International Association of Mathematical Physics

News Bulletin

July 2014

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Cover picture: Inside the Erwin-Schrödinger Institute for Mathematical Physics, Vienna. See the article by Joachim Schwermer in this issue. Photo ©Philipp Steinkellner (http://www.steinkellner.com/)

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Call for nominations for the 2015 IAMP Early Career Award

The IAMP Executive Committee calls for nominations for the 2015 IAMP Early Career Award. The prize was instituted in 2008 and will be awarded for the third time at the ICMP in Santiago, Chile, in July 2015.

The Early Career Award is given in recognition of a single achievement in mathematical physics. The total prize value amounts to 3000 Euro and is reserved for scientists whose age in years since birth on July 31 of the year of the Congress is less than 35.

The nomination should include the name of the candidate accompanied by a brief characterization of the work singled out for the prize. Members of the IAMP should send their nomination or nominations to the President (president@iamp.org) and to the Secretary (secretary@iamp.org). A list of previous winners and the details of the award selection process can be found at: http://www.iamp.org.

Nominations should be made not later than **January 31, 2015**.

Call for nominations for the IUPAP Young Scientist Prize in Mathematical Physics 2015

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 2015.
- 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 2015 in Santiago de Chile

Please submit your nomination to Jakob Yngvason (jakob.yngvason@univie.ac.at), Antti Kupiainen (ajkupiai@cc.helsinki.fi) 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, 2014**.

Call for nominations for the 2015 Henri Poincaré Prize

The Henri Poincaré Prize, sponsored by the Daniel Iagolnitzer Foundation, was created in 1997 to recognize outstanding contributions in mathematical physics, and contributions which lay the groundwork for novel developments in this broad field. The prize is also created to recognize and support young people of exceptional promise who have already made outstanding contributions to the field of mathematical physics. The prize is awarded every three years at the International Congress of Mathematical Physics (ICMP), and in each case is awarded usually to three individuals.

The prize winners are chosen by the Executive Committee of the IAMP upon recommendations given by a special Prize Committee. The Executive Committee has made every effort to appoint to the prize committee prominent members of our community that are representative of the various fields it contains. However, to be able to do its job properly the Prize Committee needs input from the members of IAMP. For this purpose the Executive Committee calls IAMP members to provide nominations for the Henri Poincaré Prize to be awarded at the ICMP 2015 at Santiago, Chile.

A proper nomination should include the following:

- Description of the scientific work of the nominee emphasizing their key contributions.
- A recent C.V. of the nominee.
- A proposed citation, should the nominee be selected for an award.

Please keep the length of your nomination within a page and submit it to the President (president@iamp.org) or the Secretary (secretary@iamp.org). A list of previous winners can be found at: http://www.iamp.org.

To ensure full consideration please submit your nominations by **September 30, 2014**.

The centenary of Mark Kac (1914–1984)

by Rafael Benguria (Pontificia Universidad Católica de Chile)

Mark Kac, circa 1980, "Archives of *Mathematisches Forschungsinstitut Oberwolfach*"

After completing my Ph.D. in Physics at Princeton University, I obtained a postdoctoral position at Rockefeller University. In the early sixties, Detlev Bronk, who was president (1953–1968) of the then Rockefeller Institute for Medical Research hired George Uhlenbeck, Mark Kac and Theodore Berlin (1961), among others, to establish a Mathematical Physics group, and Abraham Pais (1962) to lead a group in High Energy Physics. In fact Detlev Bronk successfully made the transition from a research institute to the Rockefeller University (1965). Kenneth Case joined the Mathematical Physics group at Rockefeller in 1969, and so did James Glimm in 1974. I stayed in Kenneth Case's Lab at Rockefeller University from 1979 to 1981. There I had the chance to work with Ken Case and Mark Kac [2], to meet many visitors in Mathematics and Physics and to enjoy the friendly atmosphere of the 14th floor of the Tower Building where the labs of Ken Case and Eddie Cohen were housed. This year marks the hundredth anniversary of the birth of Mark Kac (1914-1984), who was a prominent figure in mathematics and physics of the twentieth century, and I think it is appropriate to remember his life and work in the IAMP Bulletin.

Mark Kac was born three weeks after the beginning of the First World War (August 16, Gregorian Calendar) in Krzemieniec (now Kremenets). Krzemieniec, at the foot of Mountain Bona, is a city that has belonged to different countries in recent history. Even during the early years of Mark Kac it was part of the Austro–Hungarian Empire, then part of the Russian Empire, later a Polish Territory and finally part of Ukraine, where its is known as Kremenets). At the time of Mark Kac's birth, Krzemieniec was part of Vohlynia, and a typical cultural city of Central Europe. The romantic Polish poet Juliusz Słowacki was born there in the early XIXth century, and a contemporary of Mark Kac, the violinist Isaac Stern, was born in Krzemieniec in 1920. Although during the two World Wars it suffered enormously (especially during the Holocaust in the Second World War), Krzemieniec enjoyed a quiet and stimulating atmosphere in the interbellum. In 1922, the polish leader Jósef Piłsudski, reopened the Lyceum of Krzemieniec, which had been founded in the XIXth century under the supervision of Vilnius University. The Lyceum was closed by the Soviet occupation army in September 1939, at the beginning of the Second World War. A measure of the Lyceum's reputation is the fact that it was soon known as the "Athens of Volhynia". Mark Kac entered the Lyceum in 1925. In the summer of 1930 Kac had his first experience with research. Acquainted with the Cardano solution of the cubic equation, he wanted to find an alternative way of finding that solution. He exploited the invariance of the equation under bilinear transformations. Doing so, he found a two parameter flow of cubic equations and determined the parameters of the flow that yielded a trivial cubic, to finally determine the solution of the original equation. One can certainly repeat that procedure for the quartic as well, and use the two parameters to reduce the quartic into a quadratic in x^2. This was the content of Mark Kac's first paper, which appeared in the "Młody Mathematyk" (i.e., *The Young Mathematician*). In 1931, after completing High School at the Lyceum, Kac moved to Lvov (at that time a city of the region of Galicia, then part of Poland, today known as Lviv, a city in western Ukraine) to attend the Jan Kazimierz University, which was the name of the University of Lvov in the period 1919–1939 (today is known as the Ivan Franko University of Lviv) in honour of its founder, the King John Casimir (1661). Between the wars, Lvov (with its two universities, namely the Jan Kazimierz and the Technical University) was the site of the famous "Lvov School of Mathematics", which played a major role in the development of Functional Analysis. Stephan Banach at the Technical University, and Hugo Steinhaus at the Jan Kazimierz university were the leading figures of this School, which also included Stanisław Mazur, Juliusz Schauder, Stan Ulam, and many others. The mathematical atmosphere in Lvov at that time is recollected by Ulam in the Introduction of [42]. In Ulam's words, *"the mathematical life was very intense in Lwów. Some of us met practically every day, ... to discuss problems of common interest, communicating to each other the latest work and results. Apart from the more official meetings of the local sections of the Mathematical Society, there were frequent informal discussions mostly held in one of the coffee houses located near the University building –one of them a coffee house named "Roma", and the other "The Scottish Coffee House"*. There are many recollections (see, e.g., [33]) about "The Scottish Coffee House" ("Kawiarnia Szkocka" in Polish, located in 27 Taras Shevchenko Prospekt, Lvov). According to

