IUPAP Commission C18: Mathematical Physics Report to the General Assembly 2017

Manfred Salmhofer, C18 Commission Chair 2015-2017

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1 Introduction

Mathematical physics is an interdisciplinary field, covering the full range of phenomena in physics, as well as all subfields of mathematics in their interaction with physics. It has given rise to astonishing insights and cross-fertilization of the two disciplines. As it is a theoretical activity without big equipment and without high budgets, researchers in all countries of the world can, and do, make important contributions. The interdisciplinarity of the subject also manifests itself in that its proponents are affiliated to both physics and mathematics departments, and its results have always deeply influenced both mathematics and physics, but especially so in recent years.

In accordance with its mandate, C18 furthers the exchange of information, support of scientists all over the world, and scientific progress, in mathematical physics, in collaboration with the International Association of Mathematical Physics (IAMP).

This report covers the period 2014-2017, more precisely the time interval between the two general assemblies of IUPAP.

2 Members of the commission

Manfred Salmhofer	Universität Heidelberg	Germany	Chair
Patrick Dorey	University of Durham	UK	Vice Chair
Rainer Dick	University of Saskatchewan	Canada	Secretary
Rajesh Gopakumar	Harish-Chandra Research Institute	India	
Eric Galapon	University of the Philippines	Philippines	
Masao Hirokawa	Hiroshima University	Japan	
Alain Joye	Université Grenoble I	France	
Bruno Nachtergaele	University of California at Davis	USA	
Octavio Obregon	Universidad de Guanajuato	Mexico	
Joseph Renes	ETH Zürich	Switzerland	
Olga Rossi	Ostrava University	Czech Republic	
Alexander Sevrin	Vrije Universiteit Brussel	Belgium	
German Sierra	Universidad Autonoma Madrid	Spain	
Andrei Slavnov	Russian Academy of Sciences	Russia	

To facilitate the collaboration with the IAMP set down in the mandate, we have elected the current President of the IAMP as an associate member of C18:

Robert Seiringer   Institute of Science and Technology Austria   Austria

His membership is effective for the period 2015-2018.

3   Work of the Commission

The main activities of the C18 commission have been the monitoring and selection of events in mathematical physics potentially eligible for support by IUPAP, and the selection of the recipients of the IUPAP Young Scientist Awards (YSA) in Mathematical Physics.

Discussions and votes within the C18 commission have been done by e-mail and skype. Individual commission members have met in person at conferences, in particular at the ICMP, but there has not been a personal meeting of the commission as a whole during the report period.

The budget allotted to C18 was used to cover the travel and local expenses of the YSA winners to Santiago de Chile, where they were awarded their prizes during the opening ceremony of the ICMP 2015, and gave special invited lectures.

4   Young Scientist Awards

Instead of awarding one prize per year, the C18 tradition has been to give three prizes for the entire period for which the commission is appointed.

4.1   Prizes for 2015-17

The previous C18 commission had solicited nominations and appointed a jury, headed by Antti Kupiainen, at the time IUPAP commission member and president of the International Association of Mathematical Physics (IAMP), to select the recipients. They are

> Roland Bauerschmidt
>
> Joseph Ben Geloun
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> Nicolas Rougerie.

C18 has approved this choice, and the prizes have been announced on the IUPAP web page

http://iupap.org/commissions/c18-mathematical-physics/news/

as well as in the September 2015 issue of the IUPAP Newsletter. The laudations for the candidates and a short description of their background and work follow below.

All three recipients now hold tenured faculty positions at universities in Europe.

4.2   The recipients of the IUPAP young scientist awards, 2015-2017

Roland Bauerschmidt has been awarded the IUPAP Young Scientist Prize in Mathematical Physics 2015-2017 for his work on self-avoiding random walks in 4 dimensions and the development of supersymmetric renormalization group techniques for their study.

Born in Hannover, Germany, Roland Bauerschmidt studied in Bonn, Germany, and Zurich, Switzerland, and received his B.Sc. and M.Sc. in Physics from ETH Zurich. His Ph.D. in Mathematics (2013) is from the University of British Columbia, Vancouver, Canada. He spent the year 2013-2014 at the Institute for Advanced Study, Princeton, before moving to Harvard University, where he is currently a Postdoctoral Researcher. In 2016, he will return to the University of British Columbia as Assistant Professor of Mathematics.

