



# Newsletter

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## Message from the President



One of the major activities of IUPAP is the sponsorship and endorsement of conferences. This was important in the early days of IUPAP and it is even more important now. As we say on our website “Historically IUPAP came into existence charged with enhancing physics through the organization and sponsorship of the most appropriate conferences, and ensuring that all physicists had free access to the meetings. These goals basically remain today.”

We have just concluded our second meeting of the Council and Commission Chairs for 2015. A significant amount of our effort was devoted to our conferences, especially deciding which conferences to support in 2016, and what level of support could be provided for them, and also reviewing reports from our 2015 Conferences. The list of those conferences we are supporting in 2016 appears in this newsletter, and Council resolved to spend 44% of our expected 2016 income on their support.

Our review of the 2015 conferences concentrated on the level of participation by women in the conferences and was led by Vice President Alinka Lépine-Szilý, our Gender Champion. We learned that from 2014 to 2015 the fraction of women who were plenary and invited speakers had not improved significantly. On average 17% of conference participants were women, but only 13% of the invited speakers were women. IUPAP is conscious that the increasing number of women physicists needs to be better reflected in an increased fraction of women invited speakers and I strongly urge all involved, particularly host organisations, local organising committees and international program and advisory committees to work hard to make sure that we hear better reports from Alinka in future years.

Other topics which occupied us at our meeting included reviewing the work of our 18 Physics Commissions, 4 Affiliated Commissions, and 8 Working Groups. IUPAP covers a very wide sweep of physics and of policy related to physics. We approved a new Working Group, WG13: the Working Group on Newton’s Constant G, and are working on setting up two new working groups, on Accelerator Science, and of Soft Matter. It is possible that one or both of these new working groups will lead us to do something we haven’t done for 20 years — create a new commission.

It was suggested at our 2014 General Assembly that we should also link to more organisations which have related interests. Our subcommittee reported on this in some detail, but saw it as just one link in communicating better with physicists and societies of physicists world wide. This newsletter is one of the ways in which we do this, and I will be grateful if our readers can write and tell us what we should be including in it to tell you more about IUPAP and about physics world wide.

A very effective form of communication is person to person. We appointed many Associate Members of Commissions, and Inter Union representatives to facilitate our interactions between commissions and with related international unions and other similar bodies.

The Council and Commission Chairs heard of our plans to exploit the fact that our office is in Singapore to recruit new members from the south east Asian region.

If you are interested in more details about the meeting of the Council and Commission Chairs the minutes are available at <http://iupap.org/about-us/executive-council/executive-council-minutes/>

One of the great joys of being the IUPAP President is reading the reports from our conferences. These reports include a brief summary of new and interesting results presented at the conference. Reading them reinforces for me the wide variety of sub-disciplines that are a part of physics, and the exciting progress that is being made in all of them. Versions of this part of the conference reports, edited to just one or two new results, are reproduced in this newsletter so that you can also appreciate the range of advances in science being communicated in our conferences. More details are available from the conference website.

I thank you for your efforts to do and promote physics in 2015 and I wish you every success in 2016.

**Bruce McKellar**

## Message from the Secretary General



As Secretary General of IUPAP, I had a very fruitful discussion with Professor Paul Hardaker (Chief Executive, Institute of Physics) on 22 October 2015 in London.

The purpose of the discussion is to look into future collaboration especially with regards to IUPAP Women in Physics and high school physics.

We are trying our best to attract new members from Asean countries as well as other parts of Asia. We are setting up a strategic plan. I believe China will increase their share of votes.

The IUPAP accounts are in good shape and we look forward to an exciting 2016.

**Kok Khoo Phua**

## 100 Years of General Relativity

**Gary Horowitz, President** (AC2: International Society on General Relativity and Gravitation)

This year marks the centennial of Einstein's discovery of general relativity. After ten years of effort, culminating in a final month of intense activity, Einstein presented the final form of his theory to the Prussian academy on November 25, 1915. It not only contained a new theory of gravity, but it fundamentally changed our understanding of space and time. Einstein proposed that gravity is not a force acting in space as Newton had envisioned, but rather a manifestation of the curvature of space (and time) itself. This radical new view was confirmed by the observation of the bending of starlight as it passed by the sun during an eclipse in 1919.

The general relativity community joined IUPAP in 1957 with the formation of Affiliated Commission 2: The International Commission on General Relativity and Gravitation. This was an auspicious time. After the initial excitement of the bending of light died down, interest in general relativity waned. For the next 40 years, most of the effects of general relativity were believed to be too small to detect in the lab, and to have negligible effects for observational astrophysics. However starting in the late 1950's, interest in general relativity revived. It was facilitated by the Conference on the Role of Gravitation in Physics held at the University of North Carolina, Chapel Hill, in 1957 under the partial sponsorship of IUPAP, and grew rapidly after the discovery of quasars and pulsars in the 1960's. In 1971, AC2 officially became the International Society on General Relativity and Gravitation.

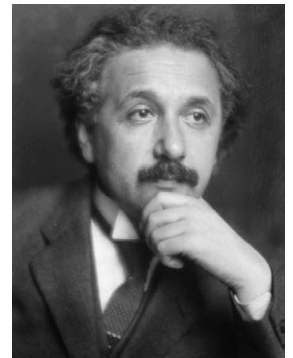
Since the formation of Affiliated Commission 2, our understanding of general relativity and its predictions has deepened enormously. This is a result of three main developments: (1) finding and studying a handful of exact solutions to the field equations of general relativity, (2) proving powerful theorems about general properties of large classes of solutions, and (3) developing the ability to numerically evolve generic initial conditions.

Experimental tests of general relativity have also improved dramatically during this time. Several predictions have now been confirmed with an accuracy of better than a hundredth of a percent. This includes the fact that time runs slower in a gravitational field. This surprising effect has not only been confirmed, but has practical applications as well. The Global Positioning System (GPS) that is widely used around the world would not work if relativistic effects were not taken into account.

General relativity has now matured from a novel physical theory to a working tool of many astrophysicists. The discovery that light is bent by massive objects has led to gravitational lensing, allowing astronomers to see very distant objects and map out the dark matter in the universe. As another application, many energetic sources are now modeled using black holes, one of the most exotic predictions of Einstein's theory.

To celebrate the centennial, many conferences were held around the world. A list can be found on our website: [isgrg.org](http://isgrg.org). In addition, we commissioned a book *General Relativity and Gravitation: A Centennial Perspective*, edited by Ashtekar, Berger, Isenberg, and MacCallum. This book contains reviews by leading experts that summarize our current understanding of the theory, and was published by Cambridge University Press.