Ulam [42], Stephan Banach in 1935 suggested keeping track of the problems occupying the group of mathematicians that were gathering there. A version of this book in English is available online in [42] where Ulam edited, in 193 entries, the problems discussed by the group between 1935 and May 1941, the year Steinhaus had to leave Lvov. Every entry has the name of the proposer of the problem. Among the proposers one finds names like Banach, Steinhaus, Ulam, Mazur, Kac, Marcinkiewicz, Kaczmarz, Sobolev, Ljusternik, von Neumann, Eilenberg, Zygmund, Auerbach, Sierpinski and several others. Several proposers offered special "prizes" for the solutions. Among the prizes offered for the solutions one finds: "five small beers", "a bottle of wine" and even "a fondue in Geneva". While still a graduate student, Mark Kac participated in this group, and in the "Scottish Book of Problems" he has four entries, which shed some light about his mathematical concerns at that time. For example in problem 126, he asks: If $\int_0^1 f(x)\,dx = 0$ and $\int_0^1 f^2(x)\,dx = \infty$, prove that

$$\lim_{n\to\infty} \left(\int_0^1 \exp(i\frac{f(x)}{\sqrt{n}})\,dx \right)^n = 0.$$

Kac asserts that when $\int_0^1 f^2(x)\,dx = A$ (finite), the resulting limit is known and in fact equal to $1/\sqrt{e}$. This problem 126 was soon solved by A. Khinchin, who published his result in Studia Mathematica. In the entry 161 (dated June 10, 1937), there is the following Theorem of Mark Kac: Let r_n be a sequence of of integers such that

$$\lim_{n\to\infty} (r_n - \sum_{k=1}^{n-1} r_k) = \infty.$$

Prove that,

$$\lim_{n\to\infty} \left[\mathbb{E}_{0\le x\le 1} \left(a < \frac{\sin(2\pi r_1 x) + \cdots + \sin(2\pi r_n x)}{\sqrt{n}} < b \right) \right] = \frac{1}{\sqrt{\pi}} \int_a^b \exp(-y^2)\,dy.$$

One can put, e.g., $r_n = 2^{n^2}$. And he asks wether the same result hold if $r_n = 2^n$ (where one can see that the condition imposed on the sequence r_n does not hold). As described in the biography [34], *in short sinusoids of independent frequency behave as if they were statistically independent though strictly speaking they are not.* See also [23, 24]. Mark Kac got his Ph.D. in 1937 [22] under the supervision of Hugo Steinhaus. He acquired from his advisor the interest and taste for working on problems related to statistical independence. Using Kac's own words [31] (see Chapter 3, p. 48) to describe his interaction with Steinhaus: *"My mathematical life began with my collaboration with Hugo Steinhaus. That three–year period (from the spring of 1935 to the end of November 1938)... was decisive in my development as a mathematician"*. In the period 1936–1937 Kac and Steinhaus wrote a series of four papers under the general title "Sur les fonctions indépendantes", which were published in the Polish mathematical journal "Studia Mathematica" founded by Banach and Steinhaus in 1929. Mark Kac completed his Ph.D. thesis [22] precisely on the subject of statistical independence in 1937. A bit more than twenty years later Kac was asked to deliver a series of lectures at Haverford College (Spring of 1958), and he retook the subject of statistical independence. As an outgrowth of these lectures, Mark Kac wrote the book "Statistical Independence in Probability Analysis and number theory" [28], in the Carus Series of the Mathematical Association of America. Kac dedicated this book to his teacher Hugo Steinhaus. As described by Henry McKean, *"This is a splendid book. It ranges from the primitive idea of statistical independence to applications of the most diverse sort: coin–tossing, anharmonic oscillators, prime numbers and continued fractions. And it does all that with Kac's customary clarity and charm..."*. In particular, in this book one can find the proof of the Kac's theorem stated as the entry 161 of "Scottish Book of Problems" quoted above.

In 1938, Kac obtained a Polish fellowship from the Parnas Foundation to visit Johns Hopkins University. He left behind his whole family, most of whom perished in Krzemieniec in the mass executions of 1942-43. He arrived at Baltimore in December 1938 [1]. Soon after his arrival in the US, Kac met Norbert Wiener and Paul Erdős, who were influential in his mathematical career. The same year Kac arrived in the US, Paul Erdős arrived at the Institute for Advanced Study (IAS) for a one year appointment. In 1939, Mark Kac was invited to give a lecture at the IAS and met Erdős. Both discovered that they could apply their respective background in number theory (Erdős) and probability (Kac) to solve a problem in number theory, namely that for any natural number n, the number of prime divisors of the integers less than n has a normal distribution. If $\nu(n)$ is the number of prime divisors of n, loosely speaking, the probability distribution of

$$\frac{\nu(n) - \log\log n}{\sqrt{\log\log n}}$$

is the standard normal distribution.

Their joint work published in 1940 in the *Journal of the American Mathematical Society* [14] is one of the pillars of the then new field of probabilistic number theory. In an interview with Mitchell Feigenbaum [15], Kac shows his pride on this particular work: *"...In retrospect the thing which I am happiest about, and it was done in cooperation with Erdős... was the introduction of probabilistic methods in number theory. To put it poetically, primes play a game of chance"*.

With the recommendation of Norbert Wiener, Mark Kac obtained an instructorship at Cornell University in 1939. It was in Ithaca, for his 27th birthday, that Mark Kac met his future wife Katherine Mayberry, whom he married in 1942. They had two children, Michael and Deborah. Kac was first promoted to Assistant Professor in 1943 and to Full Professor in 1947. He stayed at Cornell University until 1961, when he moved to Rockefeller. During the Second World War, Mark Kac worked also at the Radiation Laboratory at MIT, in Cambridge, Massachusetts. The wartime research at the Radiation Lab was mainly devoted to waveguide theory and to the study of problems

[1] Kac sailed from Poland to the US in the M/S Piłsudski, which served in the Gdynia–Amerika Shipping Lines Ltd. from Gydnia to Hoboken from 1935 to the beginning of the Second World War. The M/S Piłsudski sank on November 26, 1939 after hitting two mines off the coast of Yorkshire, on war service.

