD result in the field of physics education from the University of Melbourne. She started working in Sultan Haji Hassanal Bolkiah Institute of Education at Universiti Brunei Darussalam (UBD) as a physics tutor in 2005. She is now a lecturer who has been actively teaching in course modules of science and physics education. Her research interest focuses on the development of science and physics teachers in becoming better conceptual teachers with 21st century skills.

Chorng Haur Sow

Institute of Physics,
Singapore and National
University of Singapore

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Prof Chorng Haur Sow is the Head of Department of Physics at the National University of Singapore. He has always been passionate in teaching. He has the ability to relate abstract physics concepts to simple everyday phenomena by bringing the “Mobile Physics Laboratory” to lecture theatres. He can effectively use the engaging and interactive demonstration materials, animations, video clips and IT to help students understand difficult-to-visualize concepts. He creates design and demonstration tools to enhance students’ understanding of the topics discussed.

Sin Zang Sua

Chung Hua High School,
Malaysia

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szsua313@gmail.com

Dr Sin Zang Sua is the Principal of Chung Hua High School, Seremban, Malaysia. He has been an Astronomy lecturer at the New Era College. He graduated from the Liverpool John Moore University, United Kingdom, with a BSc in Astrophysics and Astronomy. He obtained his MSc in Astronomy from the Astrophysics Research Institute, Swinburne University of Technology, Australia. He was awarded his PhD in Science Education (Physics) by the School of Physics and Science Education Research, South West University, Chongqing, China. He is the Vice President of the Starhunter Astronomical Society of Selangor and the Founder of the Co-ordination Panel for the Malaysia Chinese School National Science Camp. He is also a member of the Technical Advisory Panel of Langkawi National Remote Observatory and the Planetary Society of the United States.

We look forward to seeing
you next year!

IAS Forthcoming Events



SAVE THE DATES

CONFERENCE ON 90 YEARS OF QUANTUM MECHANICS

23–26 January 2017

Nanyang Executive Centre
Nanyang Technological University, Singapore

CO-CHAIRS

Kok Khoo Phua
Institute of Advanced Studies, NTU

Marc Henneaux
Université libre de Bruxelles

Lars Brink
Chalmers University of Technology

Ngee-Pong Chang
City College of New York

NOBEL LAUREATES

François Englert
Nobel Laureate in Physics 2013

David Gross
Nobel Laureate in Physics 2004

Anthony Leggett
Nobel Laureate in Physics 2003

Rudy Marcus
Nobel Laureate in Chemistry 1992

Gerard 't Hooft
Nobel Laureate in Physics 1999

Arieh Warshel
Nobel Laureate in Chemistry 2013

Chen Ning Yang
Nobel Laureate in Physics 1957

TOPICS INCLUDE

- Revolutions in Quantum Information
- Applications of Quantum Technology
- Revelations in Quantum Cosmology
- History & Future of Quantum Mechanics

The distinguished speakers include other notable speakers from all over the world

For more information, please visit IAS website at <http://www.ntu.edu.sg/ias>
For enquiries, please email: IASQM90@ntu.edu.sg



Conference on **Cosmology, Gravitational Waves and Particles**

6–10 February 2017

Nanyang Executive Centre,
Nanyang Technological University, Singapore

In February 2016, physicists announced the discovery of gravitational waves, which were predicted in 1916 by Albert Einstein in his theory of General Relativity. About 1.3 billion years ago, two giant black holes collided and formed one very big black hole. During this collision, strong gravitational waves were emitted. They were discovered at the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the United States. At the conference, experts from the detectors will present their results. Theoreticians will discuss the implications of the discovery. There will also be lectures on the expansion of the universe, on cosmology, on astrophysics and on particle physics. The Standard Theory of particle physics describes the electroweak and the strong interactions, but it is still unclear, how the gravitational interaction can be included.

At the conference in Singapore, these and related problems will be discussed, including possible new discoveries at the Large Hadron Collider in CERN.

ORGANISING COMMITTEE:

Chair: **Harald Fritzsch**
University of Munich, Germany

Co-Chairs: **Kok Khoo Phua**
Institute of Advanced Studies, NTU, Singapore

Zhi-Zhong Xing
IHEP, Chinese Academy of Sciences, China

SPEAKERS INCLUDE:

Brodsky, S.
SLAC, USA

Fritzsch, H.
University of Munich, Germany

Rubbia, C.
CERN
Nobel Laureate in Physics 1984

Thomas, A.
University of Adelaide, Australia

Chang, N.
City University of New York, USA

Gunion, J.
University of California, Davis, USA

Shafi, Q.
*Bartol Research Institute at the
University of Delaware, USA*

Volkas, R.
University of Melbourne, Australia

Danzmann, K.
MPI Hannover, Germany

Gupta, M.
Panjab University, India

Smoot, G.
University of California, Berkeley, USA
Nobel Laureate in Physics 2006

Wetterich, C.
Heidelberg University, Germany

De Roeck, A.
CERN

Minkowski, P.
University of Bern, Switzerland

Sola, J.
University of Barcelona, Spain

Xing, Z.
IHEP, Chinese Academy of Sciences, China

Flambaum, V.
UNSW, Australia

Peik, E.
PTB Braunschweig, Germany

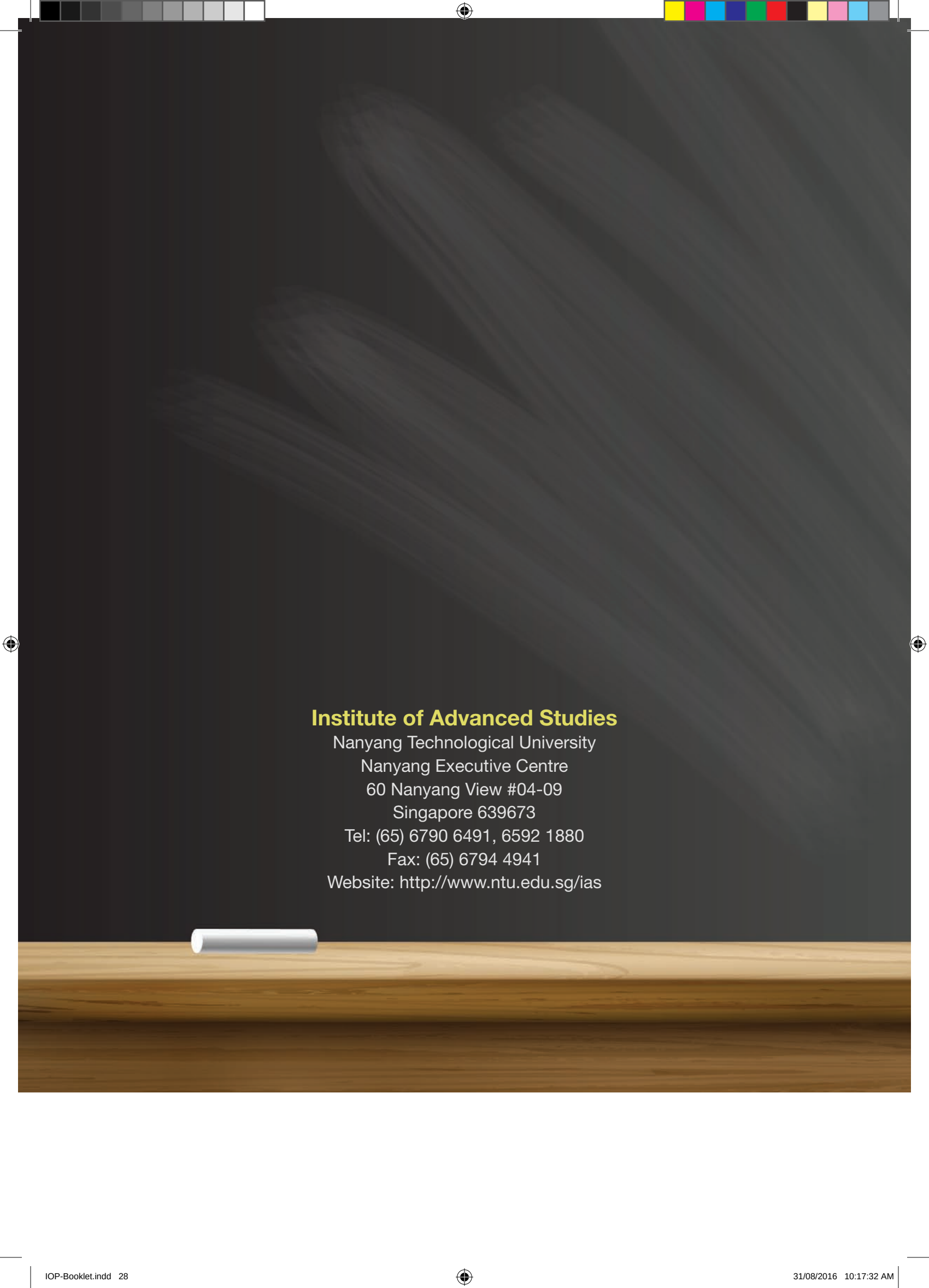
and others

For more information, please visit IAS website at <http://www.ntu.edu.sg/ias>
For enquiries, please email: Cosmology@ntu.edu.sg









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