WG5 Women in Physics

Report for C&CC Oct 2018

Summary of activities May ‘18- Oct ‘18

Prepared by

Dr Gillian Butcher (chair)

International Conference on Women in Physics

The Conference Proceedings of the 7th International Conference on Women in Physics, Birmingham, UK 2017, published by AIP, are in the final stages of preparation.

We were pleased to announce that Melbourne, Australia will host the next Conference, ICWIP2020, led by Dr Cathy Foley and Prof. Sarah Maddison. Dates are currently being finalised but will take place in July 2020.

ISC Collaborative project on the Gender Gap in Science

The ISC project *A Global Approach to the Gender Gap in Mathematical and Natural Sciences: How to Measure It, How to Reduce It?* is led by Prof Marie-Francoise Roy, of IMU, with IUPAP (led by Dr Igle Gledhill) and IUPAC (led by Prof Mei-Hung Chiu) the other main partners. The website can be found at https://gender-gap-in-science.org/.

The Joint Global Survey co-ordinated by Rachel Ivie of AIP, went live on 1st May and will run until 30th November and is available in English, French, Arabic, Chinese, Japanese, Russian and Spanish. As of 1 October 2018, there were 18,961 respondents to the survey, which is some way short of the 45,000 aimed for, so there is still need for substantial outreach effort.

The co-ordination meeting was held in Paris, 11-12 June 2018, attended by WG5 members Silvina Ponce-Dawson, Igle Gledhill and Gillian Butcher along with Rachel Ivie of the AIP. We were very pleased that IUPAP President Designate Michel Spiro was able to attend one of the days and has been very supportive of the project. We heard updates on the progress made on each of the three tasks of the project: a joint Global Survey (which builds on the previous IUPAP Global Survey(s) of Physicists), a bibliometric study of publication profiles, and a database of good practice. This included updates on the three regional workshops in Colombia, South Africa and Taiwan, held towards the end of 2017 and on news from the partners of the project with respect to Gender Gap initiatives. We also discussed communication, upcoming work in the second year of the project and organization of the final meeting of the project at ICTP in 2019.

Waterloo Charter

The final version of the Waterloo Charter, a declaration of principles and list of good practice, has been finalised, following extensive consultation and re-drafting. Silvina Ponce-Dawson will present it to the IUPAP Executive Council meeting, 1-2 Nov. for approval.

ICPE

Three members of WG5, Apriel Hodari, Nicola Wilkin, Igle Gledhill were invited by the organisers to attend and present at the ICPE International Conference on Physics Education in Johannesburg, 1-5 October 2018.

WG members 2017-2020

Gillian Butcher, UK (Chair)

Igle Gledhill, South Africa (Immediate Past Chair)

Lilia Meza Montes, Mexico (Vice-Chair)

Jackie Beamon-Kiene, USA (Secretary)

Dina Izadi, Iran

Kwek Leong Chuan, Singapore

Prajval Shastri, India

Shohini Ghose, Canada

Apriel Hodari, USA

Kuijuan Jin, China Beijing

Francisca Nneke Okeke, Nigeria

Silvina Ponce Dawson, Argentina (IUPAP Gender Champion ex-officio)

Nicola Wilkin, UK (Associate)

International Committee on Ultrahigh Intensity Lasers - October 2018 Report to IUPAP

On behalf of the committee and as Chairman of the International Committee on Ultrahigh Intensity Lasers (ICUIL), I submit this report of ICUIL-related activities and events over the past 6 months to IUPAP. Obviously the biggest news in this time period is the most recent. On October 2, Professor Gerard Mourou, who was ICUIL's first chairman from 2004 to 2008, and Professor Donna Strickland were awarded the 2018 Nobel Prize in Physics for the invention of the chirped pulse amplification concept upon which nearly all of today's ~$5B worth of ultrahigh laser activities are based. This is a banner event for the community and for the ICUIL committee in particular. Below is the photograph from the kick off meeting for the ICUIL which was held in Great Britain in 2004. Gerard is at the center of this picture. The committee will be planning several events to celebrate this achievement over the coming year.

February 2004 - ICUIL Kickoff meeting in Great Britain - Gerard Mourou in the center

The International Committee on Ultrahigh Intensity Lasers (ICUIL) was established in 2004 as an IUPAP working group devoted to the promotion and outreach of ultrahigh intensity laser capabilities around the world. By the committee's estimate there are approximately $5B of world wide projects and facilities today devoted to the creation and use of ultrahigh intensity laser capabilities.

On a biennial basis, ICUIL sponsors the International Conference on Ultrahigh Intensity Lasers. The 2018 meeting occurred in Lindau, Germany September 8 to 14, 2018. The Lindau meeting was the 8th in the ICUIL series. As with previous meetings, ICUIL 2018 brought together both the developers of next-generation capabilities, the scientists that use these capabilities and representatives from related industries. This years meeting set an attendance record and not only sold out the hotel venue but sold out the conference seating as well. There were literally no seats left. Student participation was strong, particularly from European countries. A photo of the conference attendees is below.

2018 ICUIL Conference - Lindau, Germany

At the annual meeting of the International Committee on Ultrahigh Intensity Lasers which was held on Monday evening of the conference, South Korea, Japan and China all presented proposals to host the 2020 ICUIL conference. Each proposal was strong. After careful consideration, the committee voted and chose the South Korean proposal to host the meeting on Jeju Island in fall of 2020. South Korea is currently the host of one of the premier ultrahigh intensity petawatt laser user facilities at the Guangju Institute of Science and Technology. It is anticipated that 2020 attendees will be able to tour this state of the art facility in conjunction with attending the next conference.

In other business, the ICUIL committee considered at length the issue of member rotation and in particular diversity. By vote of the majority of the quorum in attendance, 7 new voting members and 6 non-voting associate members were elected to be part of the committee. Of the 7 new voting members four were female scientists and one of these was from the African continent. In the past year we have also added 1 new participant from Australia representing the southern hemisphere.

In related conference activity, June of this year Nuclear Photonics 2018 took place in Brasov, Romania. This meeting was the second in the biennial series and saw growth from 140 participants in 2016 when the meeting was held in Monterey, California to 220 participants in 2018. The participants of this meeting toured the 300M euro Extreme Light Infrastructure - Nuclear Physics facility in Magurele, Romania prior to the meeting. ELI-NP will be the first international facility with 10 PW laser capability when it comes on line for initial commissioning experiments in 2019. At this meeting it was announced that the German government would be sponsoring a new initiative in nuclear photonics in the coming year. Given the activity in this area and the overlap with ICUIL related technologies and science, it would seem relevant for ICUIL the committee to consider adding representation from IUPAP from its nuclear science related commissions.

In August of this year, the United States began a new networking activity known as LaserNetUS. With support of the Department of Energies Office of Fusion Energy Science, the first meeting of LaserNetUS was held at the University of Nebraska home of Diocles Petawatt laser system. This meeting is viewed as a positive sign for US ultrahigh intensity laser activities as many of the charter members of LaserNetUS have ICUIL relevant capabilities and the establishment of this network should provide greater user access and growth of the community.

Since the April report to IUPAP several of the ICUIL committee membership have been recognized for their technical achievements. Professor Toshi Tajima (ICUIL's second chairman) was awarded the Association of Asia-Pacific Physical Societies (AAPPS) Division of Plasma Physics (AAPPS-DPP) Subramanyan Chandrasekhar Prize of Plasma Physics. Professor Chris Barty (ICUIL's present chairman) was awarded the R W Wood award of the Optical Society of America for his pioneering contributions to ultrahigh intensity laser science. Finally, two weeks before wining the Nobel prize in Physics, Professor Gerard Mourou (ICUIL's first chairman) was also awarded the Arthur Schawlow Award of the American Physical Society again for the invention of chirped pulse amplification.

Earlier this summer the 9th newsletter of the ICUIL was published a copy of which is appended below.

Sincerely,

Professor Chris Barty

Chairman of ICUIL

ICUIL News N°9

Volume 9 – August 2018

Chief Editor: Efim Khazanov

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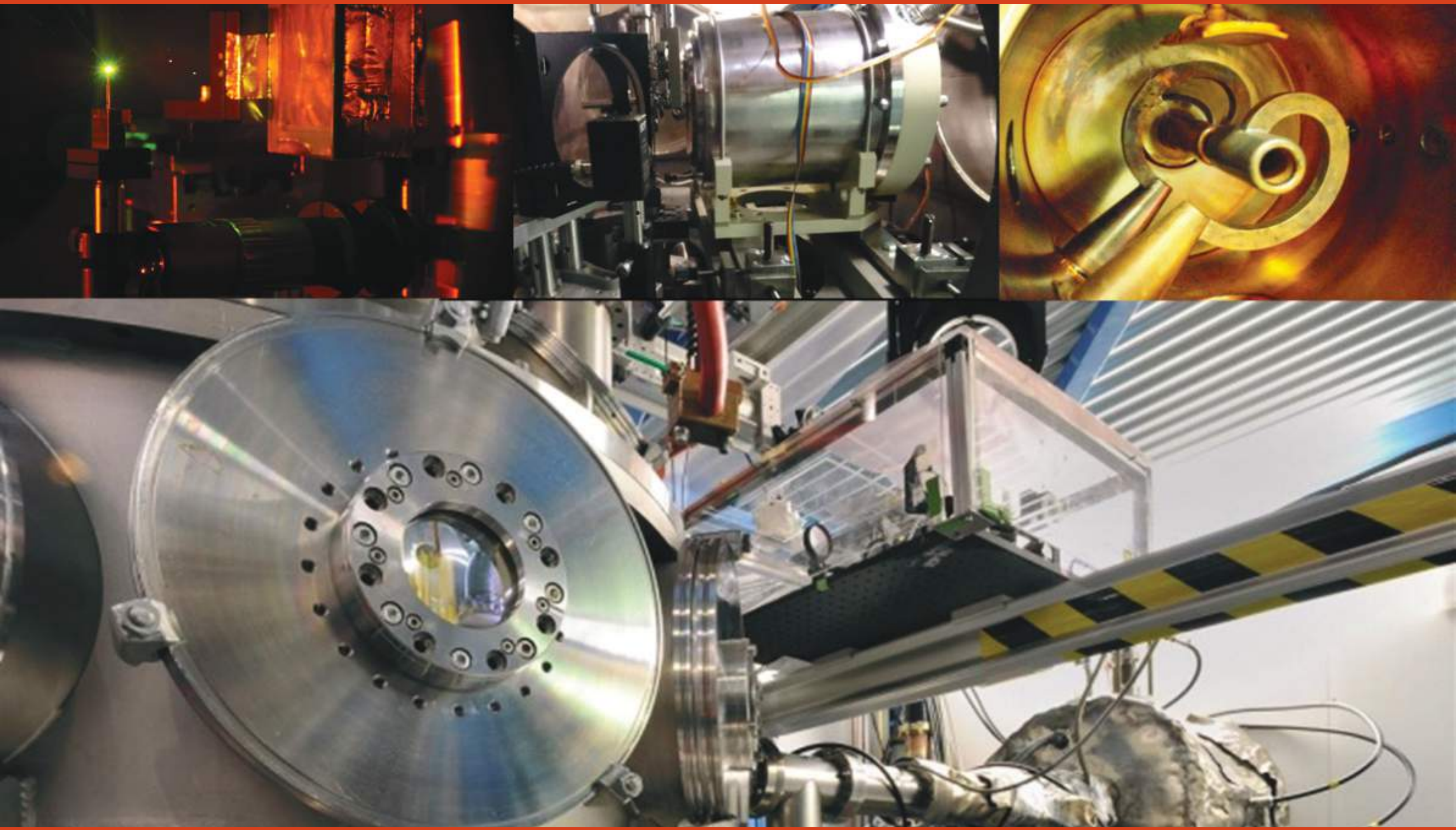