of noise in radar systems. It was in Cambridge that Mark Kac met George Uhlenbeck [17], who had left Ann Arbor, MI, to direct the Radiation Lab. Mark Kac returned to MIT in the academic year 1946–47, on leave from Cornell, supported by a Guggenheim fellowship. Kac and Uhlenbeck developed a close friendship and collaboration that lasted until Kac's death in 1984. Uhlenbeck introduced Kac to problems in physics, in particular in statistical mechanics. It was Uhlenbeck who introduced Kac to the *dog–flea* problem, a problem formulated by Paul Ehrenfest (Uhlenbeck's advisor) and his wife Tatiana in 1907 [12] to illustrate the second law of thermodynamics. The model (see, e.g.,[13]) considers N particles in two containers. The particles independently change containers at a rate λ. If $X(t) = i$ is set to be the number of particles in one container at time t, then it is a birth–death process with transition rates,

$$q_{i,i-1} = i\lambda, \qquad \text{for } 1 \le i \le N$$

$$q_{i,i+1} = (N-i)\lambda, \qquad \text{for } 0 \le i \le N-1$$

and equilibrium distribution $\pi_i = 2^{-N}\binom{N}{i}$. In 1947, Mark Kac [25] proved that if the initial state is not an equilibrium state, then the Boltzmann entropy, i.e.,

$$H(t) = -\sum_{i=1}^{N} P(X(t)=i)\log\left(\frac{P(X(t)=i)}{\pi_i}\right)$$

is monotonically increasing. The manuscript of Mark Kac [25] with the solution of the approach to equilibrium of the Ehrenfests' model was awarded the 1950 Chauvenet Prize (for expository writing) of the Mathematical Association of America. Kac got a second Chauvenet Prize in 1968 for his paper *Can one hear the shape of a drum* that I discuss later. Kac spent his sabbatical year 1951–1952 at the IAS in Princeton, where he met and collaborated with John Ward on a new combinatorial solution of the 2–dimensional Ising model, which had been solved by Onsager in 1944. Although the solution of Kac and Ward had a gap that took time and effort of various people to fill, it gave new insight into the problem. The same year, Ted Berlin and Mark Kac solved [4] another model of a ferromagnet, the so called "spherical model", which is somewhat a simplification of the Ising model. Consider a square (2–d) or a cubic (3–d) lattice containing N spin sites. But instead of allowing the spins σ_i (here i denotes a lattice site) to take only the ± 1 values, allow them to be independently distributed Gaussian variables, with the additional constraint $\sum \sigma_i^2 = N$ (constraint which is obviously satisfied in the Ising model). Berlin and Kac proved that this model exhibits a phase transition in the three dimensional case (there is no phase transition at finite temperature in lower dimension), and computed the critical temperature and the critical exponents for the model.

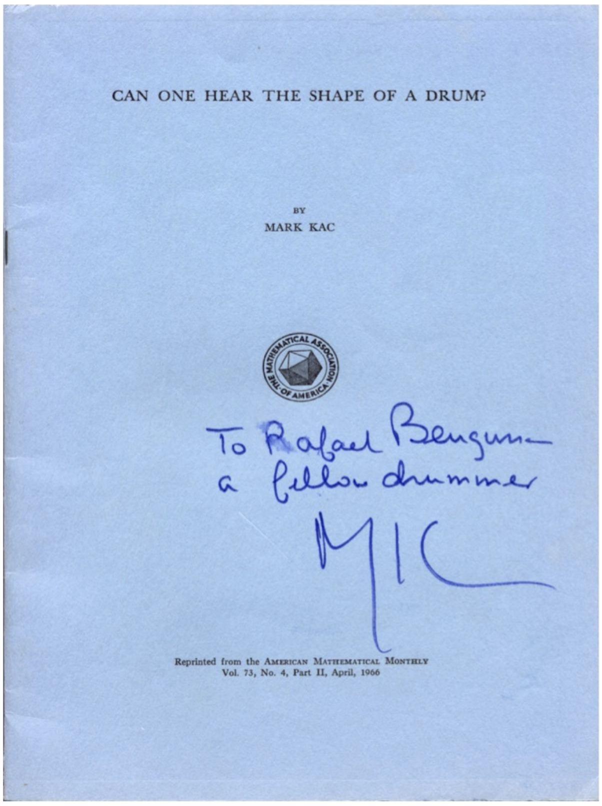
After solving the dog–flea problem, Mark Kac made further contributions in trying to solve the paradox raised by Loschmidt to the Boltzmann equation [5]. The Boltzmann equation is very successful, through the H-theorem, in establishing the approach to equilibrium in statistical mechanics and the derivation of the second law of thermodynamics. However, as Loschmidt pointed out in 1876, it is not the final picture because it is not compatible as it stands with the reversibility of the equations of motion between the interacting particles. In order to understand the problems of the Boltzmann equation, Kac [27] introduced the concept of "propagation of chaos" in connection with a specific stochastic process modeling binary collisions in a gas of a large number N of identical particles (the "Kac walk", in the space of velocities). In particular Kac was interested in the approach to equilibrium of the gas. Kac kept his interest in the "propagation of chaos" until the end of his life (see, e.g., [20]). There have been many recent developments on the properties of the "Kac Model" (see, e.g., [8, 9, 7]).

The subject of integration in function spaces was introduced by Norbert Wiener in the 1920's. According to [45], Wiener was inspired by the experimental observations on Brownian motion, in particular by the quotation in *Les Atomes* of Perrin [38]: *"...the very irregular curves followed by particles in Brownian Motion led one think of the supposed continuous non differential curves of the mathematicians"*. To justify the remark of Perrin, Wiener introduced a theory based on "the statistics of paths", constructing a measure in the space of continuous functions (see, e.g., [30, 40]). Using Wiener's measure one can prove the connection between potential theory and Brownian motion. In particular, if $T_\Omega(y)$ is the total time a Brownian particle starting at $y \in \Omega$ in $t = 0$ spends inside the bounded domain $\Omega \subset \mathbb{R}^3$, then,

$$\mathbb{E}(T_\Omega(y)) = \frac{1}{2\pi} \int_\Omega \frac{1}{|x-y|}\, dx,$$

(the potential at the interior point y produced by a uniform density supported at the boundary of Ω). Other quantities like the capacity of a set, or the scattering length of a set can be similarly characterized in terms of properties of Brownian motion. Influenced by Feynman's Ph.D. thesis [16], Mark Kac [26, 30, 32] established a rigorous connection between Schrödinger's equation and Wiener's theory, a connection which is known as the Feynman–Kac formula.

