



Newsletter

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Message from the President



It is an exciting time for a physicist. Physicists have discovered new elements (reported on the IUPAP website [<http://iupap.org>]), and detected gravitational waves (see the article [The Discovery of a Binary Black Hole Merger by LIGO] in this newsletter). IUPAP congratulates all of those involved in these major achievements. All physicists should rejoice in these and other significant results their colleagues in the many different subfields of physics are producing.

An important development for IUPAP is the formation of its new Working Group on Accelerator Science, WG14, which is reported in detail in this newsletter. The immediate task of the working group is to advise IUPAP how it can best support the needs of accelerator physicists, and make recommendations on this to the 2017 General Assembly. As its name implies, IUPAP is concerned with both pure and applied physics, and accelerator science links both of these.

Reading snippets of the history of our Union, one cannot help being impressed by the fact that many of the problems physicists and society are struggling with now have been confronted in the past. From the 1940s through the 1980s much thought was given to using physics to promote dialogue and friendship in a world of covert and overt conflicts. There are still conflicts between nations and within nations, and it remains vital that we in IUPAP continue to use our mutual interest in physics to build bridges between sides of conflicts. Let me echo the call which was made in the 1948 General Assembly of IUPAP — that we use our science and our scientific organisations to promote peace.

Bruce McKellar

Message from the Secretary General



IUPAP Singapore office is working on recruiting new members from Southeast Asia. We are in close contact with physical societies across the region. We have been having conversations with physics communities in Brunei, Myanmar, Thailand, Malaysia and Vietnam. We hope to receive favorable replies in several months time.

The International Union of Pure and Applied Physics Singapore LTD will be submitting our first annual accounts for auditing in March 2016. Subsequently, the Annual General meeting will be held in April 2016. We will publish IUPAP newsletters regularly and four issues are expected for the year of 2016.

Kok Khoo Phua

The Discovery of a Binary Black Hole Merger by LIGO

Albert Lazzarini (AC2: International Society on General Relativity and Gravitation)

About three months before the 100th anniversary of Einstein's formulation of general relativity, and ten months before the 100th anniversary of his paper postulating their existence, Advanced LIGO made its first detection of gravitational waves on 14 September 2015 at 09:50:45 UTC. The event was assigned the ID GW150914. With this discovery, an arduous journey that began in the 1960s with Joe Weber ended, and a new trek into exciting and unknown territory now lies before us.

LIGO stands for Laser Interferometer Gravitational-Wave Observatory. It consists of two detectors in the US, approximately 3000km apart, each consisting of an interferometer with 4km arms. Gravitational waves are ripples in space and time, and when one passes

through the detector, one arm expands and the other shrinks. The change in length is tiny, 10^{-18} m, but GW150914 was still detected by both LIGO detectors. Another gravitational wave detector called VIRGO is being upgraded in Italy. Although it was not online at the time of the first detection, scientists associated with VIRGO joined scientists associated with LIGO in analyzing the data.

It is appropriate to draw an analogy to where optical astronomy stood after Galileo Galilei first pointed a 37 mm, ~20X telescope at the night sky over Padua, Italy in 1609. He immediately perceived previously unsuspected wonders: the craters of the Moon; the miniature “solar system” of the Jovian Galilean moons, which immediately bolstered the Copernican world view; the phases of Venus; spots on our Sun. And that was just the beginning.

So too, we are now poised to explore and discover the gravitational-wave sky. True to the Galilean analogy, the first detection by LIGO was a surprise. While binary black hole systems had been predicted to exist on theoretical arguments, none had been known to exist until LIGO’s first event. Moreover, the pair of black holes were massive — 36 and 29 solar masses. Their merger and disappearance gave rise to a new spinning 62 solar mass black hole: LIGO witnessed this birth — actually “heard” its birth.

The signal is fully concordant with general relativity (GR) within the uncertainties coming from the LIGO instrumental noise. The correlation between the observed strain signal and the expected GR waveform is $\geq 96\%$, implying that the GR prediction for GW150914 is verified to better than 4%, or in other words that effects due to GR-violations in GW150914 are limited to less than 4%. The peak signal strain was 1×10^{-21} , corresponding to a most likely distance of 410 Mpc. Assuming the standard Λ CDM cosmological model, the distance of the merger corresponds to $z = 0.09$.