The International Committee on Ultra-High Intensity Lasers

Chairman's Remarks

Chris Barty, ICUIL Chair

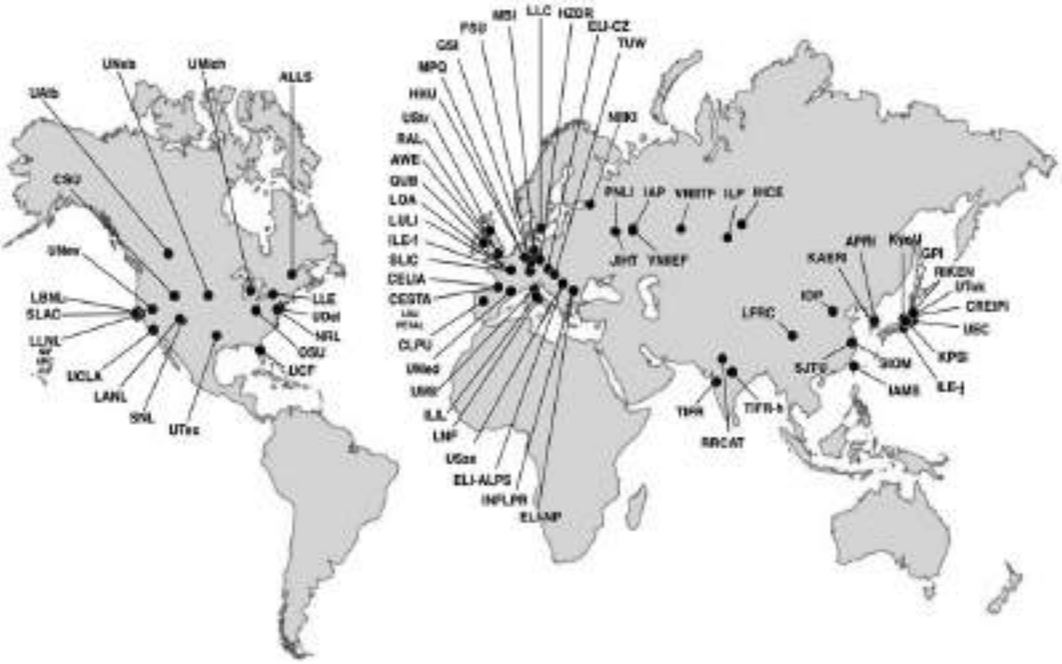
As the chairman of the International Committee on Ultrahigh Intensity Lasers (ICUIL), it is my honor to welcome you to the 9th ICUIL newsletter.

As is evident throughout the contents of this document, worldwide activities related to the development and use of ultrahigh intensity lasers are growing. Over the past year, a major new $B-scale initiative has been approved in China, the ongoing Extreme Light Infrastructure projects in Europe have met key milestones, record new capabilities have been demonstrated at facilities in South Korea and China, and the US National Academies has released its related report "Opportunities in Intense Ultrafast Lasers – Reaching for the Brightest Light." The applications of ultrahigh intensity lasers are now being discussed at a growing number of topical meetings worldwide and new applications-specific projects such as the Nuclear Photonics initiative out of Darmstadt, Germany have successfully established government funding support.

In the fall of 2018, ICUIL's 8th International Conference on Ultrahigh Intensity Lasers will take place in Lindau, Germany. Preliminary indications are that the 2018 meeting will be the largest attended to date. As an organization, ICUIL also continues to evolve, grow and change. We have a new representative from the Southern Hemisphere, Prof. Heinrich Hora of the University of New South Wales and a new board member, Prof. Dino Jaroszynski of the University of Strathclyde who in the fall of 2017 assumed the role of ICUIL treasurer. We on the ICUIL committee owe special thanks to our previous treasurer, Prof. Tsuneyuki Ozaki of INRS-EMT for his many years of service, his excellent stewardship of ICUIL's finances and his thoughtful and enthusiastic participation on the ICUIL board.

In other news three of ICUIL's senior members recently received notable recognition. Alexander Sergeev, present co-chair of ICUIL, was selected to be the president of the Russian Academy of Sciences. Gerard Mourou, ICUIL's first chairman, was selected as the 2018 recipient of the American Physical Society's Arthur L. Schawlow prize in laser science, and Toshiki Tajima, ICUIL's chairman from 2008 to 2016, was selected as the 2018 recipient of the Association of Asia-Pacific Physical Societies (AAPPS) Division of Plasma Physics (AAPPS-DPP) Subramanyan Chandrasekhar Prize of Plasma Physics.

It is our hope that you will find this newsletter to be a convenient snapshot of worldwide activities and that you will use this document as a motivation to visit the ICUIL website at www.icuil.org and to participate in upcoming ICUIL related activities.



ICUIL.org World Map of Ultrahigh Intensity Lasers

Farewell from the ICUIL Treasurer 2008 to 2016

Tsuneyuki Ozaki

I would like to start off by thanking all members of ICUIL for giving me the opportunity to take part in serving this vibrant community. My involvement as Treasurer of ICUIL started in October 2008 at the biennial ICUIL Conference held in Tongli, China. Since 2003, I have been a professor at the Institut national de la recherchescientifique (INRS) near Montreal, Canada, and from 2006 to 2012, the Director of the Advanced Laser Light Source (ALLS). Since 2008, with the excellent support from the members and Board of ICUIL, I was gradually trained into the Treasurer position, organizing committee finances and discussing ICUIL business. The periodic teleconferences of the Board were highly stimulating, and it has been an absolute pleasure working with my colleagues. In 2016, I was also lucky enough to organize the ICUIL 2016 conference at Montebello, Canada. While this required a great deal of energy (my students found me passed out in a couch after the conference), organizing this conference reinforced my belief that ICUIL is an excellent example of a tight-knit community that has succeeded in truly promoting the exciting science and technology of ultra-high intensity lasers. Capitalizing on my experience with ICUIL, I have recently taken on the responsibility as Chair of Commission 17 of IUPAP on "Laser Physics and Photonics". I hope that Iwould be given the chance to continue working together with ICUIL in the coming years to promote our common interests.

On behalf of the high intensity laser community, the ICUIL Board members would like to express our gratitude to Tsuneyuki for his accomplishments as ICUIL Treasurer and his collegial support for nearly a decade. Tsuneyuki supported four successful biennial conferences, including the most recent conference in Montebello, Canada which set a record for the largest number of attendees. His efforts made this a truly productive and memorable conference for all. We wish Tsuneyuki great success in his new role as Chair of Commission 17 within IUPAP as he works to promote the exchange of information among the members of the international scientific community in the general field of Quantum Electronics including the physics of coherent electromagnetic energy generation and transmission, the physics of interaction of coherent electromagnetic radiation with matter, and the application of quantum electronics to technology. He will maintain liaison with other IUPAP commissions and working groups, such as the ICUIL, with a view to collaborating and cooperating in joint endeavors.

Alexander Sergeev – New President of the Russian Academy of Sciences

On September 26, 2017 Academician Professor Alexander Sergeev, Director of the Institute of Applied Physics in Nizhny Novgorod and ICUIL Co-chair was elected as President of the Russian Academy of Sciences.

The ICUIL community cordially congratulates Alexander Sergeev on this outstanding step in his career, and wishes him success on this thorny path. We are sure that the science in Russia and worldwide will greatly benefit from this election.

His vision of the first-priority measures for the further development of the Russian science and the RAS the newly elected President outlined in the pre-program with a focus on 20 most important tasks to be solved. They include among others

- formulation of the scientific and technical doctrine based on the real state of the scientific complex and determining the need for conducting fundamental research on various horizons of the country's development;
- re-integration of the RAS into the national economy of the country through its participation in large high technology projects and programs, including in the framework of the Strategy of Scientific and Technological development of Russia;
- restoration and strengthening of RAS with the leading scientific and technical corporations of the country;
- supporting the activities aimed at strengthening the position of Russian science in the world through the policy of "scientific diplomacy";
- more efficient use of the potential of foreign members of the RAS; and active participation in the international projects.

