The Erwin Schrödinger International Institute for Mathematical Physics

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ESI NEWS

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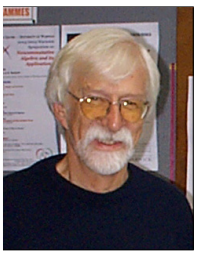
Editorial

Klaus Schmidt



The scientific activities of the ESI during the first half of 2010 began with a two-month programme on *Quantitative Studies of Nonlinear Wave Phenomena* in January and February, organized by Peter C. Aichelburg (Vienna), Piotr Bizoń (Cracow) and Wilhelm Schlag (Chicago), which was attended by 30 of the key scientists working in this area. The programme focussed on quantitative aspects of nonlinear wave phenomena, with special emphasis on asymptotic decay of linear and nonlinear waves on flat and curved backgrounds, resonances, and the dynamics of collective variables on moduli spaces.

In March and April a two-month programme on *Quantum Field Theory on Curved Space-times and Curved Target Spaces* took place at the ESI. It was organized by Stefan Hollands (Cardiff), Matthias Gaberdiel (ETH Zürich), Volker Schomerus (DESY Hamburg) and Jakob Yngvason (ESI), and investigated the construction and the understanding of quantum field theories on curved 4-dimensional space-time manifolds. Some of the advances in this area are related to ideas that have previously been developed in the context of 2-dimensional conformal quantum field theories, in particular for curved target spaces. The programme brought together 40 experts working on these problems and culminated in a one-week workshop in late March 2010.

May 2010 started off with an intensive one-week seminar on *Number Theory*, organized by Joachim Schwermer (ESI). The aim of this seminar was to introduce young researchers at the PhD and post-doc level to recent developments of current research at the crossroads of number theory and related fields. The workshop consisted of several mini-courses and invited research lectures on a variety of topics ranging from number theory proper over automorphic forms and arithmetic quantum chaos, and was attended by a total of about 30 senior and junior participants.

In May there was also a two-day symposium at the ESI on *Diskrete Mathematik*, a joint venture of the *Fachgruppe Diskrete Mathematik der DMV* and the National Research Network *Analytic Combinatorics and Probabilistic Number Theory* of the Austrian FWF, which was organized by Christian Krattenthaler (Vienna).

Currently two programmes are running simultaneously at the ESI. The first of these programmes is devoted to *Matter and radiation*, organized by Volker Bach (Mainz), Jürg Fröhlich (ETH Zürich) and Jakob Yngvason (ESI), and runs from May 3 – July 30. The programme has almost 50 participants and is devoted to the quantum mechanical description of nonrelativistic matter (i.e., atoms, molecules, and, more macroscopically, solids or gases), collecting and comparing the diversity of results established by a variety of mathematical approaches.

The second programme runs from June 7 – August 15 and has the title *Topological String Theory, Modularity and non-perturbative Physics*, organized by Ludmil Katzarkov (Vienna), Albrecht Klemm (Bonn), Maximilian Kreuzer (TU Vienna) and Don Zagier (MPI Bonn). It is devoted to the mathematical foundations of our understanding of gauge- and string theories, which in turn are the basis of our understanding of particle physics and quantum gravity. The programme contains two workshops, *D-branes, Effective Actions and Homological Mirror Symmetry* with

introductory lectures by Maxim Kontsevich and Manfred Herbst, and *Topological Strings, Modularity and non-perturbative Physics*, with introductory lectures by Thomas Grimm, Albrecht Klemm, Marcos Marino and Don Zagier. There are more than 50 scientists from mathematics and physics participating in this programme.

Due to financial constraints the budgets of these programmes had to be cut back at fairly short notice. *I would like to take this opportunity to thank the organizers for their understanding and cooperation, and to congratulate them on organizing excellent programmes in spite of the reduced budget.*

The *Senior Research Fellows Programme* of the ESI offered three lecture courses for graduate students and postdocs during the first half of 2010: *Eisenstein Series* by Neven Grbac (Rijeka), *Quantum Field Theory on Curved Spacetimes* by Stefan Hollands (Cardiff) and E_{11}*-symmetry of strings and branes* by Peter West (King's College, London).