Bauerschmidt has mastered, developed and extended a renormalization group program initiated by David Brydges and Gordon Slade, and made important contributions to this area. In a strikingly original paper, he provided a simple new way to understand the finite range decompositions of Gaussian fields that underpin the renormalization group approach. His work on the structural stability of non-hyperbolic dynamical systems is an essential ingredient in the application of the renormalization group method.

Bauerschmidt's work sheds new light on fundamental aspects of statistical physics, such as the behaviour of the self-avoiding random walk in four dimensions, quantum friction, and random matrix theory.

Joseph Ben Geloun has been awarded the IUPAP Young Scientist Prize in Mathematical Physics 2015-2017 for his pioneering work on the renormalization of tensor field theories and his discovery of their generic asymptotic freedom.

Joseph Ben Geloun was born 1976 in St. Louis, Sénégal. After graduating from Cheikh Anta Diop University in Dakar, Sénégal, he received his PhD in 2007 from Université Nationale du Bénin. After visitor's and postdoctoral positions at Université Paris-Sud, France, and University of Stellenbosch, South Africa, he held a post-doctoral position at the Perimeter Institute for Theoretical Physics, Waterloo, Canada, from 2010 to 2013. Presently he is at the Albert-Einstein-Institute of the Max-Planck society in Golm, Germany.

After his PhD, Ben Geloun entered research on quantum gravity. In just a few years he became a major expert in the field. His most striking results concern a new class of non-local renormalizable quantum field theories, called tensor field theories, whose perturbative expansion sums over random geometries weighted by a discretized Einstein-Hilbert action. In his classification of these models, he discovered an unexpected property, namely their

generic ultraviolet asymptotic freedom.

He has also started to direct the research work of younger scientists such as Dine Ousmane Samary and Remy Avohou. Now a Humboldt Fellow at the Albert Einstein Institute in Golm, Germany, Ben Geloun is becoming a role model for the next generation of young African scientists.

Nicolas Rougerie has been awarded the IUPAP Young Scientist Prize in Mathematical Physics 2015-2017 for his exceptional contributions to the theory of cold quantum gases, in particular the proof of the appearance of a giant vortex and vortex circles in rapidly rotating Bose gases.

Nicolas Rougerie was born in 1985 in Versailles, France, and received his PhD in Mathematics from Université Pierre et Marie Curie, Paris, in 2010. He subsequently became a post-doctoral associate at Université de Cergy-Pontoise. In 2011 he was awarded a permanent CNRS researcher position in mathematics, at Laboratoire de Physique et Modélisation des Milieux Condensés, Grenoble (the only CNRS position in mathematical physics awarded in all of France in that year).

Already his doctoral thesis contains seminal results on giant vortices and vortex circles, and he published two important papers on these topics in 2011. This work was pushed further in a series of papers together with Michele Correggi, Florian Pinsker and Jakob Yngvason, which appeared 2011-2013. Further important contributions concern the quantum Hall regime of rapidly rotating Bose gases (joint with Sylvia Serfaty and Jakob Yngvason), a new approach to the mean-field limit in quantum many-body physics, based on a quantum version of de Finetti's theorem (joint with Mathieu Lewin and Phan-Tanh Nam). He has furthermore published work on polarons in quantum crystals, on higher dimensional Coulomb gases and on the average field approximation for extended anyons.

5   Conference Support

2015

ICMP 2015.   The major event of the international mathematical physics community in 2015 was the *XVIIIth International Congress on Mathematical Physics*, which took place July 27 - August 1, 2015, in Santiago de Chile. The congress was preceded by the Young Researchers Symposium, July 24/25, 2015, at the San Joaquin Campus of Pontificia Universidad Catolica de Chile.

The congress was attended by 307 scientists, more than 10 percent of them female, affiliated to institutions in 30 countries. There were 17 plenary talks, three of which were given by women. Of the approximately 100 invited talks, 10 were given by women.

The plenary talks presented the highlights of research in the past three years, among them the following: Nalini Ananthamaran reported on a proof of quantum ergodicity for large regular graphs. Folkmar Bornemann discussed the efficient and accurate numerical evaluation of

Fredholm determinants, and applications to several problems of mathematical physics. Francis Brown explained how new ideas from algebraic geometry can be used in the evaluation of quantum field theoretical Feynman diagrams. Jennifer Chayes reported about network theory, models, algorithms, and various applications ranging from social networks to genetic regulatory networks. Laure Saint-Raymond gave an overview of mathematically rigorous kinetic theory and presented her recent results on the Boltzmann equation near equilibrium on long time scales. Herbert Spohn reviewed the Kardar-Parisi-Zhang equation and how it arises in a variety of contexts, from growth processes to the low-temperature dynamics of the non-linear Schrödinger equation.