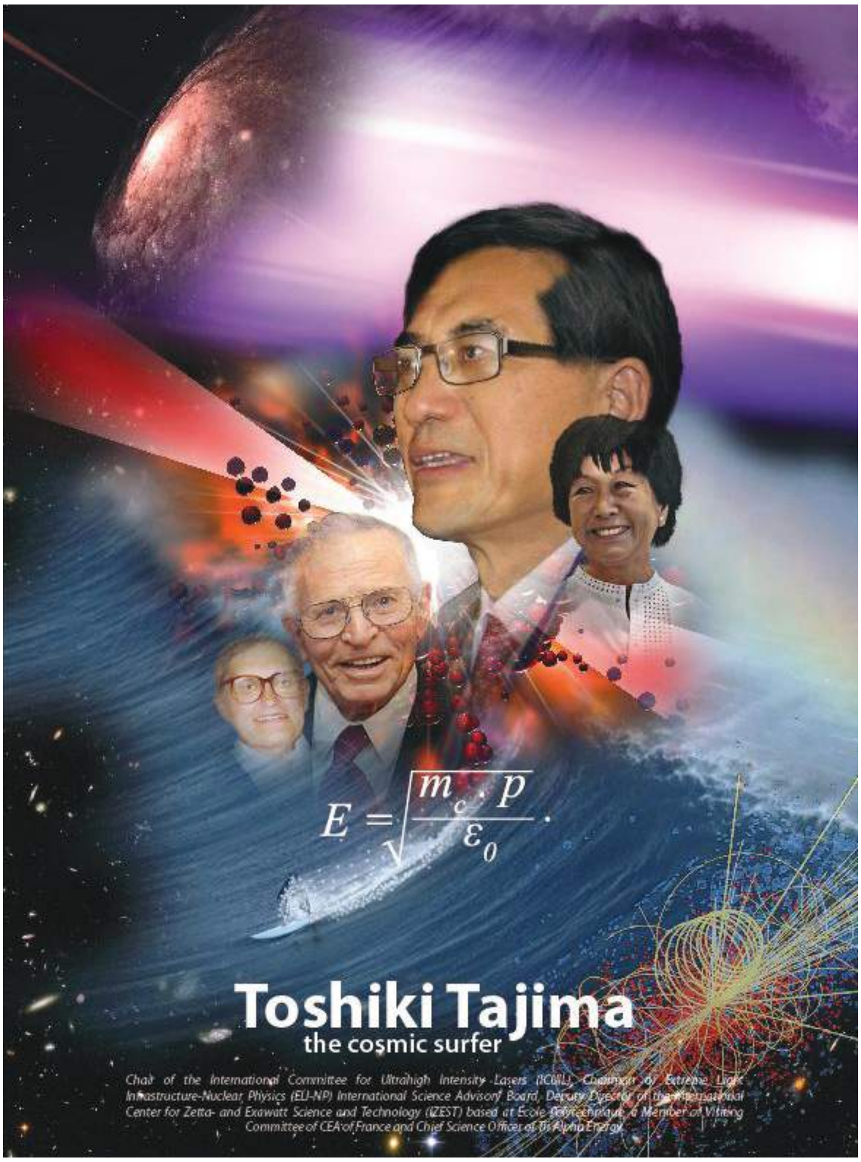
In Honor of Professor Toshiki Tajima – Inventor of Laser Wake Field Acceleration

Gérard Mourou, Professor, EcolePolytechnique Haut Collège
Zhihong Lin, Professor of Physics and Astronomy , University of California, Irvine
Dr. Michl Binderbauer, TAE Vice President, Chief Technology Officer

January 25th-26th, 2018 the Laser High Field community celebrated the 70th birthday of one of its founders, mentor and inventor, Professor Toshiki Tajima at the University of California, Irvine (UCI). This renaissance man with boundless imagination has been the driving force in building connections among the domains of ultrafast optics, plasma physics, nuclear physics and astrophysics but also nuclear medicine and pharmacology. Toshiki Tajima bridged the atomic and subatomic domains, revolutionized Laser Science and established the foundation of High Field Science and Technology. He is also the co-founder and deputy Director of IZEST*at the Ecolepolytechnique (France).

His most acclaimed contribution has been the invention with John Dawson in 1979 of Laser Wakefield Acceleration (LWA). The same concept extended to electron and proton beams by P. Chen, J. Dawson, R.WW Huff, and T. Katsouleas was demonstrated a few years later at SLAC and CERN.

Toshi Tajima's socio-economic impact has been towering involving more than 100 laboratories, 2000 researchers. Toshi Tajima was particularly active in the creation of large scale facilities in Japan Kansai with KEPSI, the Extreme Light Infrastructure ELI-NP in Romania, Czech Republic, ELI-Beam Lines and Hungary, ELI-ALPS. This activity represents >$3B investment.



Among the most prestigious awards he received the 2015 Fermi Prize, 2013 Einstein Professorship of CAS, the Blaise Pascal Chair by the Ile-de-France and the Nishina Memorial Prize from Japan. He was elected to the Russian Academy of Sciences in 2016. Today, using Toshiki Tajima scientific legacy the entire high field domain carries the hope to revolutionize high-energy physics beyond today's existing frontiers.

A cluster of more than 100 distinguished scientists and personalities from around the world including Barry Barish, 2017 Nobel prize, Robert Hunter, former Reagan's Energy Director, Jacques Biot, Président of the Ecolepolytechnique (France), Thierry Massard representative of the French DOE, attended the event at UCI. It was a distinguished honor to hear Barry Barish giving his 2017 Nobel Prize lecture on the detection of Gravitational Waves and his applications. Alongside, an impressive roster of more than 30 distinguished scientists, former Toshiki colleagues or students described their interaction with the honoree at the International Zeptosecond Exawatt Science and Technology Center.

Dense Relativistic Nanowire Array Plasmas for Micro-Scale Fusion

Alexander Pukhov[1], Alden Curtis[2], Chase Calvi[3], James Tinsley[4], Reed Hollinger[2], Vural Kaymak[1], Shoujun Wang[2], Alex Rockwood[3], Yong Wang[2], Vyacheslav N. Shlyaptsev[2], and Jorge J. Rocca[2,3]

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[2] *Electrical and Computer Engineering Department, Colorado State University, Fort Collins, CO 80523, USA*
[3] *Physics Department, Colorado State University, Fort Collins, CO 80523, USA*
[4] *National Security Technologies, Las Vegas, NV 89030, USA*

Laser-driven nuclear fusion may deliver bright sources of monoenergetic fusion neutrons with a number of applications in neutron imaging and tomography, neutron scattering and diffraction for the study of material structure and dynamics, as well as neutron and neutrino detector development. Nuclear fusion is regularly created in spherical plasma compressions driven by multi-kiloJoule pulses from the world's largest lasers. The recent experiments at the National Ignition Facility used 1.9 MegaJoule laser pulses to produce a record 7.6×10^{15} neutrons (4×10^9 neutrons/Joule) from deuterium-tritium fuel implosions. In addition, D-D fusion neutrons bursts have been produced using energetic sub-ns pulses of a few hundred Joules from chirped pulse amplification lasers, and using petawatt class lasers. However, all these experiments are limited to repetition rates of a few shots per hour or less.

Compact femtosecond lasers also are able to demonstrate fusion reactions. The targets used include deuterated bulks or thin films, cryogenic D_2, and deuterated clusters. Specifically, the irradiation of deuterated clusters formed in gas jets with low energy femtosecond laser pulses allows for efficient volumetric heating of plasmas with an average ion density of about 1×10^{19} cm^{-3} in which cluster explosions accelerate ions to multi-keV average energy. Neutron generation efficiencies of ~ 1×10^5 fusion neutrons per Joule were obtained in the form of short sub-ns bursts, a value similar to those obtained with multi-kiloJoule laser. The ultrafast irradiation of ordered nanowire arrays share with nanoclusters the advantage of efficient volumetric heating, but have the additional advantage of creating media with several orders of magnitude higher average plasma density.

Recently, it has been shown that irradiation of aligned arrays of metallic nanowires with femtosecond laser pulses of relativistic intensity can volumetrically heat dense plasmas to multi-keV temperatures [Purvis et al., Nat. Photonics **7**, 796–800 (2013)], reaching pressures only achieved in the laboratory in spherical compression with the world largest lasers [Bargsten et al., Science Advances **3**, e1601558 (2017)]. Arrays of aligned high aspect ratio nanowires have vacant spaces surrounding the wires that allow for the deep penetration of ultrafast optical laser energy into near solid density material, where light is trapped and practically totally absorbed. Using aligned nanostructures of deuterated polyethylene (CD_2) and ultra-high contrast pulses of relativistic intensities from a compact laser, accelerates ions up to MeV energies in near-solid density media. This opens a new path to efficiently drive fusion reactions with Joule-level lasers [Curtis et al., Nature Communications **9**, 1077 (2018)].

The experiment has been done at Colorado State University. Deuterated nanowire array targets [Fig. 1a] either 200 nm or 400 nm in diameter and ~5 µm in length were irradiated with ultra-high contrast frequency-doubled, λ = 400 nm, Ti:Sa laser. The laser pulses of up to 1.64 J had 60 fs FWHM duration. The average density of the arrays corresponded to 16 and 19 percent solid density, respectively.

When the laser penetrates the nanowire target, electrons are ripped off the nanowire surface by the large laser field and are accelerated to high energy in the voids. These energetic electrons interact with the nanowires rapidly heating the material to extreme temperatures, causing the nanowires to explode [Fig. 1b,d]. Ions are

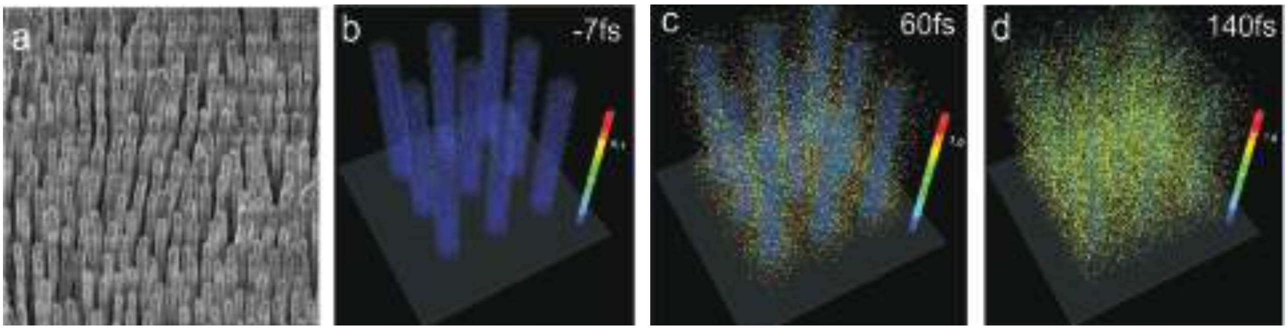

Fig. 1. (a). Scanning electron microscope image of an array of 200 nm diameter CD_2 nanowires. (b-d) 3-D PIC simulation of the evolution of the energy distribution of deuterons in an array of 400 nm diameter CD_2 nanowires irradiated at an intensity of 8×10^{19} W/cm^{-2} by an ultra-high contrast λ = 400 nm laser pulses of 60 fs FWHM duration. The laser pulses penetrate deep into the array where they rapidly heat the nanowires to extreme temperatures, causing the nanowires to explode [Fig. 1c,d]. Deuterons are rapidly accelerated into the voids up to MeV energies, producing D-D fusion reactions and characteristic 2.45 MeV neutrons. Times are measured with respect to the peak of the laser pulse. The average density of the nanowire array corresponds to 16% solid density.