Many new discoveries await us in the second century of general relativity. In the next few years we are likely to see direct detection of gravitational waves for the first time. These are ripples in space and time produced by the motion of massive, compact objects. Gravitational waves consistent with general relativity have been seen indirectly by their effect on the orbital period of binary neutron stars. (In fact, this observation received the 1993 Nobel Prize in physics.) The latest generation of gravitational wave detectors are now operating and should have the sensitivity to detect these waves directly. This will open up a new window on the universe. Another major advance will be the direct imaging of a black hole. This is within reach with the new Event Horizon Telescope. On a more theoretical side, attempts to combine general relativity with quantum theory have made great progress over the past 30 years, but we still do not have a complete theory of quantum gravity. In particular, applying quantum mechanics to black holes raises fundamental puzzles that still need to be resolved. The second century of general relativity promises to be as exciting as the first.



*Albert Einstein developed the theories of special and general relativity. Picture from 1921.*

## EINN celebrates 20 years

The conference on “Electromagnetic Interactions with Nucleons and Nuclei (EINN)” has been organized on Santorini and Milos Islands in Greece every other year since 1995. In 2011 its location was successfully moved to Paphos, Cyprus. The conference series covers experimental and theoretical topics in the areas of nuclear and hadronic physics. It also serves as a forum for contacts and discussions of current and future developments in the field. The conference has unofficially been a counterpart of the US Gordon conference on photonuclear physics and held in alternate years with traditionally a strong US participation. No proceedings are produced, in the tradition of Gordon and Euroconferences, in order to encourage the frank exchange of even tentative information.

The 11<sup>th</sup> EINN conference took place in Paphos, Cyprus 1-7 Nov. 2015 and attracted about 100 participants from 19 countries in Europe, North America and Asia. This year marked 20 years of successful organization of the conference series and a celebration took place organized by the first chair Dr. K. de Jager.

Since 2011, the conference program has dedicated sessions for postdoctoral fellows and advanced graduate students, who receive financial support. In 2013, an extra day was added before the conference with pedagogical lectures to facilitate the understanding by younger physicists of the more technical talks during the conference. This year the conference added a two day pre-conference event on *Frontiers and Careers in Photonuclear Physics – skill development and talks for students*, which was very-well received by the students. As customary, two topical

parallel workshops were organized, one on *Spectroscopy* and one on *the Spin structure of nucleons and nuclei*, which this year included selected talks from the abstracts submitted as well as invited talks. More than 40 students and postdoctoral fellows participated in the conference by receiving partial support. A highlight of the conference was the evening plenary poster session, which drew a large attendance with lively discussions. The authors of the three best posters were selected by secret vote of all attendees. The winners, who are young researchers from the Cyprus Institute, MIT and Mainz University, were awarded the Feynman Lecture Series and commemorative gifts, and presented a talk on the subject of their posters at the plenary section of the conference.

The conference covered a wide range of theoretical and experimental developments in hadron physics including, dipole moments of neutral and charged particles, the proton radius puzzle, new experimental facilities, dark matter searches, nuclear astrophysics, lattice QCD, spectroscopy, spin structure of nucleons, precision electroweak physics and new physics searches. With the study of QCD being a major focus of present activities and future plans in physics research worldwide, the EINN conference will continue to provide an important international forum, particularly for young physicists, for the foreseeable future.

More details for EINN 2015 visit:

<http://www.cyprusconferences.org/einn2015/>

For a historical overview visit:

<http://www.einnconference.org>

## IUPAP Laser Physics and Photonics Young Scientist Prizes 2015

The IUPAP Commission on Laser Physics and Photonics runs its Young Scientist Prizes every two years, awarding two prizes in each round. These are the very highest level of achievements in fundamental and applied research. The 2015 prizes attracted nominations from Australia, Austria, Belgium, Canada, Chile, New Zealand, Spain, United Kingdom and the USA.

The 2015 IUPAP Young Scientist Prize in Laser Physics and Photonics (Applied Aspects) has been won by Dr Mark Thompson, Centre for Quantum Photonics, University of Bristol, United Kingdom. Dr Mark Thompson is awarded the prize “for his contributions to the new and emerging field of quantum photonics, and particularly for his pioneering work in integrated quantum photonic circuits.” He did his Master of Physics at the University of Sheffield, United Kingdom, finishing in 2000. He completed his PhD in 2007 at the University of Cambridge, UK, in the Department of Electrical Engineering. Subsequently he has held postdoctoral fellow positions at the University of Cambridge, University of Bristol, UK; and Toshiba, Japan. He was appointed as a lecturer in the School of Physics, University of Bristol, UK, in 2010 and is now a Reader in Quantum Photonics and Director of the Quantum Engineering Centre for Doctoral Training.

The 2015 IUPAP Young Scientist Prize in Laser Physics and Photonics (Fundamental Aspects) was won by Dr Robert Fickler, Institute for Quantum Optics and Quantum Information, University of Vienna, Austria. Dr Fickler moved very recently to a postdoctoral fellowship in the Centre for Quantum Photonics, University of Ottawa, Canada. Robert Fickler is awarded “for his groundbreaking contributions to the entanglement of complex structures of photons, which have opened up new avenues for quantum communication”. He completed his Bachelor and Masters degrees (in Physics) at the University of Ulm, Germany, finishing in 2009. He completed his PhD in 2014 at the University of Vienna in the Institute for Quantum Optics and Quantum Information. His thesis, entitled “*Entanglement of Complex Structures of Photons*”, received a Doc.Award. Until recently he has been working as a postdoctoral fellow, continuing in the group of Professor Anton Zeilinger in Vienna.

## Interview with Dr Mark Thompson\*



*Dr Mark Thompson being awarded his IUPAP Young Scientist Prize, C17—Laser Physics and Photonics, Applied Aspects at CLEO—Europe/EQEC on 24th June 2015. Also pictured, Professor Luc Berge, Chair of the Quantum Electronics and Optics Division of the European Physical Society and Professor Deb Kane, Chair of IUPAP Commission 17.*

**DEB:** Welcome Mark! I'm really pleased to be able to chat to you today about your winning of the IUPAP Laser Physics and Photonics Young Scientist's Prize for applied aspects for 2015. Congratulations!