Based on the GR waveform, this merger released an amazing 3 solar masses of energy in gravitational radiation. At peak luminosity, the source was radiating 3.6×10^{56} erg/s, equal to 100,000 supernovae. In fact, during the last moment before it disappeared, the source was ~50X times brighter in gravitational radiation than the entire visible electromagnetic Universe.

The information on magnitude and alignment of spin for the component black holes is not sufficient to constrain the formation mechanism. The source could have been a field binary or a dynamically formed binary associated with a dense stellar environment: it will take additional detections before we can begin to discriminate between these two possibilities.

This single detection has also provided our first significant insights into strong-field gravity: based on numerical calculations for the best-fit waveform, the final mass and spin of the black hole deduced from the merger/ringdown portion of the waveform agrees at the 90% confidence level with the inspiral part using the relations between the binary’s components and final masses and spins provided by numerical relativity. GW150914 also allows us for the first time to set constraints on the coefficients in the post-Newtonian series expansion of the phasing up to 3.5 PN;



Two black holes about to merge into one, as seen in a computer simulation.

the best information prior to this was from the double pulsar J0737-3039, which could only provide bounds only up to 1 PN. Moreover, GW150914 provides independent information on the mass of the graviton. Solar System observations, model-dependent large-scale dynamics of galactic clusters and model-dependent weak lensing observations have set bounds on the Compton wavelength of the graviton, λ_g , that do not probe the propagation of gravitational interactions (i.e., the so-called static bounds) that are $\lambda_g \geq 2.8 \times 10^{12}$ km, 6.2×10^{19} km and 1.8×10^{22} km, respectively. The only dynamical bound to date is provided by binary-pulsar observations and it is $\lambda_g \geq 1.6 \times 10^{10}$ km. GW150914 places a lower dynamical bound $\lambda_g \geq 10^{13}$ km at 90% confidence, which corresponds to an upper bound on the graviton mass $m_g \leq 1.2 \times 10^{-22}$ eV/ c^2 at 90% confidence.

With a single 3000 km baseline, the two LIGO detectors were only able to crudely localize the source to a broad swatch of the southern sky comprising almost 600 square degrees. In the near future, the Advanced Virgo detector in Cascina, Italy will become operational and is expected to join LIGO for its next science observing run in the latter half of 2016. Once the global network has three nodes of comparable sensitivity, localization will become much more precise. Looking to the future a bit further off, the Japanese KAGRA 3 km cryogenic detector will also come online, adding a fourth node to the global network. And within a week of the announcement of the discovery, the Government of India formally gave its approval to the construction of a new green-field facility in India that will house a third Advanced LIGO interferometer. While further into the future than KAGRA, India’s decision to make this important commitment is critical to our nascent field of gravitational wave astronomy and it heralds an epoch that will see a five-node network observing the Cosmos in the gravitational wave window, using Nature’s weakest force to probe the inner workings of compact stellar systems comprised of neutron stars and black holes.

Please stay tuned for more exciting discoveries as we move forward!

For further details of GW150914, LIGO has set up a web site linking to all of the relevant papers. Please visit <https://papers.ligo.org>.

Start of Operations for the Stellarator Wendelstein 7-X Fusion Device

Isabella Milch (Max Planck Institute for Plasma Physics)

On 10th December 2015 the first helium plasma was produced in the superconducting stellarator Wendelstein 7-X device (Figure 1) at the Max Planck Institute for Plasma Physics (IPP) in Greifswald (Germany). After more than a year of technical preparations and tests, experimental operation has now commenced according to plan. Wendelstein 7-X, the world's largest stellarator-type fusion device, will investigate the suitability of this type of configuration as a commercial fusion reactor.