The ESI *Junior Research Fellows Programme* (which is in the last year of its current funding cycle) supported 13 Junior Research Fellows for varying periods during the first half of 2010 to work at the Institute and to partcipate in its scientific activities. We are hoping that a planned meeting with the Minister of Science, Dr. Beatrix Karl, in July 2010 will help to clarify future funding for this programme.

Big Game Hunting in Styria

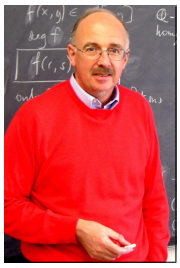
David Masser

Albert Einstein famously derided quantum-mechanical entanglement as "spukhafte Fernwirkung"[1] or "spooky action at a distance".

In 1978, Francois Ledrappier described a simple mathematical dynamical system exhibiting an unexpected, but extremely strong, dependence between observations at three arbitrarily far separated locations, although any two such observations become independent exponentially fast with increasing distance.

Mathematics tends to be less spooky than physics, but the mathematical analysis of such systems exhibiting this phenomenon of widely separated independent observations occasionally resulting in strong dependence (in the sense that any n sufficiently separated observations $a_1, \dots, a_n$ can always be independent, but can completely determine the outcome of a further observation a_{n+1} far away from the other n observations) still turned out to be quite challenging and led to surprising connections with other mathematical areas.

The following article by David Masser gives a very brief account of these developments. Much of this work was done by David Masser himself during extended visits to the ESI in 2006 and 2010.
K. Schmidt



A measure-preserving automorphism T of a probability space X is said to be mixing if for any Borel subsets B, B' of X, the sets $T^k B, T^{k'} B'$ become more and more independent as k, k' grow apart; more precisely the measures satisfy

$$\lim_{|k-k'|\to\infty} \mu(T^k B \cap T^{k'} B') \;=\; \mu(B)\mu(B').$$

In that case one might reasonably expect that for a third B'' the sets $T^k B, T^{k'} B', T^{k''} B''$ would automatically exhibit a similar independence. But no-one can prove (or disprove) this, an old problem in ergodic theory, so the latter property has to be assigned the separate name of 3-mixing. More generally one can define n-mixing for any integer $n \geq 2$. At least it is clear that 2-mixing is implied by 3-mixing is implied by 4-mixing and so on.

Perhaps surprisingly the situation changes completely when one takes another automorphism U commuting with T and replaces $T^k, T^{k'}, \dots$ with $T^k U^l, T^{k'} U^{l'}, \dots$. Namely in 1978 Ledrappier showed that the analogue of 2-mixing does not imply the analogue of 3-mixing.

His example concerns the standard shift operators T, U on the set $\mathbf{F}_2^{\mathbf{Z}^2}$ of maps φ from $\mathbf{Z}^2$ to $\mathbf{F}_2 = \mathbf{Z}/\mathbf{2Z}$, or more precisely the subset X defined by $(I + T + U)\varphi = 0$ or

$$\varphi(k,l) + \varphi(k+1,l) + \varphi(k,l+1) \;=\; 0 \qquad (1)$$

for all (k, l) in $\mathbf{Z}^2$. Then there is 2-mixing but not 3-mixing (see below).

Similar things can happen for any compact abelian group X and any mutually commuting $T_1, \dots, T_d$. It turns out that the study of such X, μ and $T_1, \dots, T_d$ is equivalent to the study of R_d-modules $\mathcal{M}$, where R_d is the Laurent polynomial ring $\mathbf{Z}[x_1, x_1^{-1}, \dots, x_d, x_d^{-1}]$. Thus for each $\mathcal{M}$ we have three possibilities:

(a) there is n-mixing but not $(n+1)$-mixing for some unique integer $n = n(\mathcal{M}) \geq 2$,

(b) there is no 2-mixing,

(c) there is n-mixing for every $n \geq 2$.

