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International Association of Mathematical Physics

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Contents

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Cover picture: Schlossplatz, in the center of Stuttgart, where Spectral Days 2017 will take place this year.

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News Bulletin (International Association of Mathematical Physics)

QMath13

by Evans Harrell (Georgia Institute of Technology)

One of the major conferences in mathematical physics took place for the thirteenth time, and the first time in the US, in October, 2016. The meeting in Atlanta counted 163 participants with sessions organized around the following themes:

- Quantum mechanics with random features
- Quantum mechanics on graphs and similar structures
- Many-body systems and statistical mechanics
- Quantum information
- New mathematical topics arising in current theoretical physics

The eight plenary lecturers were Michael Aizenman, Alessandro Giuliani, Yoshiko Ogata, Michael Weinstein, Svetlana Jitomirskaya, Maciej Zworski, Peter Kuchment, and Fernando Brandao.

In addition there were thematic parallel sessions, a session of short plenary presentations by young researchers, posters, and public lecture on the legacy of James Clerk Maxwell by Rafael Benguria.

The meeting was generously supported by the US National Science Foundation, Georgia Institute of Technology, Emory University, IUPAP, IAMP, the *Journal of Mathematical Physics*, Maplesoft, Microsoft, and Springer. Archival materials are available on a continuing basis on the conference website, http://qmath13.gatech.edu/.

From its early days as an ad hoc event in the Eastern Block QMath has evolved into a regular worldwide event that is central to the mission of the IAMP. The *News Bulletin* has taken this occasion to ask its co-founder Pavel Exner to recount its interesting history.

The QMath Conference Series at Middle Age

by Pavel Exner (Charles University, Prague)

On the occasion of the thirteenth meeting of the conference known as QMath which convened in Atlanta on October 8-11, 2016, I was asked to say something about the history of the series which we brought into being with my friend and collaborator Petr Šeba back in 1987, even if, frankly, we had no such intention at that time. We were working in the Laboratory of Theoretical Physics, JINR, in the Russian town of Dubna, then USSR.

It was a place with an interesting if troubled history, offering a convenient working environment: quiet, with a good library, and all the great Moscow seminars were just two hours by train. On the other hand, the world was then strictly divided and our personal contacts with colleagues from the other parts were limited to those who ventured across the Iron Curtain from the free world; the visit flow was weak and far from balanced.

When the eighties entered their second half, however, one could feel a change in the air. One day in the fall of 1986 – you see that the history dates back three decades already – Petr and I decided to try try to organize a meeting on the subject that interested us at that time, bringing in people irrespective of the said divide. We put on the list the names of Sergio Albeverio and Rafael Høegh-Krohn – we did not suspect it was one of the last opportunities to meet this remarkable man – together with Boris Pavlov and his students from Leningrad, Robert Minlos from Moscow, and some colleagues from the former Eastern Block countries.

The laboratory leadership approved the idea and we started working. The environment, however, was true to form. One day the deputy director came, pale, and said: "Sorry, guys, it won't work, Merzlyakov forbade it." I asked: "Who is Merzlyakov?" thinking it was a *nomen omen* indeed – translated from Russian it means something like 'scoundrelish' – and was told he belonged to the 'first', i.e. security department. I went there and found an arrogant Young-Communist-League type. I asked what does that mean, probably with some emphasis in my voice. To our luck, they were not good at handling critique coming from non-Russians; he immediately changed his tone and said that it was a mistake, of course.

Even after this obstacle was removed, it took time to proceed; communication went by snail mail only and, taking into account the inevitable surveillance of the correspondence, it sometimes took weeks to get a response. Nevertheless, at the end of September the three-day meeting opened and all the participants enjoyed it immensely. To be just, I have to add that some aspects of organizing a conference in the Soviet Union were easy indeed: once the meeting was recognized as a part of the laboratory activities, we just had to announce our requirements concerning lecture and hotel rooms and had no need to bother about things like the budget.

There are proceedings of the meeting [1], and they also had a random origin. Our idea was to have a collection of preprints related to the contributions, but this intention had collided with the Soviet paranoia about publications not well enough checked, for instance, written by a visitor to the institute. We were about to abandon the plan when

Sergio asked why not go to the *Springer Lecture Notes* series. One more problem came from the fact that, while we all speak – according to the known dictum – one universal language, a broken English, this *lingua franca* has its mutations. Petr and I spent a week in Leningrad translating the contributions of our friends from theirs to our English, hopefully a bit more understandable.

The success of the meeting encouraged us to organize a sequel. We were helped by the fact that the information spread fast, and people from many places inquired about participation, and before long we have a list of tentative attendees including great names such as Mikhail Birman – the author of these lines is proud for being later told that he helped to bring MSB back to work on Schrödinger operators – Mikhail Solomyak, Grigory Zhislin, Vladimir Buslaev, Dima Yafaev and others, as well as participants from abroad, of which let me mention, e.g., Helge Holden. But at that moment the KGB took its revenge: we were told that such 'unofficial' conferences were limited to one day. Fortunately, we found a trick, playing on the oriental-size self-esteem of a high institute official, which allowed us to overcome this obstacle. The meeting convened in September, 1988, lasting five days, to the full satisfaction of the participants, and the scope was considerably wider than the year before.

If you want to appreciate how much time has passed since then, just open the proceedings of this meeting [2] and enjoy the nice minute portraits of the speakers drawn by Nguyen Dao Dang; unfortunately many who sat for him are no longer among us. The reason why I describe the origins *in extenso* is that this may transmit some of the atmosphere of those days which, I admit, might be rather difficult to understand for people a generation or more younger. The same applies to the following history too, but in different ways and to a different degree.

The third meeting [3] occurred a year later, in October 1989, and it met no obstacles, as history quickened its pace dramatically. It was marked by a sad event, though, because during it we learned that Mark Grigor'evich Krein, a great mathematician with whom many of the participants had close personal ties, had passed away. The conference scope shifted again; this time it included for the first time talks on quantum chaos. But it marked also the end of the Dubna era, as during the next year the world changed completely and many people, including us, moved to other places.

In the optimistic atmosphere of those days we decided to add one more meeting to the previous three and held it in June 1990 in the Liblice Castle in (still undivided) Czechoslovakia [4]. One could not ignore the run of the history – the conference coincided with the first free election in the country – but what mattered for us was that the hurdles between the East and West were gone, as was clearly seen from the list of participants on which many new names appeared – Elliott Lieb, Jean-Michel Combes, Maria and Thomas Hoffmann-Ostenhof, Pierre Duclos, and Kenji Yajima, to name just a few – bringing in new topics. We all enjoyed the discussions in the splendid if a bit dilapidated castle owned by the Academy of Sciences.

After this meeting, frankly speaking, I regarded all this as a closed chapter. It was Valentin Zagrebnov who insisted that we must continue and called a preparatory meeting in Leipzig. Politics was again in the air; those were the days of dealing with the pains

coming from German reunification. Hagen Neidhardt was entrusted with the organization and his team did a splendid job. In May, 1993, the next conference met in a former trade union house in Blossin in the Berlin suburbs [5]. The scope was enriched this time by numerous contributions from many-body problems and statistical physics.

Next year, during the ICMP in Paris, I learned that a co-organizer of the Blossin meeting had told Werner Amrein, Gian Michele Graf, and others about it and its history, and inspired them to prepare a similar conference, which finally convened in June, 1996, in Ascona [6]. Enjoying the discussions at the terrace of the conference villa with a magnificent view of the lake, I maybe for the first time started thinking seriously of the whole enterprise as of an established conference series; after all it existed then for almost a decade and seemed to have a stable audience.