**MARK:** Thank you very much.

**DEB:** And thank you very much for agreeing to answer the questions that we've got for you this afternoon. The citation for your prize says "for his contributions to the new and emerging field of quantum photonics, and particularly for his pioneering work in integrated quantum photonic circuits". Firstly, can you please tell us what the award-winning research is, for someone with a physics degree?

**MARK:** My research is about harnessing the quantum mechanical properties of light, and particularly to process, encode and transmit information. That really opens up the doors to a whole new range of different, and potentially ground breaking technologies in areas such as ultra-secure communication and new types of computation; for instance, complex quantum simulations and quantum chemistry calculations, or in machine learning. Controlling the quantum properties of photons is not a particularly simple matter. You have to be able to generate single photons, manipulate single photons and detect single photons. However, research into this has been going on since the early 1970s, when people first demonstrated that you could take single photons and put them in superpositions of being in many different places, or you could entangle single photons and control and manipulate the quantum mechanical properties of these photons. So that's well understood, but what we're doing now, and particularly what my research is focusing on, is developing more usable and practical technologies where we're taking the ideas and concepts from quantum physics, and using state of the art photonic engineering approaches and techniques to create what

we call quantum microchip circuits. We're using the same sort of manufacture processes that would be used to fabricate a microprocessor in your computer, except we're using them to create quantum circuits where we can guide and manipulate single photons on the chip. That's allowing us to create new applications in quantum communications, and is enabling us to scale-up this technology so that ultimately, in the future, we may be able to make systems large enough to perform quantum computing calculations.

**DEB:** Best of luck with all of those challenges.

**MARK:** Thank you.

**DEB:** If I could ask you a follow up question. If you could translate that for somebody who was a bit earlier in their physics education, what would you say?

**MARK:** Oh, right, that's always a tricky question. In a sense, it's creating new technologies for information processing and communications, but instead of using, say for instance in conventional computing, electrons to do the computing, we're now using photons, single particles of light, to do the computing. By using single photons we can get access to a part of physics, known as quantum physics, that current computing machines don't use, and that gives us new ways of processing information and potentially incredibly powerful ways to perform computations that are completely beyond the capabilities of our current information processing machines.

**DEB:** Thank you. Do you have a feel for where your work fits into physics overall?

**MARK:** Right. It's grounded in quantum mechanics, which is one of the foundational theories of modern physics, and in a sense we're exploiting those ideas and concepts from quantum mechanics. So, I really see it as, potentially, a tool with which physics can explore an understanding in greater depth of the world as we know it. So we're creating machines that harness entanglement, super-position and quantum states on a larger and larger scale. And so this will allow us to probe our understanding of quantum physics in an ever deeper and more meaningful way. It will also allow us to create machines that can perform computations far superior to the sorts of computations that we can do now. The particular areas where this will become significant is, for instance, when you want to fully simulate real physical systems and real quantum systems. We will be able to use these technologies as a tool to ask questions about like...well, where does high T super-conductivity arise from, how do we get to room temperature super-conductivity, can we perform advanced quantum simulations on molecular dynamics? To give you an example of the advantage that a quantum computing device can give you; if, for instance, you want to perform a simulation of an electron system, and say you've got 300 electrons in that system; this might be for instance a simulation of a super-conducting material. The size, or the amount of memory that you would need for your computer to fully simulate 300 electrons is greater than the number of atoms in the universe; so it's completely beyond what you can do with a conventional computer. However, a quantum computer could perform that sort of calculation with, of order, 300 qubits. So that gives you an idea of the potential power that a quantum computer could have. We would be able to use that machine as a tool to probe various aspects of physics that we would never be able to do otherwise.



**DEB:** Thank you. You've won the IUPAP YSP prize for applied aspects. Can you tell us about the applied nature of your research?

**MARK:** I guess the applied nature of my research is really about making things. I really enjoy making devices, and laboratory-based work. And so, the applied aspects of my work are really about using state-of-the-art photonic engineering approaches and principles, and bringing that technology to bear onto the area of quantum optics and quantum photonics. So, I work a lot with big semiconductor fabrication foundries; the sort that people like Intel would be using to make microprocessors. We use exactly the same capabilities and facilities to make our quantum photonic chips that are controlling and manipulating single particles of light rather than controlling and manipulating electrons – which is what microprocessors do. My applied aspects are really about developing these new types of quantum circuits. Having them fabricated in commercial fabrication facilities, and then back in the laboratories in Bristol where we do all the testing and characterisation, exploring how they work, and developing all of the capabilities that you would need on a single microchip to scale up this technology.

**DEB:** Can you tell the listeners a little bit about how you got to be doing what you do now. What was your journey in physics?

**MARK:** Well, I've always been interested in light, ever since a very early age; light and radio waves; I used to build my own radio-transmitters when I was a kid. I had some interesting moments with some pirate radio stations, but that probably shouldn't be on the record.

*(Laughter)*

**MARK:** But yeah, I've always been interested in light. I did a degree in physics with engineering, and then straight after my degree I went to work in the telecommunications industry, designing and making devices for the world's first silicon-photonics companies. After working on various components for the telecommunications industry, I decided I wanted to go back and do something a bit more physics-based, so I did a PhD at the University of Cambridge working on quantum dot lasers. I had a fantastic time working with this new type of laser, and then towards the end of my time there, I decided I wanted to move into a new area that used both my interest in physics and my interest in engineering. This area of integrated quantum optics was the ideal place, there was a lot of interesting physics, but also some really hard engineering challenges to be overcome to have a significant impact. So that's why I've landed where I have, because I have this balance between physics and engineering. I have a passion for physics and a passion for making things.

**DEB:** I think you've answered my question which was what motivates you to do research at a high level, so we'll carry on.

*(Laughter)*

**DEB:** What are you working on now, and how do you go about deciding what you should work on?

**MARK:** At the moment I'm continuing with the development of the waveguide integrated quantum circuits. Effectively, developing a technology platform that will allow us to propel this technology forward in terms of realising ultimately a quantum computer, and before that realising devices for quantum simulations and quantum communications. What this requires is development all

of the basic components; so just like your classical computer has transistors, capacitors, resistors and ways of manipulating electrons, we need all of those sorts of components within a microchip circuit, but able to control and manipulate photons. We need photon sources, ways of switching and moving these photons around, we need quantum interference, and detection of these single photons. And so what I'm developing is the entire technology platform to get all of these components integrated onto a silicon chip. Then we'll start to scale up, but at the moment we have devices with about 100 components on them. Maybe next year we'll have devices with 1000 components on them, and then in a way we'll just keep scaling that up, while maintaining the quantum coherence of the system.