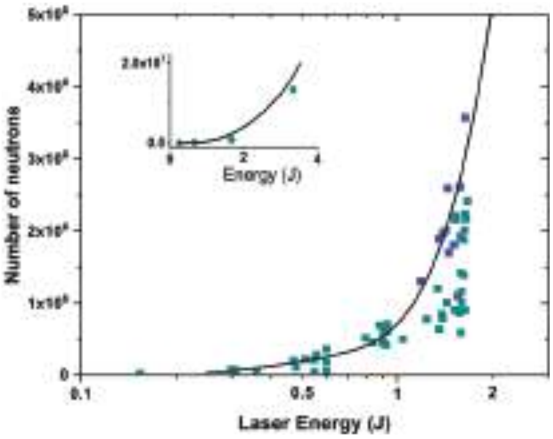

Fig. 2. Neutron yield as a function of laser pulse energy on target. The circles are shots corresponding to a target with 200 nm diameter wires. All the other shots (squares) are for targets consisting of 400 nm diameter wire arrays. The line shows the simulated energy dependence of the neutron yield calculated using deuteron energy distributions computed by the PIC model and nuclear kinetics. The inset extends the simulation to 3.5 J, where the green circles are computed values of the neutron yield. In the simulation the laser spot diameter was an adjustable parameter assumed to be 5 µm.

first rapidly accelerated across the nanowires, and the voids are filled with plasma, creating a continuous critical electron density layer that forbids further coupling of laser energy into the material [Fig. 1d]. The gaps between 400 nm diameter wires in an array with an average density corresponding to 15 percent solid density close in <100 fs. After homogenization of the material, the plasma as a whole begins to expand in the normal direction towards the laser pulse with a characteristic time scale $\tau_s \sim 1.5$ ps, but also towards the substrate, where the energetic deuterons moving into the target cause additional fusion reactions.

The maximum number of neutrons per shot was measured to be 3.6×10^6, corresponding to 2.2×10^6 neutrons/Joule, the largest fusion neutron yield obtained to date for Joule-level laser pulse energies. Furthermore, the number of neutrons was measured to increase superlinearly with laser pulse energy (Fig. 2). The rapid increase is in good agreement with the simulations we conducted using the deuteron ion energy distributions resulting from the PIC simulations and nuclear kinetics. As the laser pulse energy is further increased beyond the values explored here, the optimum D-D neutron production might require a tradeoff between a further increase in the intensity and an increase in the irradiated volume. The higher intensities are also expected to generate a directed flux of high energy deuterons that could be made to impinge in low Z convertors to drive "pitcher-catcher" neutron sources that have been demonstrated to create a large number of high energy neutrons. Finally, the simulations also show that the laser pulse drives a large forward electron current in the area around the wires. At higher irradiation intensities (e.g., 5×10^{21} W/cm^{-2}) this forward current is computed to induce return current densities of tens of Mega-amperes per µm^2 through the nanowires [Kaymak et al., PRL 117, 035004 (2016)]. The resulting strong quasi-static self-generated azimuthal magnetic field will pinch the deuterated nanowires into hot plasmas with a peak electron density exceeding 1000 times the critical density.

Acknowledgements: The work was supported by the Air Force Office of Scientific Research under award number FA9560-14-10232 and FA9550-17-1-0278, and by Mission Support and Test Services, LLC. We acknowledge the contributions of Zhenlin Su and Jose Moreno and Conrad Buss.

Detection of Radiation Reaction in Laser-electron Collisions

Mattias Marklund and Tom Blackburn
Department of Physics, Chalmers University of Technology, Sweden

June 28, 2018

The first successful detection of radiation reaction in laser-electron collisions not only broke the world record for photon energies from Compton scattering, but also hints at what to expect in the quantum regime. These experiments pave the way for forthcoming experiments in the QED-dominated regime of laser-matter interactions, raising the prospect of producing dense pair plasmas using lasers and probing extreme astrophysical environments in the laboratory.

Successfully describing and measuring radiation reaction, the momentum kick a charge experiences when emitting an energetic photon, is a long-standing issue in physics. The development of a classical theory has engaged such illustrious physicists as Abraham, Lorentz, Dirac, Landau and Lifshitz [1]. Part of the difficulty in realising experimental measurements of radiation reaction is that it only becomes significant for ultrarelativistic particles in strong electromagnetic fields. Now, with the prospect of focusing multipetawatt lasers to intensities in excess of 10^{23} Wcm^{-2}, there has been an increasing interest in reaching a regime in which radiation reaction is not only important, but dominant. In these interactions quantum effects will manifest themselves as corrections to radiation emission and as processes without classical analogues such as nonlinear pair creation [2]. This raises the possibility of creating plasma-based sources of dense electron-positron pairs and energetic γ rays, as well as studying extreme astrophysical environments in the laboratory, at high-intensity laser facilities including the Laboratoire pour l'Utilisation des Lasers Intenses (LULI) in France, the Centre for Relativistic Laser Science (CoReLS) in South Korea, the pillars of the Extreme Light Infrastructure (ELI)

Fig. 1. An electron (blue) oscillates under the action of strong laser fields (green/purple), emitting energetic bursts of γ rays (yellow). The recoil of this emission causes the electron to slow down.

in Europe, the Shanghai Superintense Laser Facility (SULF) in China, and the Exawatt Centre for Extreme Light Studies (XCELS) in Russia.

There are two parameters that control the interaction physics in strong fields: a_0 and χ. a_0 is the classical (relativistic) nonlinearity parameter, which compares the energy gain of an electron over a single laser wavelength to its rest mass; χ is the quantum nonlinearity parameter, which compares the electric/magnetic field in the rest frame of the electron to the Sauter-Schwinger field of quantum electrodynamics (QED). This critical field does work equal to the electron mass over a Compton wavelength, and marks the onset of nonperturbative quantum effects. χ controls the magnitude of the energy losses, as the radiated energy (per unit energy E, per laser cycle τ_L) is $(\tau_L /E)(dE/dt) \simeq 3\alpha a_0\chi$. It is also the ratio of the typical energy of the emitted photon to that of the electron: when $\chi \sim 1$, the emission must be treated quantum-mechanically. Reaching a regime when the total radiative loss is of order 10% in a 10-cycle laser pulse requires $a_0\chi > 0.5$. As $\chi \simeq 0.1(a_0/20)(\gamma/1000)$, this is readily achievable with existing high-intensity lasers, where the largest $a_0 \sim 20$, in collisions with wakefield-accelerated electron beams, which now reach GeV energies [7].

This 'all-optical' configuration is already used as a source of high-energy γ rays [8, 9]. However, the energy loss of the electron beam because of radiation emission has only recently been confirmed in an experiment using the Gemini laser at the Central Laser Facility (Rutherford Appleton Laboratory, UK). The collaboration, lead by scientists from Imperial College London, used one arm of the Gemini laser to accelerate electrons in a gas jet to several hundred MeV and focussed the other to high-intensity, as shown in Fig. 2. Despite fluctuations in the energy spectrum of the electron beam and the pointing of two beams, the high repetition rate of the laser system allowed the scientists to gather several shots where the beams collided successfully.

This was determined by measuring the γ ray yield from shot to shot in a scintillator stack, and looking for shots where the signal was significantly above background. Senior author of the study Dr. Stuart Mangles, said: "The real result then came when we compared this detection with the energy in the electron beam after the collision. We found that these successful collisions had a lower than expected electron energy, which is clear evidence of radiation reaction." Further analysis of the scintillator data allowed the 'critical energy' ε_{crit} of the γ rays to be reconstructed: this quantity is close to the median energy of the spectrum, i.e. 50% of the photons have an energy $\varepsilon > \varepsilon_{crit}$, and it also controls the shape of the spectrum through $dN/d\varepsilon \propto \varepsilon^{-2/3} \exp(-\varepsilon/\varepsilon_{crit})$. When these results were compared to the energy of the electrons, which was determined by a shift in the energy spectrum, it was found that the lower the electron energy, the harder the photon spectrum (see Fig. 3). This too is evidence of radiation reaction; in its absence, the correlation would be reversed. The critical energies, which were in excess of 30 MeV, mean that the experiment produced the highest-energy photons yet obtained in an all-optical Compton configuration.