This led us to organize the next meeting in June, 1998, in Prague [7]. We adopted the name which had been used at the Blossin meeting and repeated since then with minor modifications, but we also introduced the abbreviation QMath, under which the series is now known. It was followed by the meetings in Taxco (Mexico) [8] in December, 2001, organized by the team of Ricardo Weder; in Giens (France) [9] in September, 2004, organized under the supervision of Joachim Asch and Alain Joye; in Moeciu (Romania) [10] in September, 2007, organized by Ingrid Beltita, Gheorghe Nenciu, and Radu Purice; in Hradec Králové (Czechia) [11] in September, 2010, under the supervision of Petr Šeba and Jan Kříž; in Berlin [12], organized by Hagen Neidhardt and Wolfgang König; and finally in Atlanta in October of last year, through the efforts of Federico Bonetto, David Borthwick, Evans Harrell, and Michael Loss. All of the named and unnamed organizers deserve sincere thanks.

A lot could be said about the contents and participants of those meetings but it is not the purpose of this short article, and, moreover, the web pages of the QMath meetings since Prague, or at least their copies, are still available at the address `http://gemma.ujf.cas.cz/~exner/conf_mat.html`, and the interested reader can find a lot of information there. Moreover, from its random birth back in 1987 the proceedings of the QMath conference are kept being published despite the voices saying hardcopy proceedings volumes are doomed. In the series from [1] to [12] one finds an interesting historic panorama showing how various problems concerning mathematical quantum mechanics emerged and disappeared again, some making fleeting appearance, others showing a good degree of persistence.

Let me instead make a few remarks. As is well known, it is difficult to make predictions, especially about the future. Some conference series die young, others make it to the middle age. It still surprises me that the QMath series exists after three decades despite the fact that it was a process full of random factors. This concerns not only the fight with the apparatchiks we experienced at the beginning; even later the continuation several times hung in the balance, especially when we had an invitation which either did not materialize or suddenly evaporated in the process. Always we found a colleague who came to rescue at the difficult moment; I would like to appreciate here especially Ricardo Weder and Gheorghe Nenciu.

In my view the viability of the series shows that there are people who regard it a

useful forum – the attendance in the later series history oscillates between 130 and 170 – and that new problems arise in the area which this community wants to address. What is most encouraging to me, looking at the list of participants of the Atlanta meeting, is to see names of colleagues who had not yet been born when the series started. This allows me to express a humble hope that it is still not the end of the story.

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[3] *Order, Disorder, and Chaos in Quantum Systems* (P. Exner, H. Neidhardt, eds.), Operator Theory: Advances and Applications, vol.46; Birhauser, Basel 1990.

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[11] *Mathematical Results in Quantum Physics* (P. Exner, ed.), World Scientific, Singapore 2011.

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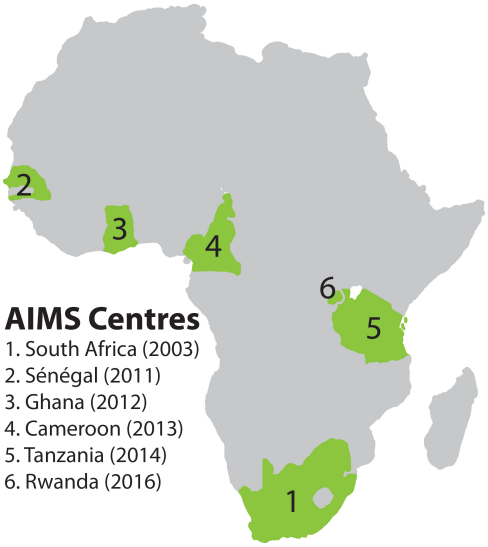
AIMS Advances Mathematics Education in Africa

by Barry Green

This past August, the African Institute for Mathematical Sciences (AIMS) opened its newest centre in Kigali, Rwanda. There was great excitement when 46 talented young African students arrived from all over the continent to begin a special one-year master's programme in the mathematical sciences, taught by local and international lecturers in a 24/7 environment.



There are six AIMS centres across Africa: one in South Africa, which opened in 2003, and others in Senegal, Ghana, Cameroon, Tanzania, and now Rwanda. These centres train over 300 students each year. AIMS' Next Einstein Initiative is working to establish 15 centres of excellence across Africa by 2023, thereby building a network of gifted young Africans in tune with the broad use of the mathematical sciences and able to contribute to new opportunities for growth in Africa. Established in 2003, AIMS is the first pan-African network of centres of excellence in the mathematical sciences. Its model prioritises international-class education of Africa's most valuable resource—its young people—for the transformation of the continent. AIMS has graduated more than 1,200 students from 42 African countries to date, 31% of them being women.

Each year over 3,000 young graduates apply for this programme, and it is our conviction that Africa has the pipeline to produce the next Einstein. The continent has what it takes to make breakthrough discoveries, either individually or collectively, that are relevant in Africa but also of global value and recognition regarding science and its use in society. AIMS is working to fulfill this potential, aware that mathematics underpins most of modern life, from information and communication technology to genetics, medicine, finance, demographics, and planning. In this way AIMS is filling the skills gap in the mathematical sciences, which will directly contribute to the development of the continent and drive Africa's transformation.

The training programme at AIMS focuses on developing scientific, technical, and entrepreneurial competence as well as creating a critical mass of well-rounded scientists with excellent problem-solving skills, capable of creative thinking and genuine innovation. AIMS students learn professional and employable skills, and are also trained in entrepreneurial methods to broaden their career preparedness for paths outside academia.

Our core programme, for which full scholarships are provided, is taught by world-class lecturers from both Africa and abroad in a continuous learning environment.

Dovetailing with this programme, we have introduced the AIMS Industry Initiative, which seeks to maximise the opportunities and potential for the mathematical sciences

to contribute to African economies via human capital, knowledge transfer, and applied scientific research and technological excellence. The initiative links the mathematical sciences to the needs of industry, focusing on eliminating the skills gap in Africa. AIMS is also piloting a cooperative programme at our centre in AIMS Senegal. This programme seeks to enhance the competencies of our students and graduates by providing them with opportunities to gain real-world experience with international and local partners, which will help them make a notable impact on Africa's economic, academic, and governmental capacity.

The core AIMS training programme is part of a broader project for development that also involves research, outreach, and community engagement. Thus, a key pillar of the institute's strategy is the facilitation of high-quality research that addresses challenges in African development. Each centre is expected to engage in relevant, multidisciplinary research. AIMS provides outstanding researchers the opportunity to conduct their work surrounded by peers in a world-class environment designed to inspire innovation and creativity. AIMS students and alumni are also able to interact with researchers through research projects, post-AIMS bursaries, and research-related workshops.

46 bright young African students from all over the continent will partake in a special one-year master's programme at the AIMS centre in Rwanda, which opened in 2016. They are the centre's inaugural group, pictured here with Thierry Zomahoun, President and CEO of the AIMS Global Network. Photo courtesy of AIMS.

AIMS' outreach and community engagement initiatives are committed to growing the pipeline of students progressing to secondary and tertiary mathematics and science education, and decreasing the failure and drop-out rate of mathematics students at all levels. Through innovative pedagogical approaches, the use of technology, and continually-updated curricula, the AIMS teacher training programmes focus on strengthening the mathematics teacher capacity and professional development of teachers. These teachers can then provide as many school learners in Africa as possible with a quality education in maths and science, investing in the future thinkers who will lead Africa's development.

The AIMS Schools Enrichment Centre (AIMSSEC) in South Africa has trained over 1,700 teachers with its Mathematical Thinking Course. The teacher training program in Cameroon—supported by The MasterCard Foundation—hopes to train 1,920 pre-service teachers and 1,200 in-service teachers over the next five years, reaching 1.7 million school children.

The AIMS Women in STEM Initiative (AIMSWIS) is dedicated to accelerating progress for African women in science, technology, engineering, and mathematics (STEM) through evidence-based reporting and advocacy, leveraging of increased investments, adoption of best practices, engagement of men, and collaboration with African women in the STEM pipeline.

AIMS is keenly aware that it has many partners with which to work and is part of a growing renewal in Africa. The Next Einstein Forum (NEF), an initiative of AIMS and the Robert Bosch Stiftung, was launched in 2013 as a platform to bring together relevant stakeholders and policymakers—from the scientific and academic sector, governments, science funding agencies, industry, media, and civil society—to showcase Africa's remarkable progress in science. By creating a community of scientists, NEF is catalysing action to translate these scientific advances into human benefit.