One of my favorite papers of Mark Kac is [29], dedicated to his friend and colleague George Uhlenbeck on the occasion of his 65th birthday. In 1965, the Committee on Educational Media of the Mathematical Association of America produced a film on a mathematical lecture by Mark Kac with the title: *Can one hear the shape of a drum?* One of the purposes of the film was to inspire undergraduates to follow a career in mathematics. The article [29] consists of an expanded version of that lecture. Consider two different smooth, bounded domains, say Ω_1 and Ω_2 in the plane. Let $0 < \lambda_1 < \lambda_2 \le \lambda_3 \le \dots$ be the sequence of eigenvalues of the Laplacian on Ω_1, with Dirichlet boundary conditions and, correspondingly, $0 < \lambda_1' < \lambda_2' \le \lambda_3' \le \dots$ be the sequence of Dirichlet eigenvalues for Ω_2. Assume that for each n, $\lambda_n = \lambda_n'$ (i.e., both domains are *isospectral*). Then, Mark Kac posed the following question: *Are the domains Ω_1 and Ω_2 congruent in the sense of Euclidean geometry?* A friend of Mark Kac, the mathematician Lipman Bers (1914–1993), paraphrased this question in the famous sentence: *Can one hear the shape of a drum?*



A signed copy of Kac's paper: "Can one hear the shape of a drum?"

In 1910, H. A. Lorentz, at the *Wolfskehl lecture* at the University of Göttingen, reported on his work with Jeans on the characteristic frequencies of the electromagnetic field inside a resonant cavity of volume Ω in three dimensions. According to the work of Jeans and Lorentz, the number of eigenvalues of the electromagnetic cavity whose numerical values is below λ (this is a function usually denoted by $N(\lambda)$) is given asymptotically by

$$N(\lambda) \approx \frac{|\Omega|}{6\pi^2}\lambda^{3/2}, \qquad (1)$$

for large values of λ, for many different cavities with simple geometry (e.g., cubes, spheres, cylinders, etc.). Thus, according to the calculations of Jeans and Lorentz, to leading order in λ, the *counting function* $N(\lambda)$ seemed to depend only on the volume of the electromagnetic cavity $|\Omega|$. Apparently David Hilbert (1862–1943), who was attending the lecture, predicted that this conjecture of Lorentz would not be proved during his lifetime. This time Hilbert was wrong, since his own student, Hermann Weyl (1885–1955) proved the conjecture less than two years after the Lorentz lecture. An account of the work of Hermann Weyl on the eigenvalues of a membrane is given in his 1948 *J. W. Gibbs Lecture* to the American Mathematical Society [44].

In N dimensions, (1) reads,

$$N(\lambda) \approx \frac{|\Omega|}{(2\pi)^N} C_N \lambda^{N/2}, \tag{2}$$

where $C_N = \pi^{(N/2)}/\Gamma((N/2)+1))$ denotes the volume of the unit ball in N dimensions.

Using Tauberian theorems, one can relate the behaviour of the counting function $N(\lambda)$ for large values of λ to the behavior of the function

$$Z_\Omega(t) \equiv \sum_{n=1}^{\infty} \exp\{-\lambda_n t\}, \tag{3}$$

for small values of t. The function $Z_\Omega(t)$ is the trace of the heat kernel for the domain Ω, i.e., $Z_{\Omega(t)} = \operatorname{tr}\exp(\Delta t)$. As I mention above, $\lambda_n(\Omega)$ denotes the n^{th} Dirichlet eigenvalue of the domain Ω.

The fact that the leading behaviour of $Z_\Omega(t)$ for t small, for any bounded, smooth domain Ω in the plane, is given by

$$Z_\Omega(t) \approx \frac{1}{4\pi t} A \,, \tag{4}$$

was proven by Hermann Weyl [43]. Here, $A = |\Omega|$ denotes the area of Ω. In fact, what Weyl proved in [43] is the *Weyl Asymptotics* of the Dirichlet eigenvalues, i.e., for large n, $\lambda_n \approx (4\pi\, n)/A$. Weyl's result (4) implies that *one can hear the area of the drum.*

In 1954, the Swedish mathematician Åke Pleijel [39] obtained the improved asymptotic formula,

$$Z(t) \approx \frac{A}{4\pi t} - \frac{L}{8\sqrt{\pi t}},$$

where L is the perimeter of Ω. In other words, one *can hear* the area and the perimeter of Ω. It follows from Pleijel's asymptotic result that if all the frequencies of a drum are equal to those of a circular drum then the drum must itself be circular. This follows from the classical isoperimetric inequality (i.e., $L^2 \ge 4\pi A$, with equality if and only if Ω is a circle). In other words, one *can hear* whether a drum is circular. It turns out that it is enough to hear the first two eigenfrequencies to determine whether the drum has the circular shape [1].

In 1966, Mark Kac obtained the next term in the asymptotic behaviour of $Z(t)$ [29]. For a smooth, bounded, multiply connected domain in the plane (with r holes),

$$Z(t) \approx \frac{A}{4\pi t} - \frac{L}{8\sqrt{\pi t}} + \frac{1}{6}(1-r). \tag{5}$$

Thus, one *can hear* the *connectivity* of a drum. Kac's formula (5) was rigorously justified by McKean and Singer [35].

A sketch of Kac's analysis for the first term of the asymptotic expansion is as follows [29]. If we imagine some substance concentrated at $\vec{\rho} = (x_0, y_0)$ diffusing through the domain Ω bounded by $\partial\Omega$, where the substance is absorbed at the boundary, then the concentration $P_\Omega(\vec{p} \mid \vec{r}; t)$ of matter at $\vec{r} = (x, y)$ at time t obeys the diffusion equation

$$\frac{\partial P_\Omega}{\partial t} = \Delta P_\Omega$$

with boundary condition $P_\Omega(\vec{p} \mid \vec{r}; t) \to 0$ as $\vec{r} \to \vec{a}$, $\vec{a} \in \partial\Omega$, and initial condition $P_\Omega(\vec{p} \mid \vec{r}; t) \to \delta(\vec{r} - \vec{p})$ as $t \to 0$, where $\delta(\vec{r} - \vec{p})$ is the Dirac delta function. The concentration $P_\Omega(\vec{p} \mid \vec{r}; t)$ may be expressed in terms of the Dirichlet eigenvalues of Ω, λ_n and the corresponding (normalized) eigenfunctions ϕ_n as follows:

$$P_\Omega(\vec{p} \mid \vec{r}; t) = \sum_{n=1}^{\infty} e^{-\lambda_n t} \phi_n(\vec{p}) \phi_n(\vec{r}).$$

For small t, the diffusion is slow, that is, it will not *feel* the influence of the boundary in such a short time. We may expect that

$$P_\Omega(\vec{p} \mid \vec{r}; t) \approx P_0(\vec{p} \mid \vec{r}; t),$$

ar $t \to 0$, where $\partial P_0 / \partial t = \Delta P_0$, and $P_0(\vec{p} \mid \vec{r}; t) \to \delta(\vec{r} - \vec{p})$ as $t \to 0$. P_0 in fact represents the heat kernel for the whole $\mathbb{R}^2$, i.e., no boundaries present. This kernel is explicitly known. In fact,

$$P_0(\vec{p} \mid \vec{r}; t) = \frac{1}{4\pi t} \exp(-|\vec{r} - \vec{p}|^2 / 4t),$$

where $|\vec{r} - \vec{p}|^2$ is just the Euclidean distance between $\vec{p}$ and $\vec{r}$. Then, as $t \to 0^+$,

$$P_\Omega(\vec{p} \mid \vec{r}; t) = \sum_{n=1}^{\infty} e^{-\lambda_n t} \phi_n(\vec{p}) \phi_n(\vec{r}) \approx \frac{1}{4\pi t} \exp(-|\vec{r} - \vec{p}|^2 / 4t).$$