**DEB:** So that sounds like that's probably going to keep you going for most of your lifetime, so you're not really thinking about what else you need to do.

**MARK:** No, this is definitely a long-term career ambition.

**DEB:** Very good. What does winning the prize at this stage of your career mean for you?

**MARK:** It's really nice to be recognised; that's absolutely true, it's nice to be recognised for the work that you're doing. You get recognition within your own institute and you get recognised by your peers. And so, it helps my career in terms of my own visibility, which is important at this stage of my career.

**DEB:** IUPAP, the International Union for Pure and Applied Physics, what role do you think an overarching union of physics commissions should play for physics in the world?

**MARK:** I think, really, looking at how physics, physicists and the problem-solving abilities of physicists can be used to solve some of the major challenges facing society today, and I think looking at how physicists can be used to solve some of the major problems in climate, in energy, and communications.

**DEB:** Are there any questions I haven't asked you that you would have liked to have been asked? This is your opportunity to tell our listeners something you really want them to know about your work, physics, what matters to you.

**MARK:** Well the question that I most often get asked is "when will we have a quantum computer?" Or "how long would it take to make a quantum computer?" And that's always a really difficult question to answer. But I do generally think that within the next 10 years we'll have large scale computing machines doing advanced simulations of some sort or another. So I think it's actually a lot closer than a lot of people realise.

**DEB:** Thank you very much Mark, and once again, congratulations on your Young Scientist prize from the Laser Physics and Photonics Commission and I wish you success in your future career.

**MARK:** Thank you very much.

*\*This transcript of the recorded interview has had minor editing for readability.*

## Interview with Dr Robert Fickler\*

**DEB:** Thank you Robert! I am joined by Dr. Robert Fickler who has just been awarded the IUPAP Laser Physics and Photonics Young Scientist's prize for 2015 for Fundamental Aspects. The citation for Robert's prize was "for his ground-breaking contributions to the entanglement of complex structures of photons, which have opened up new avenues for quantum communications." Robert, Congratulations! Firstly, can you please explain your award-winning research to someone with a physics degree, where it sits in laser physics and photonics overall, and why it matters at this time.

**ROBERT:** Okay. Thanks, first of all, and yeah the research I did was as you mentioned the entanglement of structures of light. So first of all, it's about entanglement, it's about the foundations of physics and entanglement is one key feature of quantum physics. We took advantage of the spatial structure of light, and we tried to increase its complexity and thereby gain new insights, or testing the limits, even, of quantum physics. So a few examples here are to certain spatial structures of light there's an orbital angular momentum degree, an orbital angular momentum connected, and there in principal it can be arbitrarily large, for a single photon, and even for an entangled photons. And this was one question we asked ourselves; "okay, what is...at least for the moment... the technical limit? How high can we go? And if there is a foundational limit, can we even reach that?" We are, I guess, far away from that if there is one at all, but this was one question. Another one was whether the spatial modes can be used as a laboratory realisation of high-dimensional Hilbert space. So, what does it mean for quantum information? Normally, everything is in qubits, but one could actually think of qutrits, ququarts, so not just 2 level systems but 3, 4 level systems; also infinitely high-dimensional systems. It's known that they have advantages when it comes to certain quantum particles. There, we try to find out how much information we can put in to one photon or in an entanglement. We did some research mainly trying to increase the complexity of either the theoretical state or even just the spatial structure. We tried to find out new properties; if there are new properties; if the theory is always right?, or just to see them actually in the lab we could try and get a better understanding of what was happening. This especially applies to quantum physics and quantum optics; the singular particles of light.

**DEB:** So that's quite a lot of physics. If you were to try to translate that to something that would resonate with someone a bit earlier in their physics education; have a go at doing that translation.

**ROBERT:** So I think I should first explain a little bit about entanglement. So, as I mentioned earlier, it is a key feature of quantum physics. So if you have two systems; two particles for example; at least two particles, they can be entangled. This means that they show strongly correlated features; they have some sort of connection, or it's like they know about each other. It's hard to explain. Correlations are known from classical physics as well, but quantum correlations are even stronger than classical physics can explain. So they can be separated by a big distance and still behave exactly the same; although, we can make sure that we they did not find an agreement before our measurements are done. Why we are interested in this is also a very foundational question as well. Well, with these experiments one can ask questions about how the world is, or how the properties are; if we can actually describe properties to these without measuring them or not; so it's a very philosophical discussion of course. This is what we investigate in the labs, and we try to push the limits.



*Dr Robert Fickler being awarded his IUPAP Young Scientist Prize, C17 – Laser Physics and Photonics, Fundamental Aspects. At CLEO– Europe/ EQEC on 24th June 2015. Also pictured, Professor Luc Berge, Chair of the Quantum Electronics and Optics Division of the European Physical Society and Professor Deb Kane, Chair of IUPAP Commission 17.*

In the everyday world, we don't see these quantum correlations, so we ask ourselves why this is the case. Is it just happening for little systems or can we actually use some of these properties and extend them, or increase them so much, that we should be able to see them in the classical world and then see some correlations there? So this then applies to areas such as macroscopic entanglement and whether this is observable or not.

**DEB:** Well I was going to ask you what's fundamental about your research but I think that you've already answered that question and established that your research is fundamental in nature. So we might just move onto the next questions. May I ask what your physics story is? How did you come to be doing this award-winning research?

**ROBERT:** I guess I was always interested in physics so at one point I started to study physics. I was actually kind of lucky because at the university I was studying at, there was a small philosophy department as well and they promoted it because they wanted to have people study philosophy there as well. Because of this I heard about it and I went to some of the lectures in philosophy, and I became very attracted to philosophy as well. Especially then, because of my physics studies, the interplay between the two; or the overlap between these two fields was very compelling to me. There I found out that quantum physics especially has a big overlap and a big discussion although the theory, or the mathematical framework has been known since the 1930s or so, but the interpretation of this mathematical apparatus that we have is still highly debated. There is still a big discussion going on and this attracted my attention. This is why I went for this area in my PhD with Professor Zeilinger in Vienna, because he is interested as well in the foundational questions, the philosophical questions, and is still doing experiments. I am very interested in the philosophical questions, but I also love to do experiments. So I did a degree in physics, and then one in philosophy. This avenue was then one that was very attractive to me and I followed this, and I was lucky to get an opportunity to work with the renowned Professor Zeilinger in this research. We sometimes do what we call metaphysical experiments, which is kind of a contradictory idea. However, this is what I think is the most interesting idea; at least for me it's one of the most interesting aspects of experimental physics; because it is so closely connected to philosophical questions.