This first plasma follows nine years of construction work and more than a million assembly hours, the main assembly of the Wendelstein 7-X was completed in April 2014. The operational preparations have been under way ever since. Each technical system was thoroughly tested: the vacuum in the vessels, the cooling system, the superconducting coils and the magnetic field they produce, the control system, as well as the heating devices and measuring instruments. On 10th December, the day had arrived: the operating team in the control room started up the magnetic field and initiated the computer-operated experiment control system. It fed around one milligram of helium gas into the evacuated plasma vessel, switched on the 140 GHz microwave heating for a 1.3 megawatt pulse — and the first plasma in Helium could be observed by the installed cameras and measuring devices (Figure 2)

This plasma had a duration of one tenth of a second and achieved a temperature of around one million degrees. The next step was to extend the duration of the plasma discharges and to investigate the best method of producing and heating helium plasmas using high power millimeter waves.

After this first period of study of He plasma, the W7X team focused their activities on preparing plasmas in Hydrogen, which, with its isotopes Deuterium, is the working gas in fusion plasma research (an electricity producing reactor will use Deuterium and Tritium). The German Chancellor Dr. Angela Merkel (who is herself a physicist) joined the W7X team and guests from all over Europe and the world to create the first Hydrogen discharge in W7-X on Wednesday 3rd of February 2016. The “Chancellor’s Plasma” as it is called reached an electron temperature of 80 millions degrees in the center and a density of up to $1.5 \times 10^{19} \text{ m}^{-3}$ for about 200 ms. W7X is now operational!

The whole fusion community and the IUPAP C16 Commission (Plasma Physics) congratulate the W7-X team for their hard work in bringing this ambitious project to operation and wish our colleagues all the success in their future studies.