In collaboration with the Robert Bosch Stiftung and the government of Senegal, AIMS co-hosted the first NEF Global Gathering in March 2016 in Dakar, Senegal. The gathering brought together more than 1,000 global scientific and industry thought-leaders, political leaders, and young scientists to establish a clear roadmap of Africa's future transformation by leveraging science, technology and innovation. The next Global Gathering will be held in Kigali, Rwanda, in 2018.

The spirit of AIMS distinguishes it from other institutions; AIMS is more than just the math. The organization has a caring side, concerned with the development of people and the inspiration of empowerment through understanding.

One in seven people, or 15% of today's population, is African. In 2050, a little over a generation from now, 40% of the world's youth population will be African. These numbers mean that the world will look to Africa for talent. If we increase the pipeline of students pursuing STEM fields, both in research and industry, Africa has the potential to transform and inspire the world. African countries do not lack talented potential mathematicians. But without increased investment and more conducive education policy, few of them will reach their potential.

Barry Green is the director of the African Institute for Mathematical Sciences South Africa and Chief Academic and Research Officer for the AIMS Global Network.

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https://sinews.siam.org/DetailsPage/tabid/900/ArtMID/2243/ArticleID/1724/Default.aspx)

Mathematical Physics in Malaysia

by Hishamuddin Zainuddin (Selangor) and Lamberto Rondoni (Torino)

Background

The earliest university in Malaysia was formed prior to independence under the name University of Malaya (UM) in 1949 with a campus in Singapore, while the campus in Kuala Lumpur was established in 1959. In 1962, Sir Alexander Oppenheim, known for his conjecture on quadratic forms, became the first Vice-Chancellor of the then autonomous University of Malaya in Kuala Lumpur. A year before, in September, 1961, Tony H.R. Skyrme had already joined the Mathematics Department in University of Malaya, while his wife Dorothy Millest (a nuclear physicist) joined the Physics Department. Other mathematical physicists in the same period were P. Jha (geometer) and C.J. Eliezer (relativist). This period thus marks the earliest point of mathematical physics in Malaysia.

Other universities like Universiti Sains Malaysia (USM), Universiti Kebangsaan Malaysia (UKM), Universiti Putra Malaysia (UPM), and Universiti Teknologi Malaysia (UTM) were established sometime in early 70s, and this period saw active recruitment of academic staff of local nationalities to further their studies, and later formed scattered research groups across the different universities. It is in this period that we saw the first generation of theoretical and mathematical physicists. There was Chia Swee Ping (high energy physics) and Fon Wai Chu (atomic physics) in UM, Lim Swee Cheng, and Shaharir Mohamad Zain (mathematical physics) in UKM, Lee Beck Sim (statistical mechanics) in USM, and Mohd Yusof Sulaiman (nuclear physics) in UPM.

More theoretical and mathematical physicists joined the universities in 1990s, and including the students of the above mentioned pioneers they later formed research groups at their respective universities. They are Kurunathan Ratnavelu (atomic physics), Bernadine Wong (nuclear physics), Hassan Abu Kassim (nuclear astrophysics) in UM, David Tilley, Junaidah Osman (condensed matter) and Rosy Teh (high energy physics) in USM, Geri Gopir (condensed matter) in UKM, Hishamuddin Zainuddin (quantization) in UPM, and Zainal Abdul Aziz (path integrals, nonlinearity and industrial mathematics). The establishment of International Islamic University, Malaysia (IIUM) in 1983 also saw later a new influx of former Soviet Union-trained mathematicians and mathematical physicists into Malaysia with Nasir Gonikhodjaev (statistical mechanics, ergodicity, dynamical systems) and Farrukh Mukhamedov (quantum probability, statistical mechanics).

The expansion in research in theoretical and mathematical physics in Malaysia has been sporadic and uncoordinated. Most research groups at respective universities have been working independently, and each group tends to work more with international collaborators (from their mentor's network) than with their local counterparts, much due to the different areas that they are covering. In the past, even some mathematical physics research tradition was not sustainable and faded off with the retirement of the leader.

This is partly due to attraction and pressure from more applied areas of physics and mathematics, in which some are led to change their research. It is only relatively recently that more stable research groups in theoretical and mathematical physics have formed and that each group has begun to take notice of what the rest are doing.

Current Status

Presently there are many groups of theoretical and mathematical physicists that have been established and some individual theorists and mathematicians in the relatively newer universities.

In University of Malaya, under the High Impact Research initiatives, the university has formed research centres to which theoretical and mathematical physicists are associated. They are the Centre for Theoretical Physics, the Centre of Research for Mathematical and Statistical Modelling and the Quantum Science Centre. Their principal researchers are Kurunathan Ratnavelu (atomic physics/complex networks), Lim Ming Huat (linear algebra), Hassan Abu Kassim (nuclear astrophysics), Bernadine Renaldo Wong (nuclear physics), Sithi Muniandy (statistical mechanics, stochastic & quantum dynamics, theoretical plasma physics), Raymond Ooi Chong Heng (quantum optics), Chooi Wai Leong (linear algebra), Wan Ainun Mior Othman (differential geometry), Loo Tee How (differential geometry), and Norhasliza Yusof (nuclear astrophysics). It is also interesting to mention that this university hosts the National Centre for Particle Physics headed by Wan Ahmad Tajuddin Wan Abdullah (high energy physics ecperiment, complexity). The centre was established by the Malaysia Academy of Science and has links with CERN.

For Universiti Kebangsaan Malaysia, two faculty-equivalent schools that hosted mathematicians and theorists are the School of Mathematical Sciences and the School of Applied Physics. In the former, we have Mohd Salman Md Noorani (ergodicity, dynamical systems, topology), Maslina Darus (complex analysis), Fatimah Abdul Razak (complex systems, mathematical physics) and Syahida Che Dzul-Kifli (dynamical systems). Over in the School of Physics, there are Geri Gopir (condensed matter) and theoretically-inclined experimentalist Shahidan Radiman (nuclear physics, nanoscience, quantum theory).

A similar set-up is also seen in Universiti Sains Malaysia. The School of Mathematical Sciences has Andrew Rajah Balasingam Gnanaraj (groups, algebra, Moufang loops), Azhana Ahmad (groups) and Teh Wen Chean (combinatorics, natural computing, logic). Over in the School of Physics, we have Lim Siew Choo (condensed matter), Ong Lye Hock (condensed matter), Wong Khai Ming (high energy physics), Yoon Tiem Leong (high energy physics, computational physics) and Saiful Najmi Mohamed (theoretical & computational physics).

In Universiti Putra Malaysia, the Faculty of Science is home to Department of Mathematics and Department of Physics, whose key mathematical physicists and mathematicians are active members of the Institute for Mathematical Research (INSPEM). The institute is set up to spearhead research in certain key areas, which include mathematical physics. The members include Adem Kilicman (functional analysis, topology), Isamiddin Rakhimov (Leibniz algebras, structural theory of algebras), Hishamuddin Zainuddin (quantization, quantum foundations, quantum information, cosmology, complex net-

works), Nik Mohd Asri Nik Long (integral equations, theory of cracks), Chan Kar Tim (quantum theory on hyperbolic surfaces, complex networks), Santo Banerjee (chaos, nonlinearity), Muhammad Rezal Kamel Ariffin (chaos-based cryptography), Syarifah Kartini Syed Hussain (algebra), Nurisya Mohd Shah (noncommutative quantum mechanics, biorthogonal polynomials), Syed Hasibul Hassan Chowdhury (noncommutative quantum mechanics, noncommutative geometry), Witriany Basri (algebra), and Athirah Nawawi (finite groups). Besides this, the institute also has external members from different universities collaborating on projects and events.

Universiti Teknologi Malaysia tends to focus on engineering-like subjects, and mathematicians work mostly on applied mathematics. It is noteworthy to mention that the university has set up the Centre for Industrial and Applied Mathematics (UTM-CIAM), which is in collaboration with Oxford-CIAM. The Centre is headed by Zainal Abdul Aziz (path integrals, nonlinearity) with members Shaharuddin Salleh (computational sciences), Ali Murid (complex analysis), and Taufiq Khairi Ahmad Khairuddin (group theory). There are other notable mathematicians in their Faculty of Science such as Norsarahaida Saidina Amin (non-Newtonian fluids, biofluids, transport phenomena) and Nor Haniza Sarmin (group theory, splicing systems).