In case (b) we could write $n(\mathcal{M}) = 1$ and in case (c) we could write $n(\mathcal{M}) = \infty$.

The Ledrappier example corresponds to $\mathcal{M} = R_2/\mathcal{P}$, where $\mathcal{P}$ is the prime ideal of R_2, now say $\mathbf{Z}[x, x^{-1}, y, y^{-1}]$, generated by 2 and $1 + x + y$. Here the non-3-mixing arises from the fact that $\mathcal{P}$ contains a polynomial $1 + x + y$ with only 3 terms, leading to $1 + x^{2^r} + y^{2^r} = 0$ $(r = 0, 1, 2, \dots)$ in $R_2/\mathcal{P}$ or

$$\varphi(k,l) + \varphi(k+2^r,l) + \varphi(k,l+2^r) \;=\; 0 \;(r = 0, 1, 2, \dots) \quad (2)$$

for all (k, l).

Now define B in X by $\varphi(0,0) = 0$ and $S = \{\mathbf{0}, \mathbf{e}, \mathbf{f}\}$ in $\mathbf{Z}^2$ by $\mathbf{0} = (0,0)$, $\mathbf{e} = (1,0)$, $\mathbf{f} = (0,1)$. Then with the notation $\mathbf{T^k} = T^k U^l$ for $\mathbf{k} = (k, l)$ and $q = -2^r$ the sets $\mathbf{T}^{q\mathbf{0}} B, \mathbf{T}^{q\mathbf{e}} B, \mathbf{T}^{q\mathbf{f}} B$ are not independent, because by (2) with $k = l = 0$ the intersection of any two is contained in the other. Of course here the exponent vectors have a special shape corresponding to the multiple qS.

It may be difficult to determine $n(\mathcal{M})$ in general, and it is not quite clear if this problem has a meaning. But in his 1995 monograph Klaus Schmidt has asked if it is possible to determine $n(R_d/\mathcal{P})$ for any given prime ideal $\mathcal{P}$ in any R_d.

This was done in the summer of 2006 by Harm Derksen and myself. In 2004 I had shown that non-$(n+1)$-mixing always comes from some S in $\mathbf{Z}^d$ as above, called a non-mixing set, of cardinality $n + 1$. Klaus Schmidt then asked if it was possible to find all non-mixing sets with smallest $n = n(R_d/\mathcal{P})$ (when finite). This we have now done. In particular we have proved that when $1 < n < \infty$ there are only finitely many such animals modulo a certain natural equivalence relation, and these can be found in an effective way.

Already the Basel Master Thesis of Dominik Leitner shows that $\{\mathbf{0}, \mathbf{e}, \mathbf{f}\}$ is the only class of non-3-mixing set for the Ledrappier example. Here $\mathcal{P}$ can be considered as principal in $\mathbf{F}_2[x, x^{-1}, y, y^{-1}]$, and it occurred to me that a more convincing confirmation of the above effectivity would be for a non-principal ideal. The simplest interesting example seems to be that generated by

$$x^2 + x + 1 + y,\; x^3 + x + 1 + z \qquad (3)$$

[1] A. Einstein, *The Born-Einstein Letters; Correspondence between Albert Einstein and Max and Hedwig Born from 1916 to 1955*. New York: Walker 1971. (Cited in *Quantum Entanglement and Communication Complexity* (1998), by M. P. Hobson et. al., p. 1/13.)

in $\mathbf{F}_2[x, x^{-1}, y, y^{-1}, z, z^{-1}]$. We see from the above discussion that it is essentially a question of finding all "shortest" polynomials in $\mathcal{P}$. This problem is not covered by the standard algebra algorithms of Hermann, Hentzelt, Seidenberg, Lazard, Buchberger, Gröbner,....