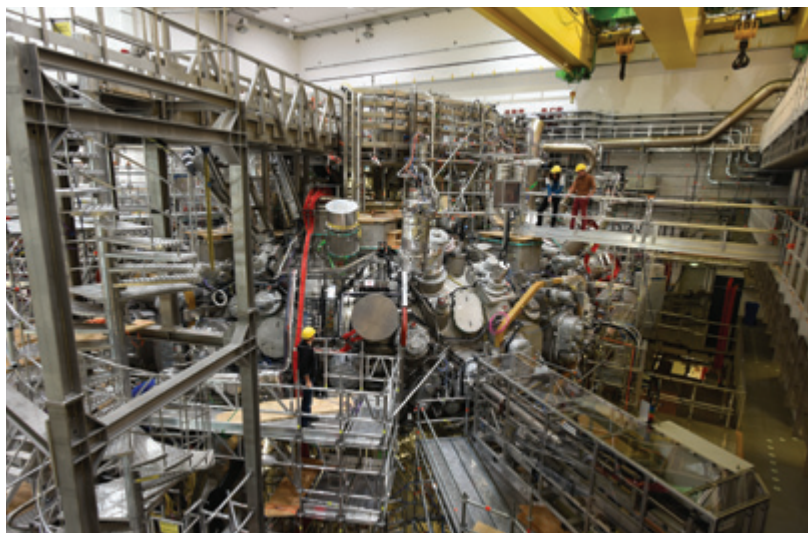


Figure 1 The Wendelstein 7-X fusion device. Photo: IPP, Thorsten Bräuer

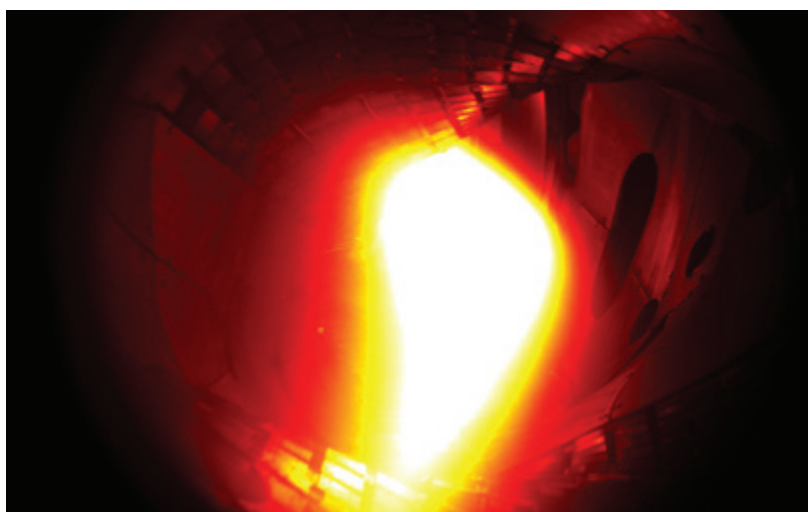


Figure 2 The first plasma in Wendelstein 7-X. It consisted of helium and reached a temperature of about one million degrees Celsius. (coloured black-and-white photo) Photo: IPP

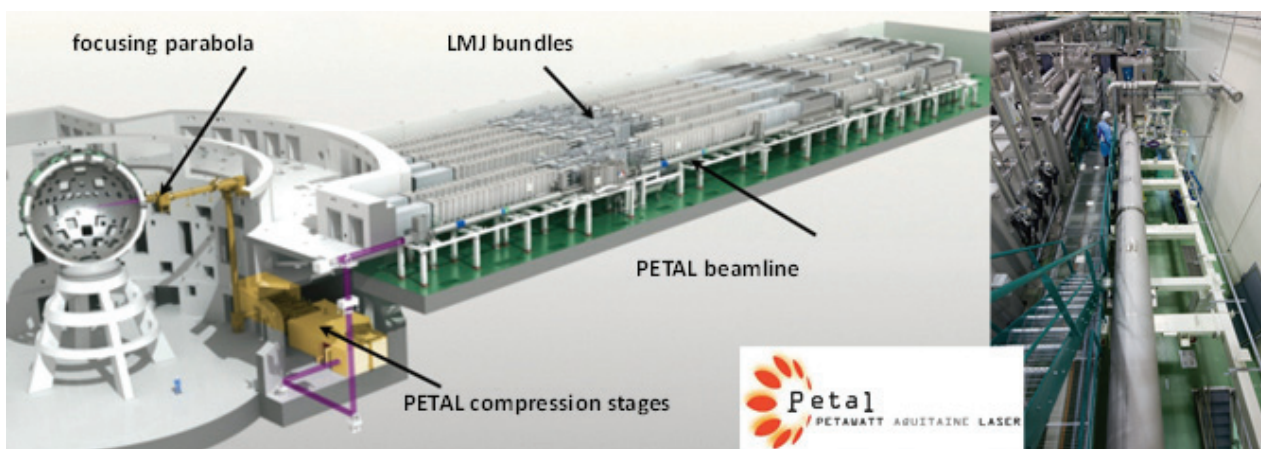


From left to right we have Prof. Dr. Th. Klinger, Director of the IPP Greifswald Branch, Prof. Dr. Otmar Wiestler, President of the Helmholtz Association, Prof. Dr. S. Guenter Director of the Max Planck Institute for Plasma Physics, the German Chancellor, Dr. A. Merkel Mr. Erwin Sellering, Minister president of the federal state of Mecklenburg-Vorpommern and Mr. Stefan Müller parliamentary, Secretary of State in the Federal ministry for Education and Research). The Chancellor, Dr. Merkel, is going to start the Hydrogen “Chancellor’s discharge” in W7-. Photo: IPP, Didier Chauvin.

France at the Forefront of Promoting Ultra-High Power Laser-Based Sciences

The International Year of Light was commemorated in France by the inauguration of two large-scale laser facilities, at the highest international level. Both facilities deliver high-energy high-power pulses and they will produce intense and ultra-short radiation sources and plasma accelerators¹, for both electrons and ions, which will offer new research capabilities in plasma physics.