Simulations of the collision confirmed that the critical energies and electron energy loss were consistent with theoretical expectations of radiation reaction. The critical energies predicted in the absence of radiation reaction (the green region in Fig. 3) were not consistent with the measured electron energies. However, the limited number of shots, together with experimental uncertainties, meant that the experiment could not distinguish between different models of radiation reaction at high significance. The models compared were a fully classical model based on Landau and Lifshitz (orange) and a stochastic QED model of radiation reaction (blue). An important difference between these two is that in classical electromagnetism there is no upper bound on the frequency of radiation that can be emitted. This causes the total energy loss to be overestimated, as well as the number of photons with energy comparable to that of the electron. This explains why the classical model predicts a higher critical energy than the quan-

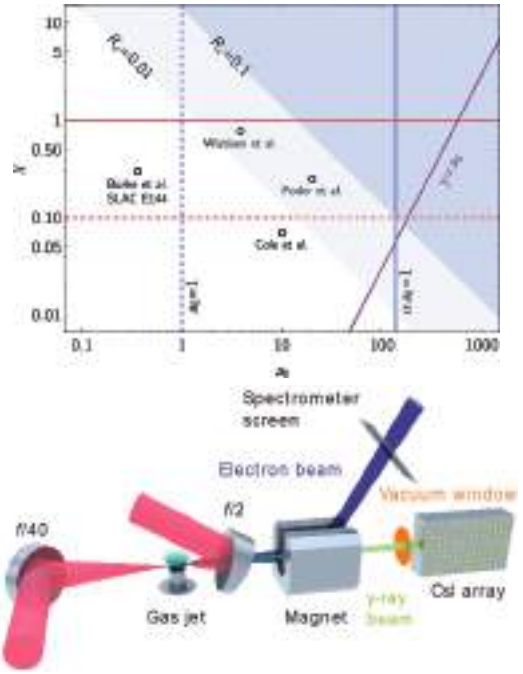

Fig. 2. Experimental progress towards radiation reaction and the quantum regime, from SLAC experiment E144 [3, 4], to the latest studies using the Gemini laser at the Central Laser Facility in the UK [5, 6]. To the left, the phase space shows how the current experimental efforts line up in terms of parameter values, and that there are large unexplored regions that will be reachable using next generation systems. To the right we see the all-optical setup for the experiment reported by Cole et al. [5]

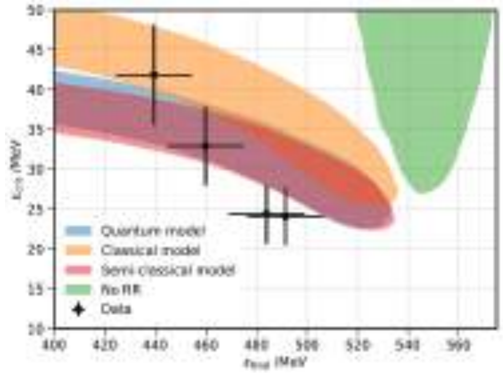

Fig. 3. The key experimental result: the lower the final energy of the electron beam ε_{final}, the harder the γ ray spectrum. This is parametrized by the 'critical energy' ε_{crit}, which controls the shape of the spectrum $dN/d\varepsilon \propto \varepsilon^{-2/3} \exp(-\varepsilon/\varepsilon_{crit})$. The sign of this correlation indicates that radiation reaction has occurred in the collision; in its absence the gradient would be reversed. The coloured regions give the theoretical expectation at 1σ for different models of radiation reaction. [Adapted from Cole et al. [5]]

tum model does. A 'modified classical' model is obtained by reducing the radiated power by a factor $g(\chi)$ that accounts for quantum corrections to the spectrum. While this does not include stochastic effects, these are expected to become significant only at larger χ. For the parameters reported by Cole et al, there is no significant difference between the predictions of the stochastic and the modified classical models of radiation reaction (compare the red and blue regions in Fig. 3).

That radiation reaction did indeed occur in the laser-electron collision was the conclusion of another experiment on the Gemini laser led by scientists from Queen's University Belfast. The setup differed in that a gas cell, rather than a gas jet, was used, thereby producing electron beams at higher energies. Like Cole et al, this team used the total γ ray signal to isolate successful collisions, while the data analysis was based on comparing the detailed shape of the electron energy spectrum between shots with and without the colliding laser. By comparing the spectra to simulation predictions, the team found that their results were better explained by the 'modified classical' model of radiation reaction than by either the classical or stochastic model.

These results leave high-field physics in an interesting place. While both experiments produced clear evidence of radiation reaction, there remain open questions that will be resolved only by further study. Indeed, the collaboration led by Imperial College will be returning to the Gemini laser later in 2018, armed with the lessons of the first experimental run. The aim is to obtain hundreds of collisions with improved stability and higher electron energy. It is hoped that these new data will shed light on the exact nature of radiation reaction, improving our understanding about the fundamental interaction of charged particles with strong electromagnetic fields. The results so far represent a vital first step towards this goal.

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Experimental evidence for short-pulse laser heating of solid-density target to high bulk temperatures

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Institute of Applied Physics of the Russian Academy of Sciences

The investigation of the Warm dense matter (WDM) is one of the hottest topics in modern physics. The matter here is characterized by a density close to or above that of a solid, and by a temperature >1 eV. This regime is challenging because Coulomb interactions, atomic physics, and electron degeneracy must be considered together. Meanwhile, WDM is ubiquitous throughout the Universe. And it is of high relevance for the ignition of inertially confined fusion fuel.

To investigate WDM, samples need to be prepared at homogeneous temperatures and densities, i.e. in gradient-free conditions. The short-pulse lasers allow heating solids over ultrafast time scales but are limited to extremely thin (nm-scale) foils. Ultrafast particles generated by the same lasers permit heating thicker (μm-scale) samples; however, an ultrahigh temporal contrast for the laser pulse is needed to maintain gradient-free conditions.

Recent experiments performed in Nizhny Novgorod, Russia at the Institute of Applied Physics RAS with the PEARL laser facility showed that almost isochoric heating to high temperatures (300 eV) of μm-thick solid-density foil can be achieved in a compact and efficient manner.

PEARL is an Optical Parametric Chirped Pulse Amplification (OPCPA) laser system. With this technology no signal is triggered before the pump pulse arrival.

Hence, the prepulse duration is limited to the duration of the pump. Although no contrast enhancement technique such as plasma mirrors or cross wave polarization (XPW) has been utilized in the setup, the temporal contrast in intensity, and in the nanosecond range, after compression was measured to be $1/(2\times10^8)$.

The pulse was focused on an Aluminum (Al) foil. The on-target laser energy reached 8 J in a 60 fs pulse. The wavefront correction system enabled reaching a focal spot of 2.9 μm radius with resulting intensity of $\sim2.5\times10^{20}$ W/cm^2.

A high-resolution X-ray spectrometer was installed to observe the radiation from the front surface of the target. Its crystal was aligned to operate in the photon energy range of 1.47–1.74 keV. The spectrum shown in Figure 1 exhibits Ly_α (1727 eV) and He_α (1598 eV) lines together with their satellites. There is also a recombination continuum that is reflected by the third order of the spectrometer crystal. The continuum is consistent with the emitted plasma temperatures of ~300 eV. There are also spectral components that attributed to the emission of KK and KL hollow atoms. To generate the X-rays required to produce the hollow atoms, the fast electrons need to be longitudinally refluxed multiple times. For this reflux to take place the density gradients at the surfaces need then to be sharp.

This is consistent with the density profile obtained from the hydrodynamic simulation. It shows that although there is a substantial underdense preplasma, most of the target persists to have solid-density and the density gradient at the front surface is small and sharp.

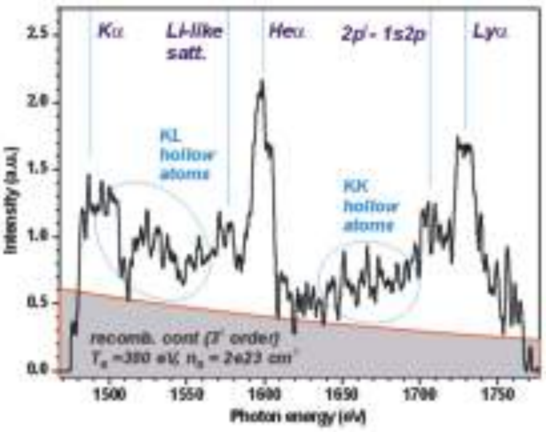

Fig. 1. X-ray spectrum measured by means of the spectrometer from the front surface of an Al target and accumulated in four shots

Modeling of the X-ray spectra gives a measurement of the temperature of the target bulk. The fitting of the continuum and the ratio between the Heα and Lyα lines intensities, corresponds to the emission of an Al plasma at $\sim2\times10^{23}$ cm^{-3} density and 280–320 eV electron temperature.

In summary, by using a high-power, high-contrast femtosecond laser system, a highly efficient coupling of laser radiation to the surface of a solid has been achieved, resulting in heating of the target of μm thickness to a temperature of 300 eV, preserving a small density gradient at the front surface. Such effective energy deposition is owed to the intrinsic high contrast of the laser which results from the OPCPA technology it is based on.

Germany Invests 30 M€ in to Demonstrate User-oriented Laser-driven Particle Facilities

Dr. Thomas Kühl
GSI Helmholtzzentrum, Professor, HI Jena and Mainz University

Laser-driven particle acceleration has been studied in the laboratory for the past twenty years. Electrons with an energy in excess of 4 GeV and protons nearing the 100 MeV mark have been demonstrated using the state of the art ultra-high intensity (UHI) lasers at various laboratories worldwide. The versatility of UHI lasers is such that this performance can be obtained in many places for a moderate investment, such that many recommend going from the laboratory experiment to the demonstration of user-oriented laser-driven particle facilities.

The Helmholtz Association in Germany has decided to support this move and is investing 30 M€ in the ATHENA project that will establish two laser-driven particle facilities in Germany, one at the Deutsche Elektron-Synchrotron (DESY) in Hamburg and the second at the Helmholtz center Dresden Rossendorf for ions. The Helmholtz center for heavy ion research (GSI) in Darmstadt is part of this effort and focuses on the coupling of laser-accelerated light ions into standard accelerator components.

With ATHENA, the test stand at GSI will be equipped with the necessary hardware to study the reliability of such sources for applications that use the sub-nanosecond duration and high particle numbers of the laser-generated ion pulses. This could be used for instance in time-resolved studies of fast processes on the nanosecond scale as well as showing that such a laser-based source is capable of being coupled to GSI's accelerator. In addition to experimental demonstrations, a large effort of ATHENA will be to push the development of effective high-average-power high-energy lasers, one of the current bottlenecks in laser-driven particle acceleration.