One relatively large group of mathematical physicists and theorists can be found in International Islamic University, Malaysia. They are Nasir Gonikhodjaev (statistical mechanics, ergodicity, dynamical systems), Abdumalik Rakhimov (spectral theoy), Mansoor Saburov (dynamical systems, functional analysis, statistical mechanics), Pah Chin Hee (statistical mechanics, dynamical systems, number theory), Muhammad Ridza Wahiddin (quantum optics, theoretical physics), Jesni Shamsul Shaari (quantum cryptography, quantum information), Fatkhulla Abdullaev (solitons, Bose Einstein condensate, nonlinear optics, solid state physics), Bakhram Umarov (solitons, nonlinear optics, nonlinear dynamics), Suryadi (nonlinear optics, quantum optics experimentalist working closely with theorist).

Other notable groups are at Xiamen University, Malaysia: Teo Lee Peng (quantum geometry of Riemann surfaces, complex analysis, Casimir effect), Darren Ong Chung Lee (spectral theory, quantum walks, Schrödinger operators), Huang Yen-Chang (differential geometry); and at University of Nottingham, Malaysia: Toh Sing Poh (Kochen-Specker theorem, quantum foundations) and Tay Buang Ann (quantum open systems, statistical mechanics).

One can also find individuals at other universities like Nazri Halif (Bose-Einstein condensate) in Universiti Malaysia Perlis, Lee Yen Cheong (quantum gravity, quantum field theory) in Universiti Teknologi Petronas and Ahmad Nazrul Rosli (density functional, condensed matter) in Universiti Sains Islam Malaysia.

Future Prospects

The theoretical and mathematical physics community in the country is still relatively small in comparison with other areas. However, there is a keen interest among the younger generation to pursue challenging and intellectually satisfying theoretical and mathematical topics. Workshops and lecture series like the Expository Quantum Lec-

ture Series (EQuaLS) organized by Institute for Mathematical Research at UPM has helped in garnering more interest among young researchers and students by bringing internationally known theoretical and mathematical physicists to Malaysia. It is hoped that such workshops and lecture series will continue to receive support both locally and internationally.

Another forthcoming promising prospect for theoretical and mathematical physics in Malaysia is that the Italian Government has given the endorsement to initiate the Malaysia-Italy Centre for Mathematical Sciences (MICEMS) at Universiti Putra Malaysia (UPM). The centre will initially cooperate closely with the Institute for Mathematical Research in UPM and the Italian partner, the Department of Mathematical Science in Politecnico di Torino (Polito), which has a good reputation in mathematical physics, ranging from rather abstract quantum groups to technological and bio-physical applications. The partners are keen to share and develop their expertise through the centre. The centre is poised to grow as an international center, and currently in place are exchange programmes between staffs and students of UPM and Polito. We look forward to the further expansion of operations of this centre.

Mathematical Physics in Thailand

by Paolo Bertozzini (Thammasat University, Thailand)

Background

Academic departments of mathematics and physics were first established in Chulalongkorn university in 1933 and 1934.[1] In 1955 Prom Panichapakdi was the first mathematician from Thailand to obtain a PhD under the supervison of N.Aronszajn at the university of Kansas.[2] A Master degree program in mathematics started in Chulalongkorn in 1963; the first PhD program in mathematics running in Thailand was opened in 1980 in Chulalongkorn university and produced graduates beginning around 1986.[3] Master degrees in physics had been awarded since 1942 (even before the formal opening of a graduate school in 1962);[4] a PhD program in physics was established from 1982, with the supervision of Henry R.Glyde from the university of Delaware.[5]

The exposure of the Thai academic system to mathematical physics was relatively early: in 1975 Moshe Flato was officially invited by UNESCO and the Thai government to evaluate all the graduate programs in science in the country: the final report, vitriolic in the sharp negative judgement of all the research activities in mathematics and theoretical physics, is a masterpiece of clarity and understanding of the obstacles towards the establishment of an efficient research community, with twelve important suggestions (never completely implemented since then).[6]

Ahpisit Ungkitchanukit, who obtained a PhD in 1976 from Royal Holloway University of London with Kevin J.M.Moriarty, was the first Thai researcher who specialized in theoretical high-energy physics.

In 1985 Eab Chai Hok[7] obtained his PhD under the supervision of Gianfausto Dell'Antonio in SISSA, Italy, and can be considered the first Thai researcher formally trained in

[1] To be precise, in 1934 a Bachelor of Science degree program in physics was created, but a department of physics had been officially already in place since 1924 (Abraham Press was the first head) and a school of physics/mathematics, offering support courses for students of medicine and engineering, was present even before the foundation of Chulalongkorn university in 1917.

Information gathered from the Chulalongkorn physics department web-site and the Chulalongkorn faculty of science web-site.

[2] Thanks to David Yost from Federation University in Australia for providing this information (math genealogy web-site).

[3] Information available from the Chulalongkorn mathematics department Thai web-site.

[4] R.H.B.Exell, an English expert in low temperature physics, worked in both mathematics and physics departments, from1962 to 1972, before moving to Asian Institute of Technology and then to King Mongkut Institute of Technology Thonburi.

[5] Information obtained from H.R.Glyde on-line CV. See also: H.R.Glyde, V.Sa-yakanit (1985) Institutional Links, an Example in Science and Technology *Higher Education in Europe* X(4):51-59 (1985).

[6] M.Flato (1976) Evaluation of Programme for Graduate Studies, UNESCO, Paris, Technical Report PP/1975-76/1.31.4, FMR/ED/HE/76/180(Flato). We thank Ms.Akané Nozaki from UNESCO - Bangkok, who provided a scanned copy of this document from Paris.

[7] E.Chai Hok (1985) Renormalization Group Transformation as a Map in the Space of Probability Measures: Continuity and Fixed Points, PhD Thesis, SISSA.

mathematical physics.

Chulalongkorn University's "Forum for Theoretical Science," created in 1986 under the leadership of Virulh Sa-yakanit (one of the most influential theoretical solid-state physicists in the Thai scientific community), Eab Chai Hok (affiliated to the chemistry department) and Sydney S. Mitchell (an American differential geometer who, after moving to Thailand in the early seventies, had significant impact on the establishment of mathematics graduate programs in Chulalongkorn), attracted for a decade some high-level seminarial and conference activities also in mathematical physics, as can be attested by the records of talks by H. Araki, O. Bratteli, E. Lieb, S. J. Summers and other mathematical physicists.[8]

In that pioneering period, the push towards research activities related to mathematical physics was locally driven by theoretical (mostly condensed matter) physicists: Virulh Sa-yakanit (Chulalongkorn), Suthat Yoksan (Srinakharinwirot), I-Ming Tang (a Chinese-American condensed matter theoretician who has been working at Mahidol University since 1974), Eab Chai Hok (Chulalongkorn), Ahpisit Ungkitchanukit (high-energy physics / cosmology, Chulalongkorn), Preedeeporn Limcharoen (physical chemistry, Mahidol), Rainer Radok (applied mathematics),[9] Julian Poulter (an English theoretical condensed matter physicist who started his work in Chulalongkorn at the end of the eighties and later in 1993 moved to the mathematics department in Mahidol university) and David Ruffolo (an American astrophysicist who moved to Thailand in 1991, first in Chulalongkorn and later in Mahidol).

Eckart Shulz (PhD in Saskatchewan with K. Frederick Taylor in 1990) has been the first operator algebraist moving to Thailand, initially in Khon Kaen and then from 1993 in Suranaree University of Technology. His current research interests also cover harmonic analysis and wavelets.

Mark Hall (an American mathematical physicist, now in Hastings, Nebraska, working in Lie algebras, computer science, logic, λ-calculus and type theory) collaborated with the mathematics department in Chulalongkorn and Mahanakhon University of Technology for ten years in the nineties.