The first one, PETAL, is located near Bordeaux. Funded partly by the Aquitaine Region, along with European and national funds, it is operated by the French *Commissariat à l'Energie Atomique et aux Energies Alternatives* (CEA) and has already delivered in May 1.2 petawatt (PW) in the picosecond regime. PETAL is now coupled to the Laser MégaJoule (LMJ) and the first academic experiments are scheduled for next year. PETAL will be later upgraded to 7 PW. Breakthroughs in high-energy-density physics is possible, whether it is in the field of planetary sciences, laboratory astrophysics or inertial fusion. LMJ-PETAL will for instance allow (i) putting matter under extreme conditions and probing its structural changes at the microscopic scale, (ii) mimicking violent phenomena occurring in the Universe, such as supernova explosions or accretion processes, and diagnosing the magnetic fields involved or (iii) demonstrating the feasibility of shock ignition, an energy-relevant alternative fusion scheme.



Schematic of the PETAL implementation in the LMJ facility and view of the laser bay.

The second one, APOLLON, was inaugurated in October on the Plateau de Saclay, near Paris. Operated by the *Laboratoire d'Utilisation des Lasers Intenses* (LULI), hosted by Ecole Polytechnique and funded partly by CNRS and the Île-de-France Region, APOLLON should be the first laser in the coming years to deliver 5 PW in the femtosecond regime, and ultimately 10 PW. The intensities thus reached will allow physicists to explore new "terra incognita" in laser-matter interaction. Driving multi-gigaelectron volts (GeV) particles to nearly the speed of light, APOLLON will open up opportunities to explore fundamental questions, from the very small (offering means to observe, at the nanoscale, matter quickly evolving over attoseconds) to the very large (helping understanding e.g. γ -ray bursts) and the very complex (creating electron-positron pairs and observing quantum vacuum effects).



Views of the APOLLON compression vessel and of the operating front-end.

For more details, please refer to the url at: <http://www-lmj.cea.fr>, <http://petal.aquitaine.fr>, <http://apollon-laser.fr> and www.luli.polytechnique.fr.

¹ see paper from R. Bingham in the IUPAP newsletter dated September 2015

IUPAP at the UN: Women in Physics

On Thursday February 11, 2016, Dr. Renee Horton and Jacquelyn Beamon-Kiene attended the first United Nations International Day of Women and Girls in Science representing the IUPAP Working group 5, Women in Physics. The event was hosted by the Royal Academy of Science International Trust (RASIT), with welcome remarks by HRH Princess Dr. Nisreen El-Hashemite, Executive Director, Royal Academy of Science International Trust, and Founder of Women in Science International League. This event was brought about by a groundbreaking Resolution which came forth at the 70th Session of the United Nations General Assembly held on December 22, 2015. The goal of the Resolution is to bring awareness and parity for women in science.

There were speakers from many regions of the world, who spoke on topics in fields of physical science, technology, engineering, mathematics, medicine, law, library science, economics and political science just to name a few. However we were honored in that Dr. Horton's presentation on behalf of the IUPAP WG on Women in Physics was the only presentation in the field of Physics on the agenda. Dr. Horton provided background on IUPAP and the accomplishments of the WGWP since its realization in 1999.

The theme for the day was "Transforming the World: Parity in Science", with a goal of bringing awareness to the issue and going a step further by taking actions to ensure that parity becomes a reality. Webcast of the event can be found in two parts on the UN WebTV at <http://webtv.un.org/>.

There was a lot of excitement and sharing throughout the entire day, and it was very thrilling to be a part of the inaugural celebration. Most people went away with ideas on things they can do within their communities to bring about change. New information was received to think about and work with to make a change and impact in our communities. A positive take away was stated by Professor William Best, Professor of Practice Electrical and Computer Engineering and co-Director of Lehigh's innovative IDEAS, Lehigh University, USA, "*don't argue with changing the world, but change your little corner of the world and with thousands and thousands of women and girl scientist and engineers changing their corner of the world there will be hope.*" Additional information on the International Day of Women and Girls in Science can be found at <http://womeninscienceday.org/>.

Dr. Renee Horton can be reached at krhorton@alumuni.lsu.edu

Jacquelyn Beamon-Kiene can be reached at beamon@aps.org



Dr. Renee Horton, IUPAP Working Group Women in Physics Member, USA.