**DEB:** I will follow up on that in that it's obviously quite competitive to become a PhD student in Professor Zeilinger's group. So was it a lucky outcome that a joint philosophy/physics background was advantageous in that regard?

**ROBERT:** I guess it helped. (*Laughter*). But you would also have to ask him about that. Apparently I didn't do that many things wrong because I was able to work there, but I'm not certain if that gave me a distinct advantage.

**DEB:** But it's certainly part of your motivation. So in terms of your motivation for doing what you do, you've given us a good sense of that already, is there anything you would like to add to that in terms of motivation?

**ROBERT:** I guess I think physics, or at least part of it, should not try to only follow avenues to produce new applications or to make existing technologies better; this is obviously very important, but blue sky research is also really important, and it's my field so this is definitely the most interesting thing for me. The other parts of physics research are important as well, but I think it is always nice if one does experiments where they are not directly working on applications. Some people challenge the relevance of foundational research; they believe it does not help society, they are sceptical about providing funding for this kind of research. However, in quantum optics, even though it started as a completely foundational field, one knows already that there's new technologies on the verge of becoming available to the public. And you can show the people of society that there are really useful things coming out of foundational research, even though it usually begins out of pure curiosity.

**DEB:** Research overall is a very small fraction of human activity, but within that we do want to see a very broad range of things explored, because we don't know what we're going to need in 10, 20, 30 years' time.

**ROBERT:** Exactly. I even realised in this conference that when you see how many people have their job because of the laser, even though at the start the laser was a solution with no problem. So, one could almost say it was useless, and yet now look at the significance it has.

**DEB:** Absolutely. So, you've just recently made a move from Vienna to Ottawa in Canada, so my next question which is about what you're working on now and how you go about deciding what you should work on; clearly you've just been putting quite a lot of thought into that step, so give us an insight into how you go about making those decisions.

**ROBERT:** So, I hope that whatever is interesting to me I will be able to follow in the research, without having to make big justifications the research will have applications coming out of it. So I hope I can follow that. Of course with Professor Bob Boyd I can do it as well. To be more precise, I will continue to work on complex structures, and use modern technology which has evolved so much that things are more complex, we'll add more complexity and control the quantum state perfectly. So, we're working on that,. I haven't been involved so far because I've just moved there, but I hope I can work as well on extending similar methods to not just photons but to electrons. Some people have started exploring that already and I think it's highly interesting, because then you have mass particles and charge particles, which adds another complexity to the system. Another motivation for me was the group; the group in Ottawa is very diverse, and since

my background so far is mainly quantum information and foundations. I think because they produce photonic crystals and do some plasmonics, so I can learn a lot there, and maybe even combine some other fields with my knowledge to develop new areas of research that are hopefully interesting and fun physics.

**DEB:** Well I wish you all the best in your new position. So, I'll ask you now: what does the prize mean to you at this stage in your career?

**ROBERT:** Well, first I will say that it's a big honour. Being awarded by such a huge, global organisation such as IUPAP is truly humbling, especially when you consider the long history of IUPAP. As well, I guess it helps you become recognised in your field, in your specific field, and even to a broader audience; the whole optics community, which helps for doing more interesting experiments because you can start collaborations. It also helps with the funding, as you have to get funding, and I hope this will help with that as well.

**DEB:** I hope so too. So regarding IUPAP, the International Union of Pure and Applied Physics, what role do you think an overarching union of physics commissions should play for physics in the world?

**ROBERT:** Well, I like the explanation you gave today, saying that it's kind of like the U.N. of physics. I think this is a nice way of phrasing it; I think it should bring the global community, and physics research in general is very global, together to share ideas, to collaborate, and thereby develop new areas of research that are hopefully interesting and fun physics.

**DEB:** I hope so too. So regarding IUPAP, the International Union of Pure and Applied Physics, what role do you think an overarching union of physics commissions should play for physics in the world?

**ROBERT:** Well, I like the explanation you gave today, saying that it's kind of like the U.N. of physics. I think this is a nice way of phrasing it; I think it should bring the global community, and physics research in general is very global, together to share ideas, to collaborate, and thereby develop new ideas; helping physics in general to tackle new problems develop new ideas; helping physics in general to tackle new problems of physics. I think because of technology, and this huge development in technologies over the last 20 years, I guess physics is developing incredibly; all different fields.

**DEB:** Absolutely. It's been very interesting and enjoyable to learn about insights into your research and why you do it. Thank you very much indeed for giving your time to this interview, and I wish you every success in your future career.

**ROBERT:** Thank you very much.

*\*This transcript of the recorded interview has had minor editing for readability.*

#### **Acknowledgement**

IUPAP gratefully acknowledges the Quantum Electronics and Optics Division of the EPS and the European Physical Society for hosting the IUPAP C17 Young Scientist Prize Awards ceremony at CLEO-Europe/EQEC 2015.



## “Medical Physics Capacity Building in Developing Countries” – IUPAP supports an AC4-Workshop at the World Congress on Medical Physics & Biomedical Engineering in Toronto, June 2015

Fridtjof Nüsslin

According to the WHO-World Cancer Report 2014 cancer is the major global health problem. Cancer cases are expected to increase from currently 15 million to about 24 million annually in 2035. Due to their populations growing and living longer the increasing cancer burden is threatening developing countries more than the industrialized world. More than 60% of the world's cancer cases and about 70% of the world cancer deaths occur in Africa, Asia, and Central and South America. Radiotherapy plays an important role in cancer management, i.e. according to current standards approximately 50% of all cancer patients should receive radiation treatment. Radiotherapy is a most effective modality and simultaneously a relatively cheap one, particularly compared to drugs. A radiotherapy clinic requires access to diagnostic imaging facilities, dedicated computers for treatment optimization and modern treatment units (typically today electron linear accelerators with X-ray and electron beam capability). To operate this equipment properly, an infrastructure with sufficient trained medical, physical and technical staff is essential. However, the disproportionality of cancer incidence hits particularly the developing countries due to lack of resources, both for investing in equipment and staffing. About 85% of the world's population lives in low-medium-income countries, but there are installed only one third of world's radiotherapy units. Even more threatening is the lack of staffing. In particular, medical physics capacity building should be part of all cancer control programmes in developing countries (supporting both - diagnosis and treatment). Therefore, several education and training initiatives have been launched by international, professional and non-governmental organizations to raise the staffing levels in developing countries.