During the Russian scientific diaspora, several experts in applied mathematics from ex-USSR moved (some of them temporarily) to Thailand: Boris Kvasov (splines), Sergey Meleshko (group analysis in partial differential equations), Nikolay Moshkin (numerical methods in continuum mechanics and diffusion equations) all in Suranaree University of Technology; and Anatoli Loutsiouk (representation theory, Lie group analysis) in King Mongkut Institute of Technology in Thonburi.

Research in mathematical physics of non-linear systems stated with Michael A. Allen (PhD in physics, Warwick, 1994, with G.Rowlands) who joined Mahidol University in

[8]Information obtained from several sources, including web-sites, personal conversations, past activity reports of FTS.

[9]A well-known German academic from Australia who worked as professor of applied mathematics in Asian Institute of Technology and later, from 1985, in Silapakorn and Mahidol.

Information gathered from Mahidol web-site and Australian Mathematical Society Gazette March 2005:26-27.

1996.

With the arrival of Edward B.Manoukian, a well-known expert in quantum field theory, who collaborated around 1993-1994 with Ahpisit Ungkitchanukit and Chai Hok Eab at Chulalongkorn University, before moving to work at Suranaree University of Technology and later to the Institute of Fundamental Studies in Naresuan, the first school of mathematical physics was established in Thailand.

Starting from 2001, Roberto Conti (my long time Italian collaborator, now in Rome, working in algebraic quantum field theory, operator algebras and non-commutative geometry) visited Thammasat (where I have been based since end 1997) and in 2005 joined Wicharn Lewkeeratiyutkul in Chulalongkorn for two years. Since then we have slowly continued our research collaboration.

Before 1990-2000 there were essentially a couple of dozen of people with PhDs, barely active in mathematics research, publishing just a few papers/year mostly related to graduate student's supervision and some international collaboration.[10] Since 2000 there has been a sharp phase transition with a more than exponential increase in the number of research publications: today (December, 2016) there are hundreds of people publishing and the volume of publications is unprecedented.

The following table presents the data on publications from Thailand, respectively in mathematical physics (MP), high energy physics (HEP), mathematics (Math) and physics (Phys), for the 20 years period 1996-2015, as reported from SCIMAGO website.[11]

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
MP	-	2	4	-	-	3	-	2	3	3
HEP	-	4	6	-	-	-	-	12	17	12
Math	20	27	40	39	69	68	91	128	140	172
Phys	40	65	70	69	103	94	118	180	255	338

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MP	3	3	8	8	10	17	22	26	23	11
HEP	17	22	14	17	23	34	58	81	118	126
Math	215	259	329	443	522	656	758	872	896	721
Phys	417	568	649	742	903	885	852	1014	1050	1007

In some (internationally very specific) areas of mathematics and theoretical physics Thailand has apparently reached full maturity: fixed point theory and non-linear functional analysis (KMITT, Chiang Mai, Naresuan, Khon Kaen, Thammasat, etc), mathematical modeling in biology, medicine, technology (Mahidol, Suranaree, KMITL, KMITT, etc), algebraic semigroups (Chulalongkorn), solid state physics (Chulalongkorn, Mahidol, Chiang Mai, etc), space physics (Mahidol), cosmological models (Naresuan), particle physics (Suranaree), theoretical physics (Chulalongkorn, Naresuan) ... still the situation in mathematical physics has been essentially refractary to any significant visible change.

[10] A detailed analysis of the development of mathematics research in Thailand is beyond the limited scope of this report and will be the object of a separate forthcoming work.

[11] The data reflect only the papers appearing in the journal classified by SCIMAGO in the respective categories (and hence many publications on local journals are missing), but are anyway indicative of the general trend.

Current Status

Currently (December, 2016), with extremely rare exceptions, the main organized research groups with activities "related to" mathematical physics are still almost exclusively composed of theoretical physicists. Here is a partial list of some physics centers, affiliated researchers and their main areas:

Institute of Fundamental Studies - Naresuan University - Phitsanulook

complex networks, physics of social systems, cosmology (Burin Gumjudpai, Pradeep Bhadola);
cosmology, gravity (Khampee Karwan, Pitayut Wongjun, Teeraparb Chantawat, Mattew James Lake);[12]
quantum field theory, mathematical physics (Edouard Manoukian, Seckson Sukhasena, Jorge Ovalle);
string theory (Pichet Vanichchapongjaroen, Shen Lan Ko);
quantum field theory on curved space-time (Shingo Takeuchi).

Theoretical Physics Group - Department of Physics - Chulalongkorn University

string theory, supergravity, string cosmology (Auttakit Chatrabhuti); string theory, holographic RG flows, gauged supergravity (Parinya Karndumri); cosmological models (Ahpisit Ungkitchanukit); quantum gravity, string theory, early cosmology, non-perturbative gauge theory (Oleg Evnin); superstring theory, D-brane, M-brane systems, AdS/CFT, conformal field theory (Hiroshi Osono); discrete quantum gravity, random tensor networks, M-theory, cosmology (Yuki Sato); supergravity, string cosmology (Rob Knoops); supersymmetry, CFT, Wilson loops (Benedict Fraser); conformal field theories, string theory (Andrea Leonardo Guerrieri).

Always at the Department of Physics in Chulalongkorn University, another "High Energy Physics Theory Group" (without web-page), is doing research in holographic duality, AdS/CFT, black hole physics, dark matter; members of the team are Piyabut Burikham, Rujikorn Dhanawittayapol, Tosaporn Angsachon (now in Thammasat) and Adisorn Adulpravitchai (now without an academic position!).

Department of Physics - Mahidol University

Space Physics and Energetic Particle Group: space physics, random walk, turbulence (David Ruffolo, Alejandro Saiz Rivera and collaborators);

Non-linear Systems Group: nonlinear waves, complex systems, fractals, chaos (Michael A.Allen);

[12] Antonio De Felice, now based in Kyoto, has been one of the most productive researchers in the group.

theoretical condensed matter mathematical modeling (I-Ming Tang); path-integral, field theory and supersymmetry (Udom Robkob); computational physics (Julian Poulter - since 2013 in Srinakharinwirot Physics Department); computational geophysics (Weerachai Siripunvaraporn, Chaiwoot Boonyasiriwat).

Nuclear and Particle Group - Suranaree University of Technology

QCD, chiral quark model, heavy ion collisions, supersymmetry (Yupeng Yan, Chinorat Kobdaj, Khanchai Khosonthongkee, Ayut Limphirat, Warintorn Sreethawong, Christoph Herold, Daris Samart).

Theoretical and Computational Physics Group - King Mongkut University of Technology Thonburi

Calogero-Moser and Ruijsenaars-Schneider integrable systems (Sikarin Yoo-kong and collaborators).

Individual lines of research in theoretical physics are now pursued in several other departments of physics, just to mention a few:[13] applications of Lie algebras and their representations, many-body perturbation theory, Konstant Dirac operator, superconformal field theory (Teparkson Pengpan) in Prince of Songkla University; physics beyond the standard model, modified gravity, dark energy, inflation (Phongpichit Channuie) in Walailak University; black-hole physics (Suphot Musiri), high energy phenomenology (Patipan Uttayarat), chiral quark model (Kem Pumsa-ard), all of them in Srinakarinwirot University (whuch under the initial leadership of Suthat Yoksan - one of the most well-known condensed-matter theoreticians in Thailand - always kept quite a good level in theoretical physics).

"Rigorous mathematical physics" still appears only very sporadically in Thai mathematics departments.

Here is a list of some of the very few researchers with a training/interest in mathematical physics:[14]

- Wicharn Lewkeeratiyutkul - Chulalongkorn University (PhD 1998 Cornell with L. Gross):
  functional analysis, analysis and quantum theory on Lie groups, logarithmic Sobolev inequalities, operator algebras and non-commutative geometry;

- Sujin Suwanna - Mahidol University, physics department (PhD Virginia 2007 with I. Herbst):
  statistical mechanics, Anderson localization, linear response, quantum information/algorithms;

[13] All of the many omissions here are the sole responsibility of my limited acquaintance with the theoretical physics community and do not imply in any way a dismissive opinion on the research performed.