Thus, when set $\vec{p} = \vec{r}$ we get

$$\sum_{n=1}^{\infty} e^{-\lambda_n t} \phi_n^2(\vec{r}) \approx \frac{1}{4\pi t}.$$

Integrating both sides with respect to $\vec{r}$, using the fact that ϕ_n is normalized, we finally get

$$\sum_{n=1}^{\infty} e^{-\lambda_n t} \approx \frac{|\Omega|}{4\pi t}, \tag{6}$$

which is the first term in the expansion (5). Further analysis gives the remaining terms (see [29]).

Remark: In 1951, Mark Kac proved the following universal bound on $Z(t)$ in dimension d:

$$Z(t) \le \frac{|\Omega|}{(4\pi t)^{d/2}}. \tag{7}$$

This bound is sharp, in the sense that as $t \to 0$,

$$Z(t) \approx \frac{|\Omega|}{(4\pi t)^{d/2}}. \tag{8}$$

Harrell and Hermi [21] proved the following improvement on (8),

$$Z(t) \approx \frac{|\Omega|}{(4\pi t)^{d/2}} e^{-M_d |\Omega| t / I(\Omega)}. \tag{9}$$

where $I_\Omega = \min_{a \in \mathbb{R}^d} \int_\Omega |x-a|^2 \, dx$ and M_d is a constant depending on dimension. Moreover, they conjectured the following bound on $Z(t)$, namely,

$$Z(t) \approx \frac{|\Omega|}{(4\pi t)^{d/2}} e^{-t/|\Omega|^{2/d}}. \tag{10}$$

Geisinger and Weidl [18] proved the best bound up to date in this direction,

$$Z(t) \approx \frac{|\Omega|}{(4\pi t)^{d/2}} e^{-\overline{M}_d t/|\Omega|^{2/d}}, \tag{11}$$

where $\overline{M}_d = [(d+2)\pi/d]\Gamma(d/2+1)^{-2/d} M_d$ (in particular $\overline{M}_2 = \pi/16$. In general $\overline{M}_d < 1$, thus the Geisinger–Weidl bound (11) falls short of the conjectured expression of Harrell and Hermi.

In the quoted paper of Mark Kac [29] he says that he personally believed that one cannot hear the shape of a drum. A couple of years before Mark Kac' article, John Milnor [36], had constructed two non-congruent sixteen dimensional tori whose Laplace–Beltrami operators have exactly the same eigenvalues. In 1985 Toshikazu Sunada [41] developed an algebraic framework that provided a new, systematic approach of considering Mark Kac's question. Using Sunada's technique several mathematicians constructed isospectral manifolds (e.g., Gordon and Wilson; Brooks; Buser, etc.). See, e.g., the review article of Robert Brooks (1988) with the situation on isospectrality up to that date in [6]. Finally, in 1992, Carolyn Gordon, David Webb and Scott Wolpert [19] gave the definite negative answer to Mark Kac's question and constructed two planar domains with the same Dirichlet eigenvalues.

After twenty years at the Rockefeller University (1961–1981), Mark Kac joined the University of Southern California, where he served as the Chair of the Mathematics Department. Mark Kac had many distinguished Ph.D. students and postdocs, including Daniel Stroock, Harry Kesten, Murray Rosenblatt, Henry McKean and many others. Kac earned several distinctions and awards. Apart from the two Chauvenet Prizes and the Guggenheim fellowship awarded to him, which I have already discussed, he was the John von Neumann Lecturer (SIAM) in 1961, the Josiah Williard Gibbs lecturer in the joint AMS-MAA meeting in 1967. In 1978 he was awarded the George Birkhoff prize of Applied Mathematics (AMS–SIAM). He was elected a member of the National Academy of the United States. For a long time Mark Kac served as co–chair of the "Committee of Concerned Scientists," an association which monitors and document violations of the human rights and scientific freedom of scientists all over the world. Mark Kac died on October 25, 1984 [10] after a long battle with cancer. To conclude I would like to recall some thoughts of Henry McKean [34], which I certainly share:

"...I am sure I speak for all of Kac's friends when I remember him for his wit, his personal kindness, and his scientific style. In a summer at MIT, I had the luck to have Kac as my instructor. I was enchanted not only by the content of the lectures but by the person of the lecturer. I had never seen mathematics like that, nor anybody who could impart such (to me) difficult material with such a charm."

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Erwin Schrödinger International Institute for Mathematical Physics — Restart

by Joachim Schwermer (Universität Wien)

1 Restart

In October 2010, when the Erwin Schrödinger International Institute for Mathematical Physics (ESI) had been in existence as an independent research institute since 1993, the scientific directorate and the international community of scholars had to learn with great distress of the intention of the government of Austria to cease funding for the ESI. Due to budgetary measures affecting a large number of independent research institutions in Austria, funding of the ESI would be terminated as of January 1st, 2011. Since its start it was the mission of the ESI to advance research in mathematics, physics and mathematical physics at the highest international level through fruitful interaction between scientists from these disciplines. An abrupt end for the scientific activities of the Institute and the closure of the ESI appeared on the horizon. Weeks of trembling uncertainty followed, mixed with signs of a solution in which the University of Vienna would be involved. In the wake of a protest action by renowned scholars and academic institutions worldwide, an agreement was achieved in January 2011 that the ESI could continue to exist but now as a research centre ("Forschungsplattform") at the University of Vienna. As a partner in this agreement the Ministry of Science and Research (BMWF) guaranteed to fund the "new" ESI through the University yearly with a reduced budget until 2015. At a time when pure research and scholarly activities are undervalued, the opportunities for scholars and young researchers that the Institute provides have never been more necessary. The University of Vienna took the chance and created a home for "one of the world's leading research institutes in mathematics and theoretical physics", as Peter Goddard, the chair of the international review committee for the Institute, commissioned by the BMWF, and its members put it in 2010 in a letter to the Ministry.

2 Stabilisation

With this new institutional framework in place since June 2011, it was the main task of the new governing board of the ESI, called the "Kollegium", to carry on the mission of the ESI and to retain its international reputation. These aims include, in particular, to support research at the University of Vienna, to contribute to its international visibility and appeal, and to stimulate the scientific environment in Austria. Setting aside all the technical issues the transition process of the ESI involved, and which had to be taken care of, the ESI could begin restoring its fundamental scientific activities. This was and still is the prevalent task: striving to be excellent and thereby keeping its position within the international scientific community of scholars as a research institute with a specific unique character. The ESI is a place that is very conducive to research and, at the same time, integrates scientific education and research in mathematics and mathematical physics.