Of course (3) themselves are good candidates and each one implies that there is no 4-mixing. One can prove relatively quickly that there is 3-mixing, so it is now a question of finding all polynomials in $\mathcal{P}$ with four terms. Already Derksen had observed that the sum $x^3 + x^2 + y + z$ of (3) is one, as well as

$$x^2 + 1 + xy + z \;=\; x(x^2 + x + 1 + y) + (x^3 + x + 1 + z).$$

We expected that there might be at most a couple more, so I happily embarked on the hunt, working interactively with Maple. Unfortunately it took me about 20 hours of stalking, during which time more and more examples turned up. I stuck to it, supposing that they would sort themselves into relatively few equivalence classes. But no! As well as the harmless

$$x + xy + y + z \;=\; (x + 1)(x^2 + x + 1 + y) + (x^3 + x + 1 + z)$$

and the wilder

$$x^7 + 1 + xz^2 + z,\; x^{10} + x^5z^2 + y^2 + yz^3,$$

the ferocious

$$x^{21} + 1 + x^{16}yz + y^4z^4$$

turned up in a country house near Murau over Easter; and finally

$$x^{21}z + x^{20}y + y^{12} + z^4,\; x^{25} + x^{20}yz + y^{12} + z^4 \qquad (4)$$

were detected lurking in the suburbs of Vienna. In all I found 137, which would have pleased Sir Arthur Eddington, and I am fairly sure that these are all; on the other hand one or two may well have escaped under cover of the exceptionally drinkable Murauer beer.

I do not know any explicit expressions for (4) as combinations of the generators (3). But here the ideal membership can be tested very easily, because we get an isomorphism from $R_3/\mathcal{P}$ to $\mathbf{F}_2[x]$ by sending y to $x^2 + x + 1$ and z to $x^3 + x + 1$. So for the last in (4) all one has to do is check that

$$x^{25}+x^{20}(x^2+x+1)(x^3+x+1)+(x^2+x+1)^{12}+(x^3+x+1)^4 \;=\; 0 \qquad (5)$$

in $\mathbf{F}_2[x]$.

In fact it is the study of equations like $G_0+G_1+G_2+G_3 = 0$ in (5), to be solved in elements of a finitely generated multiplicative group, that lies behind the material explained here. This connexion was first observed by Klaus Schmidt and Tom Ward in 1993, and here it is the analogue for positive characteristic that is needed. Such analogues, even in the much broader context of so-called Mordell-Lang for semiabelian varieties, had been proved by logicians such as Hrushovsky, Scanlon, Moosa, Ghioca using model theory; but Derksen and I gave a more elementary approach in the multiplicative case leading to effective and even explicit estimates. The estimates are large but they have to be; and we close this article with some really big game: the smallest solution of $x^{42}G + G' = 1$ with G, G' in the group generated by x^{83} and $1 - x$ in $\mathbf{F}_2(x)$ is

$$G = (x^{83})^{29130742641316365655570},$$

$$G' = (1 - x)^{24178516392292583494123 52}.$$

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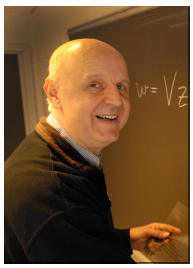
Emigration of German–speaking mathematicians from Nazi Germany: the case of the Austrian emigrants

Reinhard Siegmund-Schultze



Introduction

In a recent book (2009) I have discussed the emigration of "German-speaking" mathematicians from Nazi Germany after 1933, and from Austria and Czechoslovakia after 1938/39. Most of them had to leave their countries as "Jews" (by Nazi definition) or due to political dissent. But for the sake of tracing the effects on the mathematics as a whole and for lack of complete information about motives I have tried to find all mathematicians who emigrated, even if other reasons for emigration might have existed.