The state of the art in mathematical physics was further exposed in the parallel sessions of the congress, which were organized in ten topical sections.

ICMP 2015 was accompanied by the satellite meetings *Summer-school on current topics in mathematical-physics*, in Valparaíso, Chile, August 3-7, 2015, *Disordered models of mathematical physics*, in Valparaíso, Chile, July 21-24, 2015. *Operator Algebras and Quantum Physics*, in Sao Paulo, Brazil, July 17-23, 2015. *Inverse Problems in the Physical Sciences*, in Santiago de Chile, August 3-5, 2015.

This was the second time that the ICMP took place in South America (after the ICMP 2006 in Rio de Janeiro). This also reflects the strength and activity of the South American mathematical physics community.

2016

In 2016, two conferences within the scope of C18 received IUPAP support:

IMSE 2016: *The 14th International Conference on Integral Methods in Science and Engineering* in Padova, Italy, July 25-29, 2016, and

QMATH 2016: *The 13th International Conference on Mathematical Results in Quantum Physics*, at the Georgia Institute of Technology in Atlanta, USA, October 8-11, 2016.

IMSE 2016 had 128 attendees from 24 countries, including 104 attendees from outside Italy. Unfortunately, 11 participants from Turkey could not attend the conference due to political turmoil at the time. 26% of the participants and 33% of the invited speakers were female. Regretfully, many invitations to female speakers were rejected due to double bookings, while all invited male speakers attended. 27 scientists from developing countries and countries with a lack of national funding received travel support.

In their report, the organizers provided an impressive list of important new work presented at the conference. Highlights of particular interest to the physics community include theoretical studies of resonances of plasmonic nanoparticles, singular perturbation problems, new developments in the solution of boundary value problems through integral equations with applications to the heat equation, and applications of operator theory in magneto-hydrodynamics and in photonic crystals. The organizers provided a considerably longer list which also includes advancements in applied mathematics and in the mathematical analysis of engineering problems.

QMATH 2016 is the 13th conference in a series that P. Exner and P. Seba initiated in 1987. It was attended by 163 scientists from 25 countries, 106 of whom presented invited papers. Of the participants, 19 were women, 15 of whom presented invited papers. Two of the six members

of the international organizing committee are female. Both the plenary and parallel sessions at the conference were very well attended. While most presenters were mathematical physicists, there were also well-received presentations from experts in quantum information, quantum control, and condensed matter physics. Yoshiko Ogata from the University of Tokyo gave a very interesting and well-received plenary talk on the class of asymmetrically gapped Hamiltonians, which she introduced to advance our understanding of equivalence classes of gapped Hamiltonians, and ultimately a classification of energy gaps in band structures of materials. Among the other highlights were the lectures by Subir Sachdev (Harvard) on the Sachdev-Ye-Kitaev model and Nicholas Read (Yale), who used K-theory to characterize periodic lattice fermion systems that allow for compactly supported Wannier functions. Many of the other presentations at the conference were also motivated by advancements in condensed matter physics or quantum information, and several talks at QMATH 2016 addressed topological phase transitions and the classification of topological materials.

2017

In 2017, there were no mathematical physics meetings satisfying the IUPAP conditions for funding under Category B, because the number of participants in topical mathematical physics meetings rarely reaches 100, hence is below the current IUPAP threshold.

6   Summary and Outlook

The IUPAP activities and funding have been instrumental for the development of mathematical physics as an interdisciplinary field connecting physics and mathematics. The Young Scientist Award has become one of the major distinctions for excellent young researchers in the field, and all recipients of the prize have continued to lead their respective research areas. The support of major conferences in the field and of the participation of scientists from less favored countries has been greatly appreciated by the mathematical physics community.

The next major conference in mathematical physics will be the XIXth International Congress on Mathematical Physics (ICMP 2018), which takes place at Montreal, Canada, from July 23 to 28, 2018. The members of Commission C18 have unanimously voted to endorse this conference and to recommend it for funding as a IUPAP Category A conference.

The call for nominations for the YSA 2018-2020 was made in January. The deadline for nominations was August 31, 2017. A number of excellent persons has been nominated, and the preparations for the assessment of nominees and the selection of the winners have begun. The prizes will be awarded at the ICMP in Montreal.

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