In retrospect, though the planning horizon was very short, the *Thematic Programmes*, scheduled already far ahead for 2011 and 2012, turned out in the end to be successful scientific events. Additionally, various workshops and other activities could be solicited for the year 2012 on short notice, involving, in particular, young researchers who came to the Institute for the first time as organisers. In addition, by January 1, 2012, the Erwin Schrödinger Institute had established the *Research in Teams Programme* as a new component in its spectrum of scientific activties.

The transition of the Erwin Schrödinger Institute from an independent research institute to a "Forschungsplattform" at the University of Vienna was a complicated process. There are far-reaching differences in operation as a consequence of the university's involvement in the running of the Institute. This includes issues concerning payments to participants, modifications to the premises and future funding prospects. However, the Institute has continued to function, even flourish, during the radical changes of its status.

The Institute currently pursues its mission in a number of ways:

– Primarily, by running four to six *thematic programmes* each year, selected about two years in advance on the basis of the advice of the International ESI Scientific Advisory Board.

– By organizing *workshops* and *summer schools* at shorter notice.

– By a programme of *Senior Research Fellows* (SRF), who give lecture courses at the ESI for graduate students and post-docs.

– By a programme of *Research in Teams*, which offers teams of two to four *Erwin Schrödinger Institute Scholars* the opportunity to work at the Institute for periods of one to four months, in order to concentrate on new collaborative research in mathematics and mathematical physics.

– By inviting *individual scientists* who collaborate with members of the local scientific community.

Even through the transition period the ESI had to go through in the years of 2010 and 2011, the ESI has remained a leading international center for research in the mathematical sciences. This position has been achieved with a minimal deployment of resources, financial and human, especially when compared with similar institutes in other countries.

3 The Institute's Scientific Management and its Resources

The arrangements that provide for the scientific direction and administration of the Institute are perhaps among the noteworthy features of the ESI. Indeed, the Institute is run in a quite minimalist fashion.

The organizational structure of the ESI is as follows: The ESI is governed by a board ('Kollegium') of six scholars, necessarily faculty members of the University of Vienna.

These members of the board are appointed by the President (Rektor) of the University after consultations with the Deans of the Faculties of Physics and Mathematics. It currently consists of Goulnara Arzhantseva (Mathematics), Adrian Constantin (Mathematics), Piotr T. Chruściel (Physics), Joachim Schwermer (Mathematics), Frank Verstraete (Physics), and Jakob Yngvason (Physics). All members of the Kollegium still act as Professors at the University.

In addition, the Scientific Advisory Board of the ESI plays a crucial role in keeping this Institute alive scientifically. The members of the Scientific Advisory Board of the ESI, which currently consists of seven international scholars, have a variety of tasks: they assess the programme proposals submitted to the ESI, they point out interesting scientific developments in the areas of Mathematics and Mathematical Physics, and suggest topics and possible organizers for future activities of the Institute, and, most importantly, during the yearly meeting, they review – and criticize – the scientific performance of the Institute during the past year and make suggestions for possible improvements. Though the name of the Institute only contains Mathematical Physics as the subject of concern, Mathematics plays an equally important role in its scientific activities.

On June 1, 2011, the Scientific Advisory Board of the ESI was restructured. Only scholars who are not affiliated with a scientific institution in Austria can be appointed as members. Thus, at the same time, its composition changed. For the sake of continuity, John Cardy (Oxford), Horst Knörrer (ETH Zürich), Vincent Rivasseau (Paris) and Herbert Spohn (München) were reappointed. As new members Isabelle Gallagher (Paris), Helge Holden (Trondheim) and Daniel Huybrechts (Bonn) joined the Board, starting January 2012.

The day-to-day functioning of the ESI is overseen by the Director. The Director is appointed by and accountable to the Rektor of the University. Besides the ongoing oversight of the ESI, the Director chairs the Kollegium, represents the ESI at meetings of the European Institutes and has responsibility for the budget of the ESI. The Director makes sure the ESI functions in a way manner with its mission.

The administrative staff of the Institute, currently consisting of three people, two of them working on part time basis, is also extremely lean but very efficient in handling the approximately 450 visitors per year.

Situated at Boltzmanngasse 9 in Vienna, the ESI is housed in the upper floor of a two hundred-year-old Catholic seminary. This building provides a quiet and secluded environment. By its distinctive character, the ESI is a place that is very conducive to research.

The Institute is still funded by the Austrian Federal Ministry for Science and Research, via the University of Vienna, but it works on the basis of much smaller resources financially than in the years before 2011.

4 Thematic Programmes and Workshops

The Institute's scientific activities are centred around four to six larger thematic programmes per year. Planning for these programmes typically begins two years in advance.

About three quarters of the scientific budget are used for these activities each year. In addition, smaller programmes, workshops and conferences are organized at shorter notice, as well as visits of individual scholars who collaborate with scientists of the University of Vienna and the local community.

The list of research areas in mathematics, physics and mathematical physics covered by the scientific activities of the Erwin Schrödinger Institute in the years 1993 to 2013 shows a remarkable variety.

The pages of the annual ESI report, available on its web page, provide ample evidence that the high quality of the scientific programmes was sustained and, in particular, undiminished during and shortly after the radical changes the Institute had to face. Longer thematic programmes and the open approach to research they offer and encourage form a fundamental pillar of the work of the ESI. The Institute provides a place for focused collaborative research and tries to create fertile ground for new ideas.

It is generally noted, as already the Review Panel of the ESI pointed out in its report in 2008, that over the last years the ESI has widened the range of its thematic programmes and other scientific activities from being originally more narrowly focused within mathematical physics. The Scientific Directorate has increased the scope of the activities mounted by the Institute into areas of mathematics more remote at present from theoretical physics. This process will continue in the same fashion, with special emphasis on the fruitful interactions between mathematics and mathematical physics.

The themes of the programmes which were in place in 2013 range from "The Geometry of Topological D-branes", "Jets and Quantum Fields for LHC and Future Collidiers" over "Forcing, Large Cardinals and Descriptive Set Theory" to "Heights in Diophantine Geometry, Group Theory and Additive Combinatorics".

In 2014 the ESI will host four thematic programmes, the first one dealing with "Modern Trends in Topological Quantum Field Theory", followed by one centered around "Combinatorics, Geometry and Physics". The programmes "Topological Phases and Quantum Matter" and "Minimal Energy Point Sets, Lattices and Designs" cover the second half of the year, supplemented by various workshops.