The Exawatt Center for Extreme Light Studies (XCELS) Strengthens Cooperation with European Partners

Catalin Miron, Laboratoire Interactions, Dynamiques et Lasers,
LIDYL, CEA, CNRS, Université Paris-Saclay, France

Successfully ending on August 31st, 2018, CREMLIN was a Coordination and Support Action (CIA) supported by the Horizon 2020 framework programme of the European Union (EU) for 36 months, intending to foster cooperation in the research infrastructures' sector between the European Union and the Russian Federation. The project, funded by the EU with a budget of 1.7 MEUR, had a particular focus on the six Russian magascience projects, and was gathering 19 Beneficiaries, among which 6 Russian organizations where the megascience projects are hosted or planned and 13 European research infrastructures and organizations. The coordinator of the project was DeutschesElektronen-Synchrotron (DESY). More information about the project can be found at https://www.cremlin.eu.

The six Russian megascience projects

In 2011, based on a highly selective process, the government of the Russian Federation identified 6 national projects of very large research infrastructures, generically called the "megascience" projects, which were proposed to international cooperation.

- Scientific and Research Reactor Complex **PIK** at NRC "Kurchatov Institute" B.P. Konstantinov PNPI, Gatchina
- Nuclotron-based Ion Collider Facility **NICA** at Joint Institute for Nuclear Research, Dubna
- Fourth Generation Special-purpose Synchrotron Radiation Source **SSRS-4** at NRC "Kurchatov Institute", Moscow
- Exawatt Center for Extreme Light Studies **XCELS** at Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod
- Super Charm-Tau Factory **STC** at Budker Institute of Nuclear Physics, Novosibirsk
- **IGNITOR** Fusion Project at NRC "Kurchatov Institute", Moscow

One of the work packages of CREMLIN, WP6, was dedicated to the collaboration with the Exawatt Center for Extreme Light Studies (XCELS), hosted by the Institute of Applied Physics of the Russian Academy of Sciences in Nizhny Novgorod. The other partners of this work package were the Extreme Light Infrastructure Delivery Consortium (ELI-DC AISBL), and the French Atomic Energy Commission (CEA), represented by the Lasers, Interactions and Dynamics Laboratory (LIDYL).

The working group had several objectives, among which: i) identify and map the research interests and needs of EU and Russian partners for scientific cooperation in the framework of the XCELS project; ii) develop proposals for measures and action plans to foster joint research projects towards the implementation of the project; iii) jointly develop and refine concepts for international standards for access, user policy, and governance of future large laser facilities, to only cite a few.

In the framework of CREMLIN, several high-level workshops and round tables have been organized in both Russian Federation and European Union (Germany, France and Romania) to address the scientific case and the technological challenges of the XCELS project, well beyond the current state of the art. In addition to the scientific and technological aspects, CREMLIN also explored organizational aspects of XCELS as a research infrastructure, namely in terms of internationalization, governance, users' access etc. The possible contributions of the European industry, namely from the lasers, optics and photonics sector, to the implementation of the XCELS project have been also explored in a dedicated workshop gathering industry representatives and promoters of XCELS.

The working group has concluded the work by a series of recommendations, in view of supporting the implementation and creating best conditions for a possible future integration of XCELS in the European fabric of research infrastructures. The cooperation with key European leaders in the laser science and technology sector, on the one hand, and with well-established European research infrastructures with proven expertise in delivering user access, on the other hand, was identified as being essential to the success of the design, implementation and future operation of XCELS. For the further elaboration of a technical design for XCELS, carrying out joint EU-Russian research and development efforts in high-field physics was also pointed out to be of special relevance. The production of a 2-channel demonstrator for XCELS may be an interesting step to further undertake. The importance of the cooperation with existing European networks, like for instance Laserlab Europe, and with the Extreme Light Infrastructure (ELI) was also highlighted. Finally, the establishment of a business plan for XCELS was identified as a crucial step towards the achievement of a sustainable funding of the future infrastructure.

While project timeline extends over the period 2019-2025, satisfied by the success of CREMLIN, the partners would like to further extend their collaboration, possibly by taking part into a future call for applications for Research and Innovation Actions (RIA), which is currently under preparation by the European Commission.

International Zeptosecond Exawatt Science and Technology Scientific and Socio-Economic Outlook
IZEST Fall Meeting, November 2017, INP Orsay

Extreme light is one of the most exciting domains in the laser field today. It relies on the generation of ultra-high peak power obtained by delivering the energy over a short time. Today, laser peak power exceeds typically the PW or thousand times the world grid power. The ability to produce and focus this gargantuan power over a size 10 times smaller than a hair offers unfathomable possibilities in science, technology, medicine and is a harbinger to a floodgate of socio-economic applications.

France is a well-established academic and industrial leader in lasers. Under the initiative of the Ecole Polytechnique, we proposed 10 years ago to the EU and Ile de France the construction of a Pan-European Infrastructure capable to generate the highest peak power ever produced and explore laser mater interaction at the highest possible intensities with the aim to carry out fundamental research and promote new societal applications. The infrastructure research within the framework of the 10 PW project named Apollon is currently performed on the plateau of Palaiseau.

While the LULI has the responsibility of implementing Apollon, IZEST was created in 2011 to be the prospective branch with the aim to look beyond the horizon set by ELI in terms of peak power and average power. IZEST is also looking at novel applications in science and engineering.

During the conference we described the most avant-garde laser concepts under development to segue from the petawatt to the exawatt, giving access to extremely short time structures down to the attosecond-zeptosecond regime. Pulses will be so short that the highest peak power in the x-ray regime could be reached with a modest amount of energy in the joule level yielding intensities in the Schwinger regime enough to materialize light.

The intensity of the X-ray pulse could generate gargantuan accelerating gradients in solids enough to accelerate electrons over a centimetre to the TeV level or relativistic protons widening the range of applications in subatomic physics, cosmology, vacuum physics and the like.

IZEST is always seeking new applications for the lasers they develop. For example, a few years ago, we proposed as new laser (ICAN) XCAN that could deorbit millions of small debris circling around the globe. The first test could be on the Space Station.

The infrastructures are now halfway through completion. As the initiator of both projects, ELI and Apollon, the EcolePolytechnique has carried out a study to gauge the socio academic impact of these world-class projects at all levels, regional, national and international. The conclusion of this report made at the meeting was one of the conference highlights.

Nuclear Photonics 2018

The 2nd international conference devoted to the pursuit of photon-based nuclear science and applications, Nuclear Photonics 2018, took place in Brasov, Romania from June 24th to 29th, 2018. (http://nuclearphotonics2018.eli-np.ro)

The rapidly evolving field of nuclear photonics has been enabled by the development of ultra-bright, quasi-mono-energetic gamma-ray sources based on laser-Compton scattering and by the worldwide development of $B-scale user facilities housing ultrahigh intensity lasers capable of producing field strengths of relevance to nuclear interactions. With an approximately 50% increase in attendance relative to the inaugural 2016 meeting held in Monterey, California, Nuclear Photonics 2018 clearly demonstrated a strong and growing community interest.

The nuclear-related topics discussed in Brasov embraced fundamental nuclear science and spectroscopy, nuclear medicine including radiography and radiotherapy, industrial non-destructive material imaging and evaluation, isotope-specific nuclear materials detection and management, photo-fission and materials transmutation, photon-enabled pulsed neutron generation and science, photon-enabled pulsed positron generation and science, photon-based hadron beams and applications, nuclear astrophysics and cosmology, and gamma-ray science above the giant dipole resonance.

The meeting's 200 attendees from 20 countries included experts in gamma-ray source development, ultrahigh intensity laser development, nuclear physics and nuclear-related applications. The five day conference comprised 4 tutorials, 1 keynote, 25 invited talks, 48 contributed talks and 75 posters. Representatives from the Romanian government and the US ambassador participated in the welcoming ceremony. During the course of the week, the participants from Darmstadt, Germany also announced that a major new initiative on nuclear photonics in Germany had been funded.

Prior to the start of the 2018 conference, the attendees were invited to tour the Extreme Light Infrastructure – Nuclear Physics facility in Magurele, Romania. At ELI-NP, they visited the high intensity laser, gamma beam, target fabrication and detector assembly laboratories as well as various gamma-beam and high intensity laser experimental halls. Commissioning of two 10 PW beam lines of ELI-NP was underway and by the time of the visit the laser system had produced uncompressed, amplified, chirped pulses consistent with the eventual production of 3 PW peak power pulses. Further amplification and commissioning of this system will continue into 2019.

At the conclusion of the Brasov conference it was announced that Nuclear Photonics 2020 will be held in Japan and will be hosted by the nuclear science and laser science groups of the University of Osaka.

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IUPAP Working Group 9 : Report to the C&CC Meeting October 2018

The Annual Meeting of IUPAP WG.9 was held at the Academia delle Scienze, Bologna, Italy, September 7 – 8, 2018.

Discussion about the present membership of IUPAP WG.9 :

Concerns were expressed about the participation in IUPAP WG.9 by the representatives of India and China. The current member of IUPAP WG.9 from India is the director of the Inter-University Accelerator Centre (IUAC) in New-Delhi but due to Indian Government regulations the travel funds to attend the meetings of IUPAP WG.9 are lacking. The current invitation to be the member of IUPAP WG.9 from China is the director of the Institute of Modern Physics of the Chinese Academy of Sciences in Lanzhou. A solution to this membership from China is pending. A recommendation was made to contact CERN management to have a nuclear physics representative from the CERN programs with ALICE, ISOLDE, and alike to join IUPAP WG.9.

Updating IUPAP Report 41 : Research Facilities in Nuclear Physics

As of January 2018 the descriptions of the various nuclear physics facilities with an identifiable users group have been updated. Following the Nuclear Science Symposium (NSS) held at the RIKEN Tokyo Office, August 30 – 31, 2017, the seven succinct summaries of the various presentations made have also been published in arXiv:1805.10504[nucl-ex]. The updated IUPAP Report 41 can be found at: www.triumf.info/hosted/iupap/icnp/index.html . For future nuclear science symposia more extensive summaries of the state of nuclear science and required research developments and facilities may be published as a stand-alone report provided funding can be obtained or a journal can be found to publish the contents at no page charge.