WG10 and C4: Open Data Policy and Data Sharing in Astroparticle Physics: the Case for High-Energy Multi-Messenger Astronomy

WG10 (Astroparticle Physics International Committee (ApPIC)) and C4 have entered into a discussion to prepare a position paper on open data policy and data sharing in Astroparticle Physics. The present focus is on high-energy multi-messenger astronomy, a topic that became even more important with the recent discovery of gravitational waves by the LIGO and Virgo Scientific Collaborations. ApPIC and C4 recommend an open data policy to enhance the discovery potential of this publicly funded field, in the spirit of sharing data broadly. The implementation could go in steps and would involve agreements between collaborations for joint analyses (something that has happened already between high energy cosmic ray and neutrino observatories) as well as open access to data within the community of experts following models of virtual observatories with help desks for data and codes and finally also data preservation and legacy. Obviously, resources will be needed to implement and maintain such data archives, something that should be foreseen already during the planning of experiments and observatories. The position paper, once finalised later this year will be handed to the funding agencies and to the scientific community.

Formation of the Working Group on Accelerator Science (WG14)

Accelerators have become prevalent as powerful tools for scientific discovery and as versatile instruments for societal applications. The science of accelerators is rich and challenging and becoming increasingly international, driven not only by both the size and complexity of accelerator projects, but also by the necessity to combine efforts in order to effectively confront difficult questions, e.g. advanced acceleration techniques.

IUPAP announces the formation of the long-awaited Working Group on Accelerator Science. The mission of the IUPAP WG14 is to promote the exchange of information and views among the members of the international scientific community in the general field of Accelerator Science including, but not limited to, the following:

- a. the theory and experiments concerned with the nature and properties of particle accelerators and beam physics;
- b. the improvement of international communications in Accelerator Science through the sponsorship of professional meetings;
- c. the future of accelerator facilities for various fields that benefit science and society;
- d. the industrial, medical, energy production and environmental applications of relevant accelerator technologies.



The working group will be chaired by **Lia Merminga**, SLAC National Accelerator Laboratory, merminga@slac.stanford.edu.

The other members of WG14 are:

- **Stuart Henderson**, Project Manager, Advanced Photon Source, Argonne National laboratory, United States of America, hendersons@anl.gov
- **Chris Barty**, Co-Chair of ICUIL, Chief Technology Officer for the National Ignition Facility and Photon Science Directorate at Lawrence Livermore National Laboratory, United States of America, barty1@llnl.gov
- **Caterina Biscari**, Director, ALBA Synchrotron Light Source, Spain, cbiscari@cells.es
- **Di-Jing Huang**, the Deputy Director, National Synchrotron Radiation Research Center, Taiwan, djhuang@nsrrc.org.tw
- **Bob Bingham**, past-Chair of C16, Professor, STFC Rutherford Appleton Laboratory, United Kingdom, bob.bingham@stfc.ac.uk
- **Qing Qin**, Deputy Director of IHEP, China and the Chair of Accelerator Division, China, qing@ihep.ac.cn
- **Seiya Yamaguchi**, Director of Accelerator Laboratory, KEK, Japan, seyia.yamaguchi@kek.jp
- **Gianluigi Arduini**, Chair, European Physical Society – Accelerator Group Elected Board and Head, Accelerator and Beam Physics Group, CERN, Switzerland, Gianluigi.Arduini@cern.ch
- **Swapan Chattopadhyay**, Distinguished Professor of Physics and Director of Accelerator Research at Northern Illinois University and a member of the Director's Senior Leadership Team at Fermi National Accelerator Laboratory, United States of America, schaterji@niu.edu
- **Leonid Rivkin** (Lenny), Head of Large Research Facilities Department and member of the Board of Directors of the Paul Scherrer Institute and Professor of Accelerator Physics at the Swiss Federal Institute of Technology in Lausanne (EPFL), Switzerland, leonid.rivkin@psi.ch
- **Joachim Mnich**, ICFA Chairman, Director for Particle Physics and Astroparticle Physics, DESY, Germany, joachim.mnich@desy.de
- **Michael Moyers**, Chairman and Professor Department of Medical Physics, Shanghai Proton and Heavy Ion Center (SPHIC), China, MFMoyers@roadrunner.com
- **Mats Lindroos**, Head of Accelerator Division, European Spallation Source and Particle Physics division, Physics department Lund University, Sweden, mats.lindroos@esss.se

Plans are underway to hold the first WG14 meeting in Korea in May 2016.