[14] Some of them are no longer active or moved to other areas of research.

- Kamthom Chailuek - Prince of Songkla University (PhD Notre Dame 2007 with B. Hall):
  analysis on holomorphic function spaces, Bergman spaces;
- Prim Plansangkate - Prince of Songkla University (PhD 2009 Cambridge with M. Dunajski):
  complex manifolds, twistor theory, integrable systems;
- Petarpa Boonserm - Chulalongkorn University (PhD 2009 Wellington with M. Visser):
  general relativity, non-relativistic quantum physics, differential equations;
- Wanyok Atisattapong - Thammasat University (PhD 2009 Mahidol with J. Poulter): computational physics, Ising model, artificial intelligence, artificial neural networks;
- Keng Wiboonton - Chulalongkorn University (PhD 2009 - Lousiana State with G. Olaffson):
  harmonic analysis, Segal-Bargmann transform, gyrogroups;
- Noppakhun Suthichitranont - working in private business (PhD 2013 Tokyo with Y. Kawahigashi):
  algebraic quantum field theory, conformal field theory, operator algebras, category theory;
- Apimook Watcharangkool - (completing PhD in King's College London with M. Sakellariadou): non-commutative geometry in high energy physics, cosmology.

Two outstanding Thai researchers are working abroad in mathematical/theoretical physics:

- Gaywalee Yamskulna - associate professor, mathematics, Illinois State University (PhD 2001 Santa Cruz with Chongying Dong): vertex operator algebras, infinite dimensional Lie algebras;
- Noppadol Makereeya - researcher, physics, Universitá di Milano Bicocca, Italy (PhD 2011 Imperial College London with A. Hanany): supersymmetric gauge theory and quiver gauge theory.

In the closely related field of operator algebras (for differential geometry see below), several researchers have been trained at the doctoral level: Somlak Utudee (now in Chiang Mai University) obtained her PhD with Łazło Zsido in Rome II under a Royal Golden Jubilee[15] scholarship in 2005; Jittisak Rakbud (now in Silapakorn) in 2006 and Titarii Wootijirattikal (now in Ubon Ratchatani) in 2009, both graduated from Mahidol university, under the supervision of Patchara Chaisuriya and Sing-Cheong Ong (Central Michigan University); Anchalee Khemphet (now in Chiang Mai) graduated with

[15]Several other young researchers have been supported by this initiative of the Thailand Research Fund.

Justin R.Peters from Iowa State in 2012; Pattrawut Chansangiam in Chulalongkorn with Wicharn Lewkeeratiyutkul in 2013; Pichkitti Bannangkoon (now in Mahidol) from Penn State in 2015 with Nigel Higson.

Within a framework of long-term Joint Scientific Cooperation between Tokai University in Japan and King Mongkut Institute of Technology Ladkrabang, in the last 20 years, the Department of Mathematics in Tokai has made significant efforts to improve the level of mathematics in Thailand, also with the specific aim to develop research in differential geometry: Pakkinee Chitsakul (recently retired from KMITL) and Nathaphon Boonnam (now in Prince of Songkla University) both received their PhD in differential geometry, with Minoru Tanaka and Sorin V.Sabau (who currently supervise other students and periodically visit KMITL). Several talks in differential and Finsler geometry have been offered during the Joint International Symposium on Mathematics and Applied Mathematics, that is organized, since 2003 every few years, either in KMITL or in Tokai.

There have been no conferences or meetings specifically devoted to mathematical physics (not counting initiatives in computational and applied mathematics, which are, to the contrary, quite frequent).

Among the activities of the Forum for Theoretical Science, in January 1997 Sydney S.Mitchell organized in Suranaree University of Technology a "Workshop on Algebraic Analysis", with the participation of many Japanese mathematicians, that touched upon several aspects of mathematical physics: operator algebras (H. Araki), non-commutative geometry (H. Omori), representation theory (T. Oshima), Wiener measures (S. Watanabe), hyperfunctions (M. Morimoto), XXZ model (A. Nakabayashi); as well as more computational aspects: wavelets (W. Lawton - NUS), splines, finite differences method, partial differential equations (B. Kvasov, N. Moshkin, S. Meleshko - Suranaree).[16]

Thammasat university organized a small workshop on "Operator Algebras and Applications" (which also touched upon non-commutative geometry and algebraic quantum field theory) in September 1999, with the participation of Łasło Zsido from University of Tor Vergata in Rome.

In 2003 an attempt to submit a proposal for a EU-ASEAN University Network in operator algebras based in Thammasat[17] was unexpectedly turned down by Thammasat's central administration.

The organization of an international CIMPA school on "Spectral Triples and Applications" in 2011,[18] although didactically quite successful, was, not only financially, heavily obstructed by local actors.

[16]Virulh Sa-yakanit (1998) A Proposal for Updating the Forum for Theoretical Science (FTS) to be a Center of Theoretical Science, final report RTA/07/2538, Thailand Research Fund.

[17]The project had the already confirmed participation of Do Ngoc Diep for the Vietnam National Institute of Mathematics in Hanoi, Chulalongkorn University in Thailand, David Evans for University of Cardiff, Łaszło Zsido for University of Roma II and Jean-Luc Sauvajeot for University of Paris VI.

[18]Among the lecturers and speakers: A. Carey (ANU), R. Conti (Rome - Sapienza), R. Dhanawittayapol (Chulalongkorn), D. Goswami (Kolkata), W. Lawton (NUS), B. Mesland (Utrecht/Hannover), R. Nest (Copenhagen), R. Ponge (Tokyo/Seoul), A. Rennie (ANU/Wollongong), K. Reihani (Kansas), W. van Suijlekom and J. Boeijing (Radboud).

Several activities in theoretical physics (international symposia, workshops, seminars) are organized by the Institute of Fundamental Studies in Nasesuan ("Siam GR + HEP + Cosmo Symposium") and by the Theoretical Physics Group in Chulalongkorn ("Bangkok Workshop on High-Energy Theory") and both of these centers have achieved a level of internationalization (in terms of foreign researchers recruited, external collaborations and exposure to some topics of mainstream research) that is quite remarkable and unprecedented for the Thai academic environment.

A weeklong workshop on "Discrete Geometries and Statistics", organized by the Theoretical Physics Group in Chulalongkorn, is currently scheduled to take place at the end of January 2017.

A weekly mathematics seminar is organized in Mahidol University International College Salaya by Chatchawan Panraksa, Pornrat Ruengrot, Aram Tangboonduangit, Totsaporn Thanatipanonda and periodically hosts talks related to mathematical physics (such as operator algebras, gyrogroups, etc).

Since August 2016 a seminar dedicated to the memory of Ola Bratteli, organized in Thammasat University, has a mathematical physics session, but it is too early to predict the destiny of the initiative.[19]

[19]Previous speakers: David Evans (Cardiff - operator algebras), Przemo Kranz (Mississippi - Banach spaces), David Yost (Federation University - Banach spaces and polyhedra), Wayne Lawton (NUS/Mahidol International College - Brouwer and ham-sandwich theorems), Vorrapan Chandee (Bhurapa - L-functions and random matrix theory), Prim Plansankate (Prince of Songkla - integrability and self-duality), Gaywalee Yamskulna (Illinois State - vertex operator algebras).

Spectral Days 2017

by Marcel Griesemer (University of Stuttgart)

From April 3 to 7 the University of Stuttgart (Germany) will host Spectral Days 2017, the fourth iteration of a conference series that was initiated in 2010 in Santiago de Chile by Raphael Benguria and followed up successfully by installments in Munich (Germany), 2012, and in Luminy (Marseille, France), 2014. The gap of three years between 2014 and 2017 is deliberate and meant to be followed in the future. It will synchronize the Spectral Days with the ICMP and the QMath conference series, which have three-year periods as well. Spectral Days 2017, in spite of its name, is not exclusively devoted to spectral theory but to mathematical quantum physics at large. This is part of the tradition and so is the format that the local organizers have adopted for 2017: the bulk of the program consists of plenary talks given by invited speakers that were proposed by a scientific advisory board.