The Neutrino Panel :

The panel is currently being formed in consultations with the IUPAP Working Groups WG.1 (ICFA), WG.9, and WG.10, and the IUPAP Commissions C4, C11, C12. Heidi Schellman, Chair of IUPAP C11, is in charge of forming the panel and the formulation of its terms of reference.

POPA Report – Neutrons for the Nation :

The APS Panel on Public Affairs (POPA) commissioned a workshop in April 2017 to examine the scientific needs for neutrons currently produced by civilian research reactors and identify the obstacles and challenges to meeting those needs without the use of highly enriched uranium (HEU). The final report from the POPA study includes the state of neutron facilities worldwide in this context. A lengthy discussion followed.

Nuclear Science Symposia :

Upon the request of Timothy J. Hallman, Associate Director for Nuclear Science in the US Department of Energy to hold the IUPAP Nuclear Science Symposia at intervals of two years a NSS was held at SURA Headquarters in Washington, DC, June 4 – 5, 2015. It was followed by the NSS at the RIKEN Tokyo Office, August 30 – 31, 2017. Consequently the next NSS should take place in 2019. The International Nuclear Physics Conference (INPC2019) is scheduled in Glasgow, UK, July 28 – August 2, 2019 and also the IUPAP C12 meeting at INPC2019 in connection with awarding the three IUPAP Young Scientist Prizes in Nuclear Physics. Previous NSS were held at TRIUMF in 2009 and at Laboratori Nazionali di Frascati in 2012. Usually the Annual General Meeting (AGM) of IUPAP WG.9 follows the AGM of IUPAP C12. For various reasons including logistics the NSS should not take place at INPC2019. Active participation in the NSS is required from Funding Agency/Government Representatives and need to be consulted in organizing the NSS. The date and venue of the next IUPAP NSS are under consideration.

An ad-hoc group of IUPAP WG.9 members has been charged with developing a statement to strengthen the free and open access statement of IUPAP as it concerns nuclear physics facilities.

Nuclear Science at the Deep Underground Science Facilities :

The search for neutrino-less double beta-decay, the search for dark matter particles interactions, neutrino oscillations and CP violation, are involving various aspects of nuclear physics/nuclear science and belong within the perspective of IUPAP WG.9. There exists today a large number of such facilities. IUPAP WG.9 has a member representing these facilities.

Long Range Planning for Nuclear Science :

Long Range Planning Reports were presented by the Chair of ANPhA (Asia-Pacific), the Chair of NSAC (USA), the Chair of NuPECC (European Union). In addition there were presentations about the Five Year Planning Exercise by TRIUMF, about the Nuclear Science in Latin-America, and on the I'Themba Laboratories and SAIF in Zuid-Afrika. All these are being posted at the above website.

Willem T.H. van Oers

Secretary of IUPAP WG.9

TRIUMF, October 15, 2018

Gravitational Wave International Committee (WG.11) report to IUPAP

8 October 2018

prepared by David Shoemaker [*MIT*, Executive Secretary],
Stan Whitcomb [*Caltech,* co-Secretary], and Sheila Rowan, [*U. of Glasgow,* Chair]

The Gravitational Wave International Committee (GWIC) was formed in 1997 to facilitate international collaboration and cooperation in the construction, operation and use of the major gravitational wave detection facilities world-wide. From 1999 until 2011, GWIC was recognized as a subpanel of PaNAGIC (IUPAP WG.4). In 2011, GWIC was accepted by IUPAP as a separate Working Group (WG.11).

GWIC meets annually adjacent to an appropriate conference. In July 2018, GWIC met in Chicago Illinois, in conjunction with the 12th LISA Symposium. Other recent meetings have been held in Pasadena (2017), New York City (2016), Gwangju (2015), Banff (2014), Warsaw (2013), Rome (2012), Cardiff (2011), and Hannover (2010). Other business during the year is conducted via email or other electronic communication. The next meeting is scheduled for July 2019, in conjunction with the 13th Amaldi/GR meeting in Barcelona.

GWIC maintains a website at https://gwic.ligo.org/ which contains an up-to-date listing of members, its by-laws, announcements of its activities, and links to other items of interest to the gravitational wave community.

GWIC Membership

The membership of GWIC represents all of the world's active gravitational wave projects, as well as other relevant communities, covering gravitational wave frequencies from nanohertz to kilohertz. Each project has either one or two members on GWIC depending on size. GWIC also includes representatives from ISGRG (IUPAP AC2), International Astronomical Union (IAU) Commission on Gravitational Wave Astrophysics, and from the astrophysics/theoretical relativity community, to help facilitate communication with those bodies. One current member of GWIC in (Sheila Rowan) was also a member of ApPIC (WG.10), ensuring close communications.

The GWIC Chair is elected by its membership at its annual meeting in odd years. At our 2017 meeting, GWIC chose Sheila Rowan (Glasgow) once again as its Chair, serving until 2019; a new chair will be selected at that time. This year David Shoemaker (MIT) serves as the Executive Secretary.

Each member project in GWIC determines its representatives on GWIC. No changes have been made since the last Report to IUPAP; the membership is given at the end of this report.

GWIC Activities in August 2018-August 2018

GWIC convenes the biennial Edoardo Amaldi Conference on Gravitational Waves, sponsored by IUPAP as a "class B" Conference. The Amaldi meeting is considered by many in the gravitational wave community to be their most important international gathering. The members of GWIC serve as the Scientific Organizing Committee for the Amaldi meetings. Planning for the 2019 Amaldi meeting has continued; it will be held with the ISGRG-sponsored International Conference on General Relativity in Valencia.

GWIC's activities in this last half-year have continued to be focused on third-generation ground-based observatories ('3G'), via a subcommittee formed in late 2016. The charge for this subcommittee is to engage the community broadly to help formulate the best possible science case and to lay out the best path toward a robust international project. This committee has created subcommittees in several crucial areas: The Science Case, Governance, R&D, and Coordination.

The Science Case subcommittee has formed an informal consortium of some 200 scientists interested in exploring and documenting the science that can be done uniquely with 3G detectors and in conjunction with electromagnetic observations. They held a very successful meeting of this group in October 2018. Material is now being integrated into a final report, and priorities were determined in a very productive interactive meeting.

The Governance subcommittee has explored existing models for large instruments and observatories in a range of fields of science, and looked at the suitability and difficulties of these models for a globally-unified network of 3G observatories. The 'ab initio' discussions of governance are being melded with the present state of the Einstein Telescope and Cosmic Explorer 3G projects. The R&D coordination subcommittee has organized sessions at R&D meetings in the field, and found leaders to gather the status and plans in various domains. The Coordination Subcommittee has been in touch with and made presentations to funding agencies and roadmapping organizations in both Europe and the US.

The objective is to prepare materials which will inform funding agencies and panels considering the future of the gravitational-wave field and more generally astrophysics and astronomy, and to help the community envision, evaluate, and plan for its future. Specifically, the European ESFRI Roadmap and the US Astrophysics Decadal Survey will be informed by appropriate submissions and white papers, which will be derived from the GWIC 3G Subcommittee report.

GWIC is also working on an update to its Roadmap for the field, as informed by the 3G studies described above. It is planned to bring this to the public awareness through an initial article in a Nature journal, and followed by a more complete in-depth Roadmap to be published by GWIC.

Membership of GWIC (as of October 2018)

Chair: Sheila Rowan, University of Glasgow, (GWIC, 2009–, Chair 2015–)

Einstein Telescope|: Michele Punturo, INFN-Perugia, 2009–

European Pulsar Timing Array (EPTA): Michael Kramer, Max-Planck-Institut für Radioastronomie and Jodrell Bank Centre for Astrophysics (University of Manchester), 2009–

GEO 600: Karsten Danzmann, Albert-Einstein-Institut fur Gravitationsphysik and University of Hannover, 1997–; Sheila Rowan, University of Glasgow, 2009–

IndIGO: Bala Iyer, International Centre for Theoretical Sciences (ICTS) of the Tata Institute of Fundamental Research (TIFR), 2011–; Somak Raychaudhury, Inter-University Centre for Astronomy and Astrophysics, 2017–

KAGRA: Yoshio Saito, KEK, 2013–; Takaaki Kajita, Institute for Cosmic Ray Research, University of Tokyo, 2011–

LIGO: Dave Reitze, California Institute of Technology and University of Florida, 2007–; David Shoemaker, Massachusetts Institute of Technology, 2017–

LISA Community: Kelly Holly-Bockelmann, Vanderbilt University, 2018–; Bernard Schutz, Albert-Einstein-Institut für Gravitationsphysik, 2001–; Ira Thorpe, Goddard Space Flight Center, 2016–; Stefano Vitale, University of Trento, 2001–

NANOGrav: Maura McLaughlin, West Virginia University, 2016–

OzGrav: PPTA: Matthew Bailes, Swinburne University, 2017–; Audioband: David McClelland, Australian National University, 2000–

Virgo: Jo van den Brand, Dutch National Institute for Subatomic Physics (Nikhef) and VU University in Amsterdam, 2017–: Fulvio Ricci, University of Rome, "La Sapienza", 2014–

Theory Community: Luis Lehner, Perimeter Institute, 2018–

IUPAP Affiliate Commission AC2 (International Commission on General Relativity and Gravitation): Beverly Berger, 2013–

IAU Commission D1 Representative: Marica Branchesi, Gran Sasso Science Institute, 2017–

Executive Secretary: David Shoemaker, Massachusetts Institute of Technology, 2016–