5 Senior Research Fellowship Programme

In order to stimulate the interaction of the Institute's activities with the local community, the Institute initiated a Senior Research Fellowship Programme in 2000. Its main aim is attracting internationally renown scientists to Vienna for longer visits. These scholars would interact with graduate students and post-docs in Vienna, in particular, by offering lecture courses on an advanced graduate level. This programme enables PhD students and young postdoctoral fellows at the surrounding universities to communicate with leading scientists in their field of expertise. Currently W. Ballmann (U Bonn) gives a course, entitled "Geometry of Symmetric Spaces" and L. Dabrowski (SISSA) Trieste) lectures on "Spinors: Classical and Quantum – Elements of Non-commutative Riemannian Geometry".

6 ESI Scholars

By January 1, 2012, the Erwin Schrödinger Institute had established the *Research in Teams Programme* as a new component in its spectrum of scientific activties. The programme offers teams of two to four *Erwin Schrödinger Institute Scholars* the opportunity to work at the Institute in Vienna for periods of one to four months, in order to concentrate on new collaborative research in mathematics and mathematical physics. The interaction between the team members is a central component of this programme. The number of proposals, on themes of topical interest, was and is still high. However, due to limited resources, the Kollegium could only accept four applications for the year 2012 resp. five for 2013.

Of course, by invitation only, the ESI continues to have individual scientists as visitors who pursue joint work with local scientists. In some cases these collaborations originate from previous thematic programmes which took place at the ESI.

7 Junior Fellows and Summer Schools

Funding from the Austrian Federal Ministry for Science and Research (BMWF) enabled the Institute to establish a Junior Research Fellowship Programme (JRF). Its purpose was to provide support for advanced PhD students and postdoctoral fellows to allow them to participate in the activities of the ESI. Grants were given for periods between two and six months. This programme was very successful and internationally held in high esteem but unfortunately it came to an end because funding by the BMWF was terminated with the end of 2010. The presence of the Junior Reseach Fellows at the Institute, together with the Fellows of the European Post Doc Institute, had a very positive impact on the ESI's scientific atmosphere through their interaction with participants of the thematic programmes, through lively discussions with other post-docs and also through the series of JRF seminars. In conjunction with the JRF Programme, the ESI had regularly offered Summer Schools which combined series of introductory lectures by international scholars with more advanced seminars in specific research areas. However, even though the JRF programme had to be discarded, the Institute continues its long term policy of vertical integration of scientific education and research. Summer Schools are still essential components of the scientific activities of the ESI.

In 2010, a "May Seminar in Number theory" took place to introduce young researchers to exciting recent developments of current research at the crossroads of arithmetic and other fields. During the summer 2011 a school dealt with recent developments in mathematical physics. Jointly with the European Mathematical Society (EMS) and the International Association of Mathematical Physics (IAMP) the ESI organized in 2012 the "Summer School on Quantum Chaos". This Instructional Workshop attracted more than 45 graduate students, post-docs and young researchers from all over the world. A poster session accompanied this event.

8 Conclusion

With the ESI now being a research centre within the University of Vienna, the best way of benefiting the local community is to ensure that the ESI continues to function at the highest level internationally and thus attract the world's leading scholars to Vienna where their presence will enhance and stimulate research further. This has been and still is the approach successfully followed by the ESI.

Joachim Schwermer is professor of mathematics at University of Vienna and the director of the Erwin-Schrödinger Institute.

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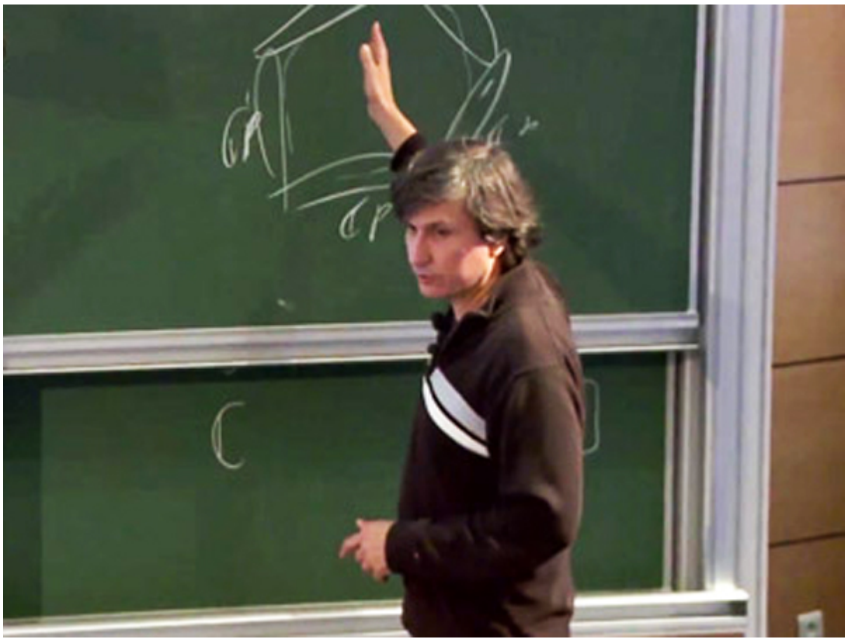
The Breakthrough Prize in Mathematics awarded to Maxim Kontsevich



Citation: *For work making a deep impact in a vast variety of mathematical disciplines, including algebraic geometry, deformation theory, symplectic topology, homological algebra and dynamical systems.*

The newly established *Breakthrough Prize in Mathematics* 2014 is awarded to Professor Maxim Kontsevich, for numerous contributions to pure mathematics. Kontsevich works at IHÉS, Paris, and is a part of Centre for Quantum Geometry of Moduli Spaces (QGM) at Aarhus University.

In 2012, Maxim Kontsevich was also awarded the *Breakthrough Prize in Physics* (then called the *Fundamental Physics Prize*), which makes him the first ever to have received both these lucrative prizes. The two prizes are given for separate scientific achievements by Maxim Kontsevich.

News from the IAMP Executive Committee

New individual members

IAMP welcomes the following new members

Prof. Xuwen Chen, Department of Mathematics, Brown University, USA

Dr. Chiara Saffirio, Mathematisches Institut, Universität Zürich, Switzerland.

Recent conference announcements

Trimester program on Non-commutative Geometry and its Applications

September-December, 2014, Hausdorff-Institut für Mathematik, Bonn, Germany

organized by
Alan L. Carey, Victor Gayral, Matthias Lesch, Walter van Suijlekom, Raimar Wulkenhaar

Web page http://www.him.uni-bonn.de/programs/future-programs/future-trimester-programs/non-commutative-geometry-2014/description

Selected Problems in Mathematical Physics

September 1-5, 2014, La Spezia, Italy

organized by
Riccardo Adami, Michele Correggi, Rodolfo Figari, Alessandro Giuliani

Web page http://sp2014.tqms.it/index.html

This conference is partially funded by the IAMP.