New compared to the previous conferences is a session of contributed talks by young researchers in the middle of the conference week. To apply for a slot in this session a title and an abstract are to be submitted along with the completed registration form (click "yes" next to young (postdoctoral) researcher to open a window for entering title and abstract). From all incoming applications the contributed talks will be selected by the scientific advisory board.

The conference venue is the campus Stuttgart-Vaihingen of the University of Stuttgart. While this campus is on the outskirts of the city, it offers the excellent lecture rooms of the university, a conference hotel, and a subway station with direct and frequent connections to the city center, the main railway station, and the Stuttgart airport. The subway ride is about 15 minutes in each case.

Photo © Kunstmuseum Stuttgart

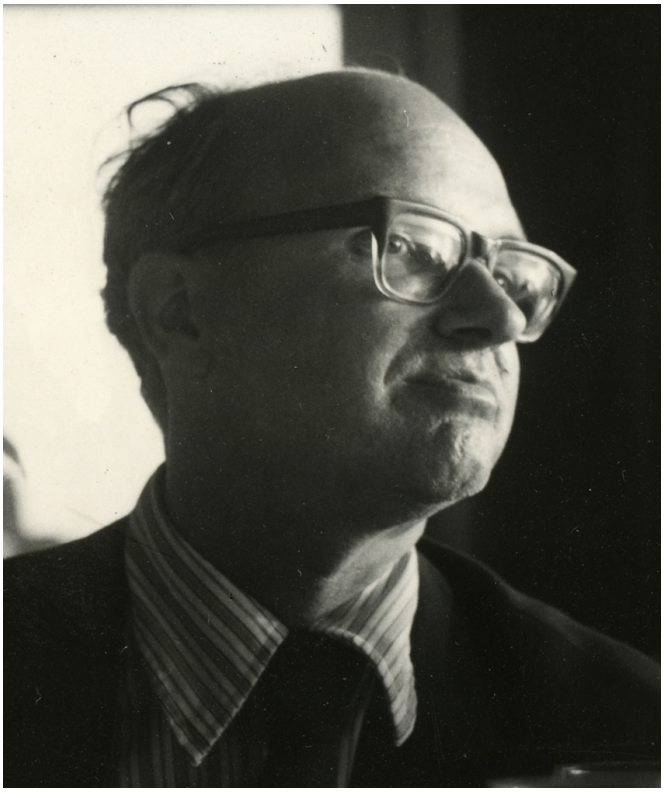
One afternoon of the conference week is left free to allow for discussions or excursions such as walks in the extensive parks of Stuttgart or visits to some of the many city attractions, such as the old and the new state gallery, the Stuttgart ballet, the state opera, or the museums of the local car manufacturers Daimler-Benz and Porsche.

The local organizers of Spectral Days 2017 are Marcel Griesemer, Christian Hainzl, Stefan Teufel, and Timo Weidl. They are supported by the members and staff of the research training group Spectral Theory and Dynamics of Quantum Systems. Spectral Days 2017 is made possible thanks to generous financial support provided by the Deutsche Forschungsgemeinschaft, by AIP Publishing, by the IAMP, and last but not least, by the University of Stuttgart.

The home page of **Spectral Days 2017** is at
http://www.mathematik.uni-stuttgart.de/grk1838/spectraldays/.

Wolfhart Zimmermann

(1928–2016)



On Sunday, September 18, 2016, Wolfhart Zimmermann passed away at the age of 88. The scientific community has thus lost a historic figure whose name will be linked indelibly with quantum field theory; he liked to remark that he was born in the same year as this theory. His mind was clear until the last moment and he seemed to consider his mission on earth as being fulfilled.

He was born on February 17, 1928, in Freiburg im Breisgau (Germany). As a high school student, when learning Latin, he decided that this was too simple and developed his own secret language ("Giganisch"), in which he communicated with his sister.

In 1946 he entered the university in his home town to study mathematics and physics. Already in 1950 he obtained his doctorate with a thesis devoted to topology [1]; a publication with the same title in 1952 [2]. Actually, as he told one of the authors, he had written an earlier dissertation, but abandoned it because he found out that the main result could be proven in a much simpler way, hence considered this work as inadequate for a doctoral degree. He published a further article on topology [3], while already working as a physi-

cist under Heisenberg; he liked to refer to this work as his "third dissertation". These papers were written in the style and spirit of BOURBAKI, on which he once privately commented "I can read BOURBAKI like the newspaper."

Soon after this, his main interest shifted to physics. In 1952 he joined the group of Werner Heisenberg at the Max-Planck-Institut für Physik in Göttingen as a Research Associate, a position which he held until 1957. Remarkably, his first physics paper [4] did not deal with quantum field theory, but with the thermodynamics of a Fermi gas. Members of Heisenberg's group, later called "der Feldverein", were not only Harry Lehmann and Kurt Symanzik, but also Vladimir Glaser, a Croatian physicist, with whom Wolfhart Zimmermann published his first paper on field theory [5]. He too was to accompany Wolfhart Zimmermann on his scientific way. The results obtained in collaboration with Lehmann and Symanzik were the first to become famous: with their *LSZ formalism*, they clarified basic notions, providing a framework for quantum field theory based on the principles of Lorentz covariance, unitarity, causality of Green functions and the S-matrix [6, 7, 8]. Another noteworthy paper in this context is a joint work with Glaser and Lehmann [9], characterizing a set of functions with certain properties as giving rise to a quantum field theory. Apart from providing a sound foundation for quantum field theory, these papers are masterpieces psychologically, showing how to get peacefully out of the shadow of a genius. Heisenberg had earlier proposed the principle of basing the entire formulation of a physical theory on observable quantities, e. g. the scattering matrix, alone. But how could one encode the notion of causality – certainly a fundamental property – in the S-matrix? LSZ gave the answer: leave the physical region ("go off shell") by using Green functions; there the postulate of causality has a simple, manageable form. Then go back to the mass shell by a "reduction formula" and you will find its restrictions for the S-matrix. Heisenberg's verdict was circumvented in a most elegant way.

In fact, the LSZ formalism provided the first axiomatic formulation of quantum field theory. Although written without reference to perturbation expansions, it proved to be greatly successful in its perturbative realization, hence extremely powerful in practice. It serves until the present day as the most efficient description of scattering amplitudes in particle physics.

In 1957, Zimmermann left Göttingen and held positions at the Institute of Advanced Study in Princeton and the University of Hamburg. From there, he visited the Physics Department of UC Berkeley, CERN, and the University of Vienna. In this period, he worked on the bound state problem, of one-particle singularities of Green functions and, more generally, of the analyticity structure of scattering amplitudes.

In 1962 he was appointed professor of physics at New York University. Visits led him to The Enrico Fermi Institute (Chicago) and IHES (Institut des Hautes Études Scientifiques, Bures-sur-Yvette, France). It is noteworthy that at this time, he also contributed to the so-called relativistic $SU(6)$-symmetry, which in hindsight turned out to prepare the way to supersymmetry, because anticommutators entered the scene in the form of Jordan algebras; this structure was later understood to define a super-algebra, i.e. graded algebra.

Zimmermann's subsequent work on renormalization theory stands as a towering achieve-

ment in that field. Bogoliubov, Parasiuk, Hepp (BPH) had worked out a recursive prescription of rendering Feynman diagrams finite. In a first step, Zimmermann solved this recursion explicitly with the help of his "forest formula", which provides an explicit solution to the BPH recursion and locates potentially divergent "renormalization parts" in a way that they do not "overlap", i.e. influence each other uncontrollably. In a second step he introduced subtractions in momentum space for every Feynman diagram such that the resulting integrals become absolutely convergent (as compared to conditional convergence in BPH) [10, 11]. Within this BPHZ renormalization scheme, as it is now called, one is not only able to derive S-matrix elements, but also the Green functions involving arbitrary composite operators. Thus, this method made it possible to study rigorously e.g. equations of motion, currents and symmetries in perturbative quantum field theory. In particular, it was now possible to define precisely the notion of anomalies, providing a fruitful link to mathematics, and also, from the point of view of physics, exhibiting truly quantum mechanical effects, not present on the classical level. A pivotal role in this is played by a set of identities between different normal products introduced by and named after Zimmermann. These identities have meaning even beyond perturbation theory. He found another, constructive way of arriving at these normal products by looking at the singularities of Green functions, expressed as sums over Feynman diagrams, when the endpoints of external lines merge to form a vertex which corresponds to a composite operator. Isolating the singularities and capturing them as coefficients of operators he arrived at the operator product expansion [12] which had been introduced by Kenneth Wilson. Their joint work provided an existence proof for the operator product expansion within perturbation theory.