Additional Conference Reports 2015

At the **International Conference on Electromagnetic Isotope Separators and Related Topics (EMIS-2015)**, held at the Grand Rapids Michigan, USA, from 10/5/2015 to 16/5/2015, topics discussed included the extraordinary progress in many areas ranging from isotope production, target and ion source techniques, separators, ion traps and laser techniques, instrumentation for radioactive ion beam experiments, to applications using radioactive ion beams. Areas that stood out in terms of advances made were the use of low-energy beam manipulation techniques including beam cooling and radiofrequency ion transport as well as the use of laser techniques for efficient and selective ionization of radioactive isotopes.



Participants at EMIS 2015.

At the **WG9-TRIUMF- Nuclear Science Symposium**, held from the 4/6/2015 to 5/6/2015 at South-Eastern Universities Research Association (SURA) headquarters in Washington, DC, USA, overviews of current forefront nuclear science research was addressed. Upgrading of current and planning for large new facilities were given by representatives from Asia, Europe, and North-America. In addition, three presentations were given on the topics of: 'Neutrino masses, neutrino mixing, neutrino-less double beta-decay and the deep underground laboratories', 'The science case for an electron-ion collider', and 'The science programs of rare isotope beam facilities'. The Nuclear Science Symposium concluded with an 'in camera' meeting of the government/funding agency representatives to discuss their individual perspectives. This, it is hoped, will lead to increasing mutual awareness of these agencies and cooperation in the funding of future large scale nuclear science facilities.



Participants at the WG9-TRIUMF- Nuclear Science Symposium at SURA, Washington DC, USA.

International Cosmic Ray Conference (ICRC) held in The Hague from 30/7/2015 to 6/8/2015, new results from multi-messenger astronomy (particles, neutrinos and high-energy photons) were presented. This will open a new era in the discovery of sources of the non-thermal universe. Studies of direct and indirect matter detection have not yet led to conclusions what the nature of dark matter (particles) might be. However, with the advent of dedicated detector systems and the cross-fertilization from neutrino- and gamma-ray observations these combined observations might be the path to settle this very fundamental question. Data from solar and heliospheric observations obtained from multi-spacecraft missions were shown. These observations open a new window in the study of solar phenomena. The conference was attended by more than 1000 participants from 58 countries.



Participants of ICRC 2015 at the Hague.

The **XIV International Conference on Topics in Astroparticle and Underground Physics (TAUP 2015)**, held at Torino, Italy from 7/9/2015 to 11/9/2015 was extremely successful, with an unprecedented number of participants (490). All the major experimental, observational and theoretical advances in the field of astroparticle physics were presented: summarized in the plenary talks and, in more detail and with a lot of discussion in the large number of contributed talks. In total, 32 plenary talks, 284 parallel talks and 55 posters were presented. Finally, two outreach events were organized as related activities.



Participants at TAUP 2015 in Torino, Italy.

All details can be found on the Conference website: <http://taup2015.to.infn.it>.

The **School on Cooperative Phenomena in Condensed Matter: From Bose-Einstein Condensates to Quantum Optics**, organized by ICTP in cooperation with the University of Buea in Buea, Cameroon from 02/11/2015 to 13/11/2015 aimed to establish cooperation between African scientists, and to let them know some of the most interesting topics and directions in condensed matter physics. The conference attracted scientists from all over Sub-Saharan Africa. The keynote speakers presented a series of pedagogical lectures on cutting edge topics of the modern condensed matter physics. Contributed talks given by young participants from African countries covered interesting research directions promoted in the region.

More information about this activity is published in ICTP online news: <http://www.ictp.it/about-ictp/media-centre/news/2015/12/field-activities.aspx>



(Left) Participants of ICTP's workshop in Cameroon; (Right) Ermanno Pietrosevoli expanding wireless connectivity in Mozambique