14th International Workshop on Pseudo-Hermitian Hamiltonians in Quantum Physics

September 5 - 10, 2014, Setif, Algeria

organized by
Chakib-Arselane Baki, Mustapha Maamache, Fayçal Kharfi, Abdelhalim Haroun, Hacene Hachemi, Kamel Bencheikh, Salim Houamer, Miloslav Znojil

Web page `http://phhqp14.univ-setif.dz`

Mathematical Challenge of Quantum Transport in Nanosystems - Pierre Duclos Workshop 2014

September 23-26, 2014, NRU ITMO, Saint Petersburg, Russia

organized by
Igor Yu. Popov, Igor S. Lobanov, Ekaterina S. Trifanova, Irina V. Blinova, Alexander I. Trifanov, Maxim A. Skryabin, Anton I. Popov

Web page http://mathdep.ifmo.ru/mcqtn2014/

This conference is partially funded by the IAMP.

Quantum Mathematical Physics

September 29 - October 2, 2014, Regensburg, Germany

organized by
Felix Finster, Jürgen Tolksdorf, Eberhard Zeidler

Web page `http://www.uni-regensburg.de/Fakultaeten/nat_Fak_I/qft2014/`

This conference is partially funded by the IAMP.

Non-Hermitean Random Matrices: 50 Years After Ginibre

October 22-27, 2014, Yad Hashmona, Israel

organized by
Peter Forrester, Yan Fyodorov, Anatoly Golberg, Eugene Kanzieper, Eugene Strahov, Jan Verbaarschot, Paul Wiegmann

Web page http://www.tinyurl.com/isf-rmt-2014

This conference is partially funded by the IAMP.

Spectral Theory and Mathematical Physics

November 24-28, 2014, Santiago de Chile

organized by
Marius Mantoiu, Georgi Raikov, Edgardo Stockmeyer, Rafael Tiedra

Web page `http://www.mat.uc.cl/~graikov/conf2014.html`

This conference is partially funded by the IAMP.

Open positions

PhD Position in Mathematical Physics at the University of Jena

A PhD position in mathematical physics will be available on October 15th, 2014, at the University of Jena. The initial appointment is for 2 years with the possibility of extension. Please send applications including

1. your CV
2. a letter of motivation or statement of research interests
3. a letter of recommendation

to David Hasler (david.hasler@uni-jena.de).

For more information see http://www.mathphys.uni-jena.de/Positions.html

Applications should be sent before August 22nd, 2014.

Postdoctoral Position in Mathematical Physics at University of Stuttgart

Applications are invited for a postdoc position in mathematical quantum physics starting October 1st, 2014 in the Stuttgart branch of the research training group *Spectral Theory and Dynamics of Quantum Systems* (GRK 1838). From applicants we expect an excellent thesis in mathematical physics or applied analysis as well as the ability and interest to contribute to the activities of the participating research groups. This is a 100 % position for 2 years without teaching assignment.

Please send your application to griesemer@mathematik.uni-stuttgart.de. For more details see: http://www.mathematik.uni-stuttgart.de/grk1838/Open/index.html.

The target date for applications is August 31, 2014.

International call from Ikerbasque

Ikerbasque, the Basque Foundation for Science, has launched a new international call to reinforce research and scientific career in the Basque Country (Europe), offering

15 positions for Senior Researchers Ikerbasque Research Professors

as permanent contract positions within any of the Basque Research Institutions, to researchers with a solid research track and leadership capabilities. Applicants must have their PhD completed before January 2006.

For further information, use this link: http://www.ikerbasque.net.

The deadline for applications is September 10th, 2014.

Postdoctoral Position in Mathematical Physics at University of Geneva

A postdoctoral position will be available starting October 1st, 2014 at the University of Geneva, in the group of J-P Eckmann. The appointment is for 2 years with the possibility of a slight extension. Candidates should have completed a PhD, and should be interested in doing research, if possible in one of the directions pursued in Geneva. Interesting proposals in other, related directions are welcome. Contact J-P Eckmann directly if you are interested.

Professorship of Applied Mathematics at University of Munich

The Faculty of Mathematics, Informatics, and Statistics invites applications for a

Full Professorship of Applied Mathematics (Chair)

commencing as soon as possible.

The chair belongs to the Analysis and Numerics group of the Department of Mathematics. Applicants are expected to complement the existing research activities of the group in a current topic of mathematical physics. Cooperation with other research groups within the Department and active participation in the current collaborative research center SFB-TR 12 and in the preparation of future proposals is encouraged.

Participation in the general teaching duties of the Department of Mathematics – including numerics – is expected. Participation in the Elite-Master-Program Theoretical and Mathematical Physics is strongly encouraged.

Prerequisites for this position are a university and a doctoral degree, teaching skills at university level, excellent academic achievements and a productive and promising research program.

LMU Munich makes a point of providing newly appointed professors with various types of support, such as welcoming services and assistance for dual career couples.

LMU Munich is an equal opportunity employer. The University continues to be very successful in increasing the number of female faculty members and strongly encourages applications from female candidates. LMU Munich intends to enhance the diversity of its faculty members. Furthermore, disabled candidates with essentially equal qualifications will be given preference.

Please submit your application comprising a curriculum vitae, documentation of academic degrees and certificates as well as a list of publications under the keyword `math7` to the Dean of the Faculty of Mathematics, Informatics, and Statistics, Prof. Dr. Andreas Rosenschon, Theresienstrae 39, 80333 Munich, Germany, and also mail the application electronically to dekanat16@lmu.de in a single pdf-file not greater than 10 MB.

The official announcement of this position is at:

http://www.uni-muenchen.de/aktuelles/stellenangebote/profs/20140717092104.html

http://jobs.zeit.de/jobs/muenchen_professur_w3_angewandte_mathematik_103509.html

The deadline for applications is September 12, 2014.

Tenure-Track Professorship in Mathematical Physics in Santiago, Chile.

The Department of Mathematics and the Institute of Physics of the Pontificia Universidad Catolica de Chile invite applications for a tenure track position at the Assistant or Associate Professor level beginning preferably in March, 2015.

Applicants should have a PhD in Mathematics or in Physics, an outstanding potential in research and a strong commitment to teaching.

Candidates are expected to be actively doing research in the area of Mathematical Physics and to have the potential of interaction with some of the established research groups both in the Department of Mathematics and in the Institute of Physics. The teaching load for this position consists of three one-semester courses per year, reduced to two courses during the first two years. Candidates are expected to be able to teach courses both in standard Bachelors in Physics and in Mathematics. The annual salary is based on a competitive scale and will depend on the level and CV of the candidate, starting from approximately USD 48,000. Moving expenses will be covered by the University. Furthermore, there exists an established system of state funded research grants in Chile. Applications must include a cover letter, description of research plans, curriculum vitae, and at least two letters of recommendation.

Application materials should be sent to Professor Alejandro Ramirez of the Department of Mathematics, aramirez@mat.puc.cl.

For full consideration, applications should be sent before October 24, 2014.

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.

Manfred Salmhofer (IAMP Secretary)

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