On this background the International Organization for Medical Physics (IOMP) in cooperation with their Regional Organizations initiated various actions aiming to improve the situation for medical physics in the developing countries, specifically to increase the number of qualified clinical medical physicists in the understaffed regions. Partnering with the IAEA and the WHO provides an excellent platform to promote medical physics in the developing countries (specifically education and training) to advice in equipment operation and dosimetry, and to implementation of medical radiation protection standards.

Following a first workshop “Development of Medical Physics in Africa” co-sponsored by the IUPAP-AC4 which was held at the International Conference for Medical Physics 2013 in Brighton/UK, another workshop “Medical Physics Capacity Building in Developing Countries” – again co-sponsored by IOMP and IUPAP-AC4 – took place at the World Congress on Medical Physics & Biomedical Engineering in Toronto in June this year. Thanks to the congress sponsoring program of IUPAP and the travel grant program of the IOMP, among the about 70 attendees many young scientists from developing countries attended these events. The Workshop in Toronto covered presentations from Brazil, Philippines, Bangladesh, Morocco, Uganda, Nigeria and Ghana. It was very encouraging to see that the majority of the presentors were women.

The Workshop Chairs (S.Tabakov, F.Nüsslin) made an introduction, which included review of the progress made after the Brighton meeting. Since resource limitations for advancing medical physics in developing countries are tremendous, P.Smith (UK) addressed the problem of cost-effectiveness of medical physics services. Under the auspices of the IAEA numerous freely available materials have been published. It was recommended these to be used as guidelines when establishing national education & training programs. J.Izewska (IAEA, *Dosimetry and Medical Radiation Physics Section*) reviewed the activities of the IAEA which (additionally to the teaching material) include dedicated courses and measures for qualification of medical physicists from developing countries. Due to the lack of recognized institutions in those countries a most critical issue in medical physics training is the practical implementation of the internationally recommended two years structured clinical in-service training (residency program) to be undertaken in a hospital. A.Peralta from Philippines reported about experiences with setting up a residency program based on the IAEA *Clinical Training of Medical Physicists Specializing in Radiation Oncology* introduced in her country, recently. The practical challenges when facing education & training programs have been reported from Bangladesh (H.A.Azhari) and Morocco (A.Ibn Seddick). An interesting aspect of building medical physics capacities in developing countries is the involvement of the governmental authorities, particularly in the recognition of medical physicists as health professionals with significant importance for the healthcare provision. The views on the role of medical physicists in a national cancer campaign are quite divergent and challenge for stronger interactions. This was learnt from the reports from Uganda and Nigeria. Finally, V. Della Atuwu-Ampoh (Ghana) gave an overview on the remarkable progress achieved in Ghana since 1970 when the medical physics training programme has been started. It was mainly the support by the Ghana Government and the Ghana Atomic Energy Commission in alliance with the IAEA which ensured implementation of a comprehensive education and training program for medical physicists, including a Master and since 2008 a PhD program. Meanwhile the whole medical physics programme matured and attracts students also from across Africa to be trained in Ghana.

In summary, the workshop on medical physics capacity building highlighted again the global problem of lacking qualified medical physicists in radiation medicine, particularly in developing countries. This is an even more serious issue when considering the complexity of modern equipment which on the other side is the condition for the evident achievements in health care, both in diagnosis and radiotherapy. In contrast, examples like the progress in Ghana demonstrate that concerted actions from national authorities, international organizations and the national medical physics community has power to change the adverse situation in less favorable regions. IOMP assured the attendees that the efforts in this field will continue and new Workshop and related activities on the subject are planned for the period ahead, including the International Conference on Medical Physics in Bangkok (December 2016) and the World Congress on Medical Physics and Biomedical Engineering in Prague (June 2018).



## Young Scientist Prize Winners – C19

### 2015 - Sylvain Guiriec



The 2015 IUPAP Young Scientist Prize in Astrophysics was awarded to Sylvain Guiriec for his “insightful and innovative contributions towards understanding the nature of Gamma Ray Burst (GRB) prompt emission, in particular the establishment of multi-component spectra, and the discovery of a new Peak Energy – Luminosity relation showing that GRBs can be used as standard candles and thereby as unique cosmological probes.”

Sylvain Guiriec was born in 1978 in Brest, France. In 2002 – 2003, he obtained a Masters degree in Material Sciences as well as an Engineering degree in Atomic and Molecular modeling and simulation, and computational structural analysis and design from the Institut Supérieur des Matériaux du Mans, France. He worked for two years as a young researcher at the Oak Ridge National Laboratory, USA, and at the Universitat Politècnica de Catalunya, Spain, where he studied radiation damage for the nuclear research field. In 2004, he obtained a Masters degree in Astrophysics, Planetology and Space Sciences & Techniques and an Engineering degree in Space Sciences & Techniques from Paul Sabatier University and the Institut Supérieur de l’Aéronautique et de l’Espace (SUPAERO), France. He received his PhD in December 2007 in Astrophysics from the Montpellier II University, France. His thesis was both theoretical and instrumental: (i) he studied the theoretical aspects of GRBs and made predictions of observability with the *Fermi* Gamma-ray Space Telescope (*Fermi*), and (ii) he participated to the integration and tests of the *Fermi*/Large Area Telescope (LAT), for which he developed an algorithm for suppressing its proton background.

After the launch of *Fermi* mid-2008, Sylvain Guiriec joined the National Space Science and Technology Center, USA – associated to the NASA Marshall Space Flight Center – with a 3-year postdoctoral position at the University of Alabama in Huntsville, USA. His main efforts focused on the observational analysis of GRBs, leading to the discovery of the first clear evidence for photospheric emission in their prompt emission. He also worked on Magnetars, Solar Flares and Terrestrial Gamma-ray Flashes. Since 2011 Sylvain Guiriec worked at NASA Goddard Space Flight Center, USA, first as a fellow of the NASA Postdoctoral Program and then as an Assistant Research Scientist affiliated with the University of Maryland, College Park and the Center for Research and Exploration in Space Science & Technology.