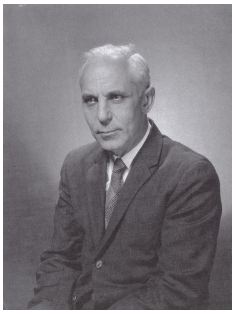
In order to make the wealth of material manageable, restrictions had to be introduced. Only those refugees were included in the systematic analysis who worked as mathematicians when the Nazis seized power or who had at least finished a full education (studies) in mathematics. The list of emigrants which could be found includes 145 mathematicians among them 15 women. (This leaves still the question open who was considered a "mathematician"; a few remarks on that below.)

The discussion of "Non-German-speaking" mathematicians, particularly of the Polish, who probably suffered the most under occupation and extermination, had to be left to the historians of the respective countries who know the languages and relevant archives better. On the other hand, mathematicians such as John (János) von Neumann, whose mother tongue was not German but who were "mathematically socialized" in German-speaking surroundings were included for the sake of the completeness and systematics of the analysis.

More for pragmatic than for principal reasons, the book focuses on mathematics as a research subject, at that time largely carried out at universities, in spite of the tentative start of "industrial mathematics." Mathematics teachers, who do not usually contribute to mathematics as a research subject, are not principally excluded. However the emigration of teachers in mathematics has rarely been investigated

so far and is consequently difficult to evaluate as to its effects upon the host countries. It seems evident, though, that teachers had much less chance of emigration than research mathematicians. Their collective destiny, especially that of the Jews amongst them, is still in need of investigation.

Evaluating gains and losses during emigration one has to be careful not to fall into the *post hoc, ergo propter hoc* trap, i.e. to claim that developments in the host countries (the gain) would not have taken place without immigration. The opposite assumption - that these developments would have taken place in the country of origin as well (the loss) - is equally illegitimate. This also shows that research on emigration cannot evade the dilemmas of "counterfactual" historical claims, which can only be handled with extreme care in a historical investigation.



***Franz Alt** (born 1910): The student of Karl Menger in topology and geometry left Vienna only a few months after the "Anschluss" in 1938 and worked in the U.S. in econometry and computing. He lives today in New York City.*
Courtesy: Franz Alt (New York City)

Nazi-enforced emigration had to be compared to emigration before and after Nazi-rule as to motives, conditions and effects. The book discusses the mechanisms of expulsion and the fate of those who did not reach safe havens abroad. The obstacles within Germany against emigration and within the host countries against immigration had to be investigated. But also the solidarity on the part of foreign colleagues and fellow-refugees is analyzed, the help which immigrants received in the host countries, among which of course the United States figures prominently with about 60 percent of the emigrants ending up there. Finally, the scientific effects of emigration, not least for the war effort, receive broad attention in the book although mostly in a non-technical manner. The specificity of the mathematical emigration compared to the emigration of physicists had to be considered. It can be argued that emigration itself and the orientation towards applications during the war, including the beginnings of digital computing, are the two historical outcomes of the Nazi regime most important to the global development of mathematics.

*This picture was taken in front of the poster dedicated to the refugee from Vienna, Franz Alt, at the Vienna exhibition titled "Cool Good Bye from Europe", in September 2001. From right to left **Franz Alt**, **Robert M. Wald** (the well-known theoretical physicist and cosmologist, son of the emigrant, Abraham Wald), **Reinhard Siegmund-Schultze**, and the organizer of the exhibit, **Karl Sigmund**.*
Courtesy: Karl Sigmund (Vienna)

The case of Austria

The present article aims at presenting some facts about the special conditions which affected refugee mathematicians from Austria. (For more details, biographical and bibliographical reference the reader is referred to the book mentioned.) The most important biographical source for Austrian mathematicians, in particular from Vienna, is the two-volume dissertation Einhorn (1985). Some work on emigration has been done before, for instance by Austrian scholars such as Reiter (2001) and Stadler (1988/89), but mostly not limited to mathematics. (See however the early work by Binder 1984 and Pinl/Dick 1974/76). An exhibit (Sigmund 2001) on refugee-mathematicians was organized by Karl Sigmund in Vienna in 2001 which hosted the only German-speaking refugee who is still alive today. This is the topologist and later pioneer in scientific computing, Franz Alt

The exhibit was later shown in extended form in various places in Germany as well. It documents the increased effort on the part of Austrian scientists for a critical view on the history of their disciplines. Reiter (2001) reminds the Austrian public to live up to its responsibilities for a critical coping with the past which — compared to Germany — was delayed in Austria by possibly a decade or so.