In 1974 Wolfhart Zimmermann became a scientific member of the Max-Planck Society and director at the Max-Planck-Institut für Physik, Munich, Germany. In 1977 he was also appointed honorary professor at the Technical University of Munich. His visits led him to Centro de Investigación y de Estudios Avanzados del IPN, Mexico City, Mexico and Purdue University, West Lafayette, IN, USA.

The prime subject of his group was the formulation of gauge and supersymmetric models to all orders of perturbation theory. Only with his renormalization technique was it possible to construct such theories unambiguously.

In the course of studying asymptotically free theories like QCD, he and Reinhard Oehme were naturally led to analyze the renormalization group in models with several effective couplings. By eliminating the running parameter, Wolfhart Zimmermann found a set of ordinary differential equations whose solutions guarantee that several "secondary" coupling constants, chosen to be functions of a "primary" one, maintain this relation in the course of renormalization. For power-series solutions one stays in the realm of ordinary perturbation theory; the functional relations between the different coupling compatible with renormalization provide a generalization of the concept of symmetry [13, 14]. Zimmermann called this the "principle of reduction of couplings" and applied it to various theories. In supersymmetric gauge models, other authors were able to show that many "finite" models exist, finite meaning that their β-functions vanish to all orders, hence realizing superconformal symmetry in as straightforward a way as in

the classical theory. In particular, the Green functions scale "naively", i.e. without anomalous dimensions, and hence provide a realization of conformal symmetry . While such models are mainly of theoretical interest, it is clear that the reduction principle also has enormous phenomenological implications. Within the standard model of strong and electroweak interactions bounds on Higgs and top mass were derived. Once those were overruled indirectly by precision experiments – i.e. assuming the existence of Higgs and top quark, without having direct evidence for them – it was clear that the model had to be extended. And indeed, by applying the reduction principle to supersymmetric extensions of the standard model, the Higgs mass was predicted correctly two years before it was discovered [15]. Wolfhart Zimmermann was pleased by this.

In 1991 he was awarded the Max-Planck-Medal, the highest prize of the German Physical Society. In 1996 he retired, but kept ties to the institute until his end.

So far, we have considered the scientist and his work, but of course he was also a man of flesh and blood. He enjoyed eating and drinking well, showing exquisite taste also in this respect. He loved having company for dinner in his house, where his wife was a graceful and competent host. He was also well-known for his generosity towards members and guests of the institute. He cared very much about his three daughters, their performance at school and later their professional and personal development. He was a lover of music and theater, and of the flowers in his terrace garden. He has ended a journey in which he not only devoted his gifts to mathematics and physics but above all of this to his family, his friends and his collaborators. We will miss him.

Klaus Sibold (Leipzig), Erhard Seiler (Munich), Manfred Salmhofer (Heidelberg)

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[12] Operator product expansions and composite field operators in the general framework of quantum field theory (with K. Wilson),
Commun. Math. Phys. **24** (1972) 87.

[13] Reduction in the Number of Coupling Parameters
Commun. Math. Phys. **97** (1984) 211.

[14] Relations Between Effective Couplings for Asymptotically Free Models (with R. Oehme)
Commun. Math. Phys. **97** (1984) 569.

[15] Reduction of couplings (ed. K. Sibold)
`https://pos.sissa.it/archive/conferences/222/001/Higgs%20&%20top_001.pdf`.

Call for nominations for the IUPAP Young Scientist Award in Mathematical Physics 2018

The IUPAP Mathematical Physics C18 prize (http://www.iupap.org) recognizes exceptional achievements in mathematical physics by scientists at relatively early stages of their careers. It is awarded triennially to at most three young scientists satisfying the following criteria:

- The recipients of the awards in a given year should have a maximum of 8 years of research experience (excluding career interruptions) following their PhD on January 1 of that year, in the present case 2018.
- The recipients should have performed original work of outstanding scientific quality in mathematical physics.
- Preference may be given to young mathematical physicists from developing countries.

The awards will be presented at the ICMP in July 2018 in Montreal.

Please submit your nomination to Manfred Salmhofer (salmhofer@uni-heidelberg.de), Rainer Dick (rainer.dick@usask.ca) and Patrick Dorey (p.e.dorey@durham.ac.uk) as officers of the IUPAP C18 Commission for Mathematical Physics.

The deadline for nominations is **August 31, 2017**.

News from the IAMP Executive Committee

New individual members

IAMP welcomes the following new members

1. Prof. Boris Nahapetian, Armenian National Academy of Sciences, Yerevan, Armenia
2. Prof. Vadim Malyshev, Lomonosov Moscow State University, Moscow, Russia
3. Dr. Rajesh Kumar Gupta, Central University of Punjab, Bathinda, India

Recent conference announcements

Dyson-Schwinger equations, topological expansions and random matrices

August 28-September 1, 2017. Columbia University, New York, USA.

Organized by I. Corwin and Y. Sun.

http://www.math.columbia.edu/department/probability/seminar/guionnet.html

Random Matrix Theory Summer Session

June 25-July 15, 2017. Park City Mathematics Institute, Park City, USA.

Organized by A. Borodin, I. Corwin, A. Guionnet.

https://pcmi.ias.edu/upcoming

Quantum Theory and Symmetries

June 19-25, 2017. Varna, Bulgaria.

This conference is partially supported by IAMP.

http://theo.inrne.bas.bg/ dobrev/QTS-10.htm

Dynamics, aging and universality in complex systems

June 19-23, 2017. A celebration in honor of G. Ben Arous.
Courant Institute, New York, USA.

Organized by A. Auffinger, P. Bourgade, I. Corwin, A. Guionnet.

http://cims.nyu.edu/conferences/gba60/

Spectral Days

April 3-7, 2017. Stuttgart, Germany.

This conference is partially supported by IAMP.

Organized by M. Griesemer, C. Hainzl, S. Teufel, T. Weidl.

http://www.mathematik.uni-stuttgart.de/grk1838/spectraldays/index.html

Macroscopic Limits of Quantum Systems

March 30-April 1. Celebration of H. Spohn's 70-th birthday.
Munich, Germany.

Organized by M. Duell, W. Dybalski, S. Simonella.

http://www-m5.ma.tum.de/Allgemeines/MacroscopicLimitsWorkshop

Fifth Quantum Thermodynamics Conference

March 13-17. Oxford, UK.

This conference is partially supported by IAMP.

https://qtd5.sciencesconf.org/

Linear and Nonlinear Dirac Equation: advances and open problems

February 8-10. Como, Italy.

Organized by C. Cacciapuoti, R. Carlone, D. Noja, A. Posilicano.

http://www.lnd2017.cond-math.it/index.html

Open positions

Tenure Track Position in Theoretical Physics in Vienna

The Faculty of Physics plans to strengthen the research area "Particle Physics, Gravitational Physics and Mathematical Physics" by a Tenure Track position in Theoretical Physics, with particular focus on Gravitational Physics. Preference will be given to research directions that provide synergy with the existing expertise in mathematical relativity, but all especially qualified candidates from the fields of particle physics, gravitational physics and mathematical physics will be considered. The deadline for applications is February 28, 2017.

More information on the position and on how to apply can be found here.

More job announcements are on the job announcement page of the IAMP

`http://www.iamp.org/page.php?page=page_positions`

which gets updated whenever new announcements come in.

Benjamin Schlein (IAMP Secretary)

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