### 2014 - Nanda Rea



The 2014 IUPAP Young Scientist Prize in Astrophysics was awarded to Nanda Rea for her “her valuable contribution to the study of neutron stars. In particular for the discovery that magnetars can have low dipolar magnetic fields in line with the normal pulsar population, at variance with the long-standing belief that the electron critical magnetic field was a lower limit for magnetar-activity to take place.”

Nanda Rea was born in 1978 in Rome, Italy. She graduated from the University of Tor Vergata/INAF- Astronomical Observatory of Rome in 2006. Since then she spent several years with different post-doctoral fellowships (at SRON and The University of Amsterdam). In 2009 she started a 5 year tenure-track at the Institute for Space Sciences (ICE) in Barcelona, part of the CSIC (the Spanish National Research Council). In 2014 she was awarded an NWO Vidi grant to build a research group in The Netherlands. She is currently a tenured staff scientist at CSIC, and a research group leader at the Anton Pannekoek Institute of the University of Amsterdam.

Since her PhD years, Nanda Rea has worked on several aspects of neutron stars, both observationally and on the interpretation side. She was invited for colloquia and seminars in many worldwide institutes (Harvard, NYU, Max Plank, University of Sydney, ATNF, IAC, and others). In 2014 she was awarded the Zeldovich Medal for Astrophysics and Space Science from COSPAR and the Russian Academy of Science, for her crucial contribution to the understanding of neutron stars with strong magnetic fields.

## Young Scientist Prize Winners – C20

### 2015 - Wei-Min Wang



After his Bachelor, Dr. Wei-Min Wang has been working on theoretical and numerical-simulation investigation on laser plasma physics, which is applied to advanced schemes of inertial confined fusion, laser-plasma based particle accelerators, and novel radiation sources from terahertz to gamma-rays. Dr. Wang got his Master from Institute of Applied Physics and Computational Mathematics, Beijing, China in 2006. He got his PhD from Institute of Physics, Chinese Academy of Sciences (CAS), Beijing, China in 2009 and then he became an Assistant research scientist in the institute immediately after graduation. In this year he won the S. T. Tsai award for excellent PhD thesis in plasma physics in China. In 2012, he became an Associate Research Scientist in Institute of Physics, CAS. He was an Alexander von Humboldt research fellow at Jülich Supercomputing Centre, Germany in 2014 and 2015, and a visiting scholar at Utsunomiya University, Japan in 2010 and Rutherford Appleton Laboratory, UK in 2008.

### 2014 - Mathieu Salanne



Dr. Mathieu graduated in 2004 from Chimie ParisTech and obtained his Ph.D. in 2006 from Pierre and Marie Curie University (Paris), on the topic of modelling of molten salts for generation 4 nuclear reactors. This work was performed in strong collaboration with Pr. Paul Madden at the University of Oxford.

After a post-doc at Paris Sud university he joined the PHENIX laboratory (<http://www.phenix.cnrs.fr/?lang=en>) as an associate professor in 2007, where he now heads the Electrochemistry and Ionic Liquids group. His main activities concern the modelling of ionic liquids and materials for energy applications. In particular, he elucidated the charging mechanism of realistic nanoporous carbon based supercapacitors using constant applied potential molecular dynamics simulations. Since 2014 he also holds a chair in computational physics at the Maison de la Simulation (<http://www.maisondelasimulation.fr/en/index.php>), which is devoted to the computer design of supercapacitor materials.

## Conference Report 2015

To give you a perspective on the wide range of new physics results that are presented at the IUPAP conferences, here is a very brief extract from the conference reports, featuring just one or two items because of space limitations. The selection was difficult and the omitted items are just as interesting. For more details see the individual conference websites.

At the conference on **Electromagnetic Interactions with Nucleons and Nuclei** held at Paphos, Cyprus from 11/1/2015 to 11/7/2015, new measurements on the proton radius were discussed.

At the **XXIX International Conference on Photonic, Electronic and Atomic Collisions** held at Toledo, Spain from 7/22/2015 to 7/28/2015, highlights included the successful implementation of attosecond UV-pump/UV-probe techniques to investigate ultrafast electron and nuclear dynamics in molecules.

The **International Conference on Electromagnetic Isotope Separators and Related Topics** held at Grand Rapids, Michigan, USA from 5/10/2015 to 5/16/2015 highlighted the use of low-energy beam manipulation techniques including beam cooling and radiofrequency ion transport.

At the **21st International Conference on Few-body Problems in Physics** held at Chicago, IL from 5/18/2015 to 5/22/2015, a number of important results were presented in the areas of atomic & molecular physics, few-nucleon dynamics, cluster properties of nuclei, and hadron physics.

At the **12th International Conference on Nucleus-Nucleus Collisions** held at Catania, Italy from 6/21/2015 to 6/26/2015, new and important works presented, included Quark Gluon Plasma production at LHC, and identification of  $Z > 112$  nuclei.

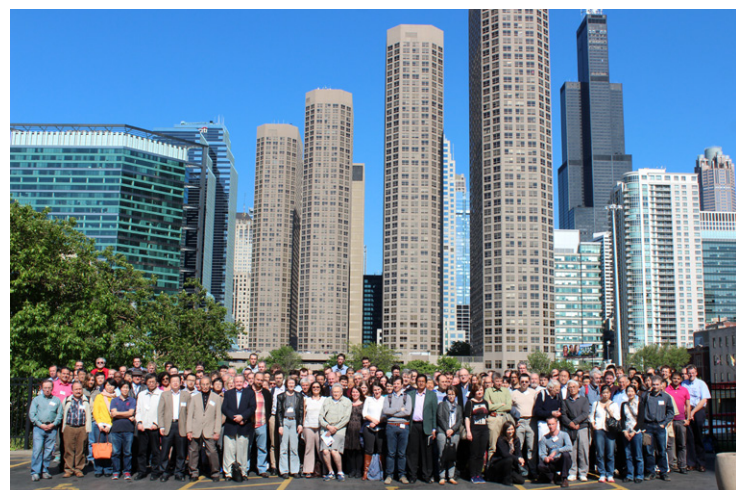
At the **13th international symposium on Origin of Matter and Evolution of Galaxies** held at Beijing, China from 6/24/2015 to 6/27/2015, highlights discussed included nucleosynthesis in the first stars, new results on  $^{12}\text{C}(\alpha, \gamma)^{16}\text{O}$  and  $^{12}\text{C}+^{12}\text{C}$  reaction rates.