Activities of the Working Group on the Newtonian Constant of Gravitation

September 2017 – October 2018

Stephan Schlamminger – WG chair

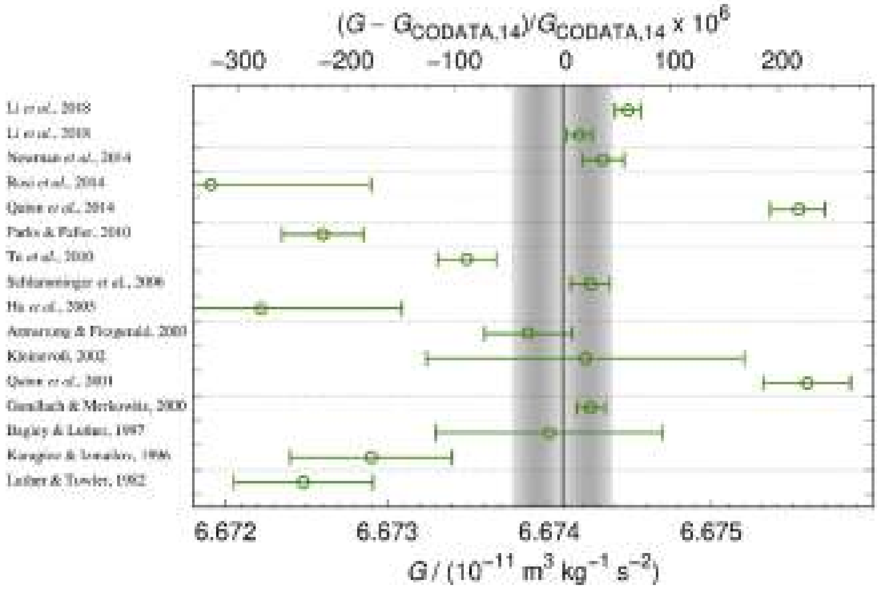
Stephan.schlamminger@nist.gov

Introduction

The working group on the Newtonian Constant of Gravitation was created at the 28th General Assembly of IUPAP in November 2014. The purpose of the working group is to coordinate experimental efforts to measure the Newtonian constant of gravitation, G. This fundamental constant of nature describes the strength of gravity, the weakest of the four known fundamental interactions. The first laboratory measurement of the gravitational constant was carried out by Henry Cavendish at the end of the 18th century. In modern times, more than a dozen measurements have been described in the literature in the last 30 years. However, the agreement between the results is poor. The best results report relative standard uncertainties of about 20 parts in a million, but the relative difference between the largest and smallest value exceeds 500 parts per million. Clearly, something is amiss. One task of the working group is to understand this problem.

Status

In 2018 two new G results were published with record-setting uncertainties. Previously the experiment with the smallest uncertainty, measured at the University of Washington, had a relative uncertainty of 13.6 x 10^{-6}. Two new results were published by researchers from the Huazhong University of Science and Technology, Wuhan, China. To both results, relative uncertainties of 11.6 x 10^{-6} were assigned. The new situation of the G data is as follows:



The new data are close to the average put forward by the committee on data for science and technology (CODATA). However, the data set has not become much more consistent. The χ^2 marginally increase, and the numbers of degrees of freedom increase from 13 to 15. Overall the likelihood for the data to be consistent is minimal.

Activities

The activities of the working group in the reporting period can be sorted in two broad categories: Support of experimental work and outreach.

Support of Experimental Work

The working group encourages reproducing existing experiments. Two experiments are currently repeated at locations different than where the experiments were conducted initially. One experiment that is presently repeated is given by the data point labeled Quinn et al., 2014 in the above figure. The other experiment is the one marked Faller & Parks, 2010. Both experiments are repeated at the National Institute of Standards and Technology.

The Quinn experiment is already taking data, and it is possible that a conclusion can be reached by December 31st, 2018. The last day of 2018 is the deadline put forward by CODATA for data to be considered for the new least squares adjustment of the available data to produce a new recommended value for G.

The Faller experiment has been set up at NIST, and preliminary measurements have been performed. Data taking will begin in earnest in 2019.

The working group encourages the gravity group at HUST to look at the difference between their new values and the numbers reported in 2005 (Hu et al. 2005) and 2010 (Tu et al. 2010).

Communication and Outreach

The chair of the working group has written a News and Views article for Nature, where the two new G values were published. Two members of the working group have written a review article in the Review of Scientific Instruments. Another review article is in preparation.

The working group is thinking about compiling a review of different numerical and analytical methods for mass integration. A necessary part of every G experiment.

Future work

The working group is planning a face to face meeting at the joint meeting of General Relativity (GR22) and Amaldi (13) in Valencia from July 7th to July 12th. The GR conferences are organized by the International Society of General Relativity, an affiliated commission of IUPAP. A session on recent measurements of the gravitational constant is in planning.

Working Group WG-15 – Soft Matter Physics
Report to the IUPAP Council & Commission Chairs meeting
October 2018

Mandate of the proposed IUPAP Working Group on Soft Matter

1. To organize/assist in organization of the International Soft Matter Conference every 3 years in each geographic region (Europe, America, and Asia/Australia).
2. To coordinate soft-matter-related regional, national & local conferences, meetings & workshops
3. To coordinate soft matter education, such as summer schools and short courses and help organize them if a need appears
4. To promote soft matter research through information exchange, publicity, prizes, publications, etc.
5. To strengthen the connections between academic and industrial soft matter research and development through outreach events, short courses, etc.

Progress since last report submitted May 2018:

The WG15 had a teleconference June 26th, 2018 to review submissions for the International Soft Matter Conference (ISMC)

Presentations were given by the following teams:

India: Guruswamy Kumaraswamy and Apratim Chatterji

Japan: Ryoichi Yamamoto

US: Niels Holten-Andersen

Questions were asked of all three groups, and WG15 members were asked to submit their ranking of proposed sites (1st, 2nd, 3rd) by June 30th. In addition, WG15 members were asked to suggest areas for 3-4 subject sub-committees of the program committee; suggest what professional societies and industrial labs to contact; send links to sample web sites to use as models for ours.

The US proposal from MIT was approved by the IUPAP Working Group 15 for year 2020 to be the site of the International Soft Matter Conference (ISMC) in America with Osaka, Japan approved for ISMC 2021.

Michael Rubinstein traveled to Boston to work directly with the MIT organizing team August 16-19th, 2018.

During the meeting with local organizing committee (faculty from several MIT departments) Michael Rubinstein discussed essential steps in organizing a successful conference:

a. reserving rooms for plenary & parallel sessions, posters, lunches, etc. as soon as the dates for the conference are fixed
b. arranging for equipment for lectures and poster sessions
c. dorm rooms reservations - as many as possible at MIT, but also at other local universities (BU, etc...)
d. negotiation of lower rates and reservation of hotel rooms after the dates of the conference are fixed (this could be done through MIT Conference Services Office)

e. establish industrial contacts - for conference support and participation in the conference (both equipment exhibits and posters; potential industrial speakers need to be coordinated with program committee).
f. proposals to NSF (there are several divisions related to soft matter), NIH, DOE, ... to partially support the conference
g. contact MIT departments for partial support
h. fundraising at other local universities (Harvard, Brandeis, BU, BC, Northeastern, ...)
i. organizing banquet - preferentially at a nice location off campus (e.g. Isabella Steward Garden Museum, Harvard Annenberg Hall, of similar) arranging for transportation
j. organizing a short course before the conference in consultation with the program committee
k. potentially job/career fair for both academic and industrial track in soft matter, publication fair with editors
l. organizing excursions, tours for accompanying people, childcare options, ...
m. designing and building a website for the meeting, designing a logo for the meeting (in consultation with the program committee)
n. running registration, budget accounting
o. advertising the meeting (who controls distribution lists)
p. fun social/scientific events - design (soft robotics) competition, Soft Olympiad from regional teams, cooking, cosmetics, public events

The WG15 -Americas had a teleconference in September 19th, 2018 in which planning for the 2020 conference was discussed.

1. Potential program committee members (11 members)

~ 5 members from the American sub-unit of WG-15

1 representative from ISMC 2021 (Asia – Hajime Tanaka to nominate)

1 representative from ISMC 2019 (Europe –Gerhard Gompper to nominate)

1 representative from local organizing committee (MIT)

1 representative from the Council of Soft-Matter-Related **Professional Organizations** APS (GSOFT, DBIO, DPOLY, GSNP, DFD, …), ACS (Colloidal, POLY, PMSE, …), MRS, AIChE, Rheology, …

1 representative the Advisory Board Council of **Regional** Soft Matter Organizations

1 representative from the Advisory Board **Industrial** Council

1 representative from the Advisory Board Council of **American Countries** (Mexico, Brazil, Canada, …)

2. Potential advisory board members

a. Potential advisory board members suggested were: Council of Soft-Matter-Related **Professional Organizations** (Biophysical, MRS, AIChE, Rheology, Adhesion, APS, ACS, …); Representatives from IUPAP Commissions C3 (statistical physics), C6 (biological physics), C10 (structure & dynamics of condensed matter), C20 (computational physics); Representatives from IUPAC Divisions (Physical & Biophysical, Polymer)
b. Council of US **Regional** Soft Matter Organizations. Geographic representatives from regional soft matter organizations (New England Complex Fluids, New York, Mid-Atlantic, Virginia, Triangle, Atlanta, Chicago, California, …)

c. **Industrial** Council (Dow, Exxon, Cabot, L'Oreal, DuPont, BASF, Unilever, P&G, Mitsubishi Chemical, Merk, JSOL/J-OCTA, Toray, AGC, Hosokawa Micron, …)
d. Council of **American Countries** (Mexico, Brazil, Canada, …)

3. Conference speaker logistics
Need to carefully select topics/speakers for ~24 sessions and ~8 plenary talks. Solicit ideas from the advisory board. Program committee selects and assembles the optimal subset of sessions/plenary talks in consultation with a local committee to fit the program schedule.

4. Proposed Job description of the program committee
Designing the structure and topics of the sessions and selecting speakers.

5. Proposed job description of the advisory committee

a. Developing ideas/proposals with topics for scientific sessions and suggesting them (along with names of potential speakers) to the program committee
b. Developing ideas for other events at the conference - roundtable discussions, forums on future directions of soft matter including life and AI, funding, international and cross-country collaborations
c. To solicit and discuss proposals of future American ISMC 2023. It would be great to announce the next meeting at the ISMC 2020.
d. Council of US regional soft matter organizations to discuss coordination and exchange between regional meeting as well as developing proposals for the ISMC2023.
e. Industrial council to design a possible roundtable on basic research for industry: what will in the future replace Bell, Exxon, ... labs of the past?
f. Should we contact editors of the relevant journals asking them for suggestions of topics, inviting them to the conference and, possibly, organizing an event related to publishing (besides poster prizes)?