At the **Materials and Mechanisms of Superconductivity 2015**, held at Geneva, Switzerland from 8/23/2015 to 8/28/2015, the recent discovery of superconductivity at 190 Kelvin in pressurized  $\text{H}_2\text{S}$ , and transient superconductivity close to room temperature using excitation with infrared light were discussed.





*Electromagnetic Interactions with Nucleons and Nuclei held at Paphos, Cyprus.*



*21st International Conference on Few-body Problems in Physics held at Chicago, IL.*



*International Symposium on Quantum Fluids and Solids, 2015 held at Niagara Falls, USA.*



*International Conference on Laser Spectroscopy 2015 at Singapore.*

At the **International Conference on Phenomena in Ionized Gases** held at Iasi, Romania from 7/26/2015 to 7/31/2015, new results presented included the use of plasma nanotechnology and new fabrication techniques including synthesis of nano-structured thin films, nano-tubes, nano-wires and nano-patterned surfaces.

At the **27th International Symposium on Lepton Photon Interactions at High Energies** held at Ljubljana, Slovenia from 8/17/2015 to 8/22/2015, highlights included the first results of LHC Run2 presented by ATLAS and CMS, and the pentaquark discovery by LHCb.

At the **International Symposium on Quantum Fluids and Solids, 2015** held at Niagara Falls, USA from 8/9/2015 to 8/15/2015, new results were reported by several investigators on the unusual crystal properties of solid  $^4\text{He}$ . In superfluid  $^3\text{He}$ , it was reported, surprisingly, that no Landau critical velocity was observed.

At the **International Conference on Laser Spectroscopy 2015** at Singapore held from 6/28/2015 to 7/3/2015, new results presented at the conference included improved accuracy and stability for atomic clocks and an updated electron dipole moment measurement.

At the **21st International Conference on Electronic Properties of Two-Dimensional Systems and 17th International Conference on Modulated Semiconductor Structures** jointly held at Sendai International Center, Sendai, Japan from 7/26/2015 to 7/31/2015, many new results on emerging two-dimensional materials other than graphene, such as molybdenum disulfide, phosphorene, silicene were discussed.

The **22nd International Colloquium on Magnetic Films and Surfaces** was held at Kraków/Cracow, Poland from 7/12/2015 to 7/17/2015. The ICMFS-2015 aimed at exchange of new results and ideas for advancing the field of magnetism at surfaces, interfaces, in micro- and nanostructures as well as of spin-dependent phenomena.

At the **Workshop on the determination of the fundamental constants** held at Eltville, Germany from 2/1/2015 to 2/6/2015, new data on the Rydberg constant, electron-to-proton mass ratio, the fine structure constant, the Planck and Avogadro constants, the electronic charge, the Boltzmann constant, and the Newtonian constant of gravity were presented.

## 2016 Conferences

The mission of IUPAP is to assist in the worldwide development of physics, to foster international cooperation in physics, and to help in the application of physics toward solving problems of concern to humanity. One of its means of fulfilling this mission is by sponsoring international meetings. The support rendered to these conferences takes up 44% of our budget.

The conferences supported by IUPAP for the year 2016 are:

### 1-13 March 2016

**9th International Meeting on Photodynamics and Related Aspects,** Mendoza

### 7-10 March 2016

**Sixth International Conference on Nanostructures,** Kish Island Iran

### 9-13 May 2016

**International Conference on Precision Physics of Simple Atomic Systems,** Jerusalem

### 30 May - 3 June 2016

**3rd PANDA Symposium on Multi-Wavelength Time Domain Astronomy,** China

### 12-25 June 2016

**African School on Electronic Structure Methods and Applications,** Accra

### 19-24 June 2016

**International Symposium on Nuclei in the Cosmos,** Nigata

### 27 June - 1 July 2016

**International Congress on Plasma Physics - 2016,** Kaohsiung

### 27 June - 9 July 2016

**SUSY (Supersymmetry) 2016,** Melbourne

### 4-9 July 2016

**XXVII International Conference on Neutrino Physics and Astrophysics,** London

### 10-14 July 2016

**International Conference on Computational Physics,** Gauteng

### 10-15 July 2016

**21st International Conference on General Relativity and Gravitation,** New York City

### 11-13 July 2016

**Nonequilibrium and nonlinear phenomena in statistical mechanics,** Brussels

### 11-15 July 2016

**International Laser Physics Workshop,** Yerevan

### 11-17 July 2016

**Contemporary Science Education and Challenges in the Present Society: perspectives in Physics Teaching and Learning,** Sao Paulo

### 13-15 July 2016

**International workshop on jamming and granular matter,** London

### 18-22 July 2016

**Identification of Dark Matter,** Sheffield

### 18-22 July 2016

**The 26th IUPAP International Conference on Statistical Physics,** Lyon

### 24-29 July 2016

**25th International Conference on Atomic Physics,** Seoul

### 25-29 July 2016

**14th International Conference on Integral Methods in Science and Engineering,** Padova

### 25-29 July 2016

**Entrepreneurship Development for Physicists,** Gujarat, India

### 25-29 July 2016

**Long-range interacting many-body systems: from atomic to astrophysical scales,** Trieste

### 31 July - 5 August 2016

**33rd International Conference on the Physics of Semiconductors,** Beijing

### 30 July - 7 August 2016

**COSPAR E1.9: Origin of Cosmic Rays,** Istanbul

### 1-19 August 2016

**The 4th Biennial African School of Fundamental Physics and Applications,** Kigali

### 3-10 August 2016

**International Conference on High Energy Physics,** Chicago

### 11-16 August 2016

**International Conference on Quantum Fluids and Solids,** Prague

### 25-29 August 2016

**19th International Symposium on Very High Cosmic Ray Interactions,** Dubna

### 5-8 September 2016

**25th European Cosmic Ray Symposium,** Torino

### 5-9 September 2016

**22nd International Congress on Acoustics,** Buenos Aires

### 11-16 September 2016

**International Conference on Nuclear Physics,** Adelaide

### 11-16 September 2016

**18th International Conference on the Physics of Highly Charged Ions,** Kielce

### 19-24 September 2016

**XXIII International Baldin Seminar on High Energy Physics,** Dubna

### 8-22 October 2016

**Mathematical Results in Quantum Theory: QMATH 13,** Atlanta

### 17-21 October 2016

**Joint ICO Topical Meeting and German Society for Applied Optics: [Integrated Polymer Optics and Photonics, from Research to Applications],** Hannover

### 2-5 December 2016

**22nd International Conference on Medical Physics,** Bangkok