Early emigration from Austria due to Nazification before 1938

Many Austrians had left their country already before 1938. Some had left even before 1933 such as Richard von Mises (1883-1953) and his future wife Hilda Geiringer (1893-1973), others such as topologist Karl Menger (1902-1985) could not tolerate the gradual process of Nazification in Austria after 1933. Austrians, working in Germany such as von Mises and Geiringer, were affected by the Nazi seizure of power in 1933, others were temporarily protected (such as the physicist Lise Meitner), if they had retained their Austrian citizenship. For all these reasons one has to look for early emigrants from Austria, i.e. those before 1938, too.

In any case, Austria was certainly no possible resort for refugees from Nazi Germany after 1933. The differential geometer Adalbert Duschek, then a Privatdozent at the Technical University in Vienna, wrote in November 1934 a pessimistic letter about the prospects of the young German function theorist Peter Thullen:

"Quite confidentially, and in order to spare Mr. Thullen a disappointment, I want to remark that he has no prospects at all here, if he happens to be a Jew. To be sure they are not yet as rigid in this point as in the German Reich, but a certificate of baptism (not a recent one) and corresponding looks are also here a prerequisite."

Already in October 1933, Menger had been worried about the political censorship of letters and therefore wrote to his colleague O. Veblen in Princeton from Geneva rather than from Vienna:

Karl Menger

***Karl Menger** (1902-1985), the famous topologist (dimension theory) went to the United States already before 1938, due to increasing anti-Semitism in Austria*
Courtesy: Karl Sigmund (Vienna) (reproduced from Sigmund (2001), p. 14)

"What I could not write you from Vienna is a description of the situation there. You know how fond I am of Vienna and how many things I started there in the intention of staying there still a good many years. But the moment has come when I am forced to say: I hardly can stand it longer. First of all the situation at the university is as unpleasant as possible. Whereas I still don't believe that Austria has more than 45 percent Nazis, the percentage at the universities is certainly 75 percent and among the mathematicians I have to do with, except of course some pupils of mine, not far from 100 percent."

At the same time Menger acknowledged that - for all his "fondness of Vienna" - he had found "a good many years" a move to the United States as being in the interests of his scientific career:

"I never did anything to move to America (v. Neumann, for instance, told me in September that he sometimes was wondering if I would like to go), though it has been my desire since a good many years, ... since I realized that in some of the most important matters of culture particularly in sciences, America is the presence and Europe the past."

Menger had to wait three more years before finding a position at the University of Notre Dame near Chicago; but he came in January in 1937, one year before the Germans occupied Austria, making him technically speaking an "early" emigrant according to our definition.

Voluntary emigration?

Connected to the topic of "early emigration" another problem comes up: under which circumstances is one allowed to consider emigration as "voluntary" as opposed to "forced" by the Nazis? This question had also importance for the "coping with the past" after the war, in particular compensation claims by refugees. Richard von Mises,

***Richard von Mises** (1883-1953): The versatile applied mathematician, engineer, positivistic philosopher and Rilke specialist had to leave Berlin in 1933 and went through an exile in Turkey finally to the United States*
Courtesy: Magda Tisza (Boston)

for one, had to struggle with German authorities after the war who wanted to deny him compensation because he had left Berlin already in 1933. Formally he was then still protected by a clause in the anti-Semitic laws which left out from dismissal those who were pre-World War I-officials or participants in World War I. But this clause was cancelled in 1935. Anyhow, Jewish mathematicians such as von Mises were clearly under threat, they left in awareness of the impending developments. As in the case of von Mises, they often had to leave their work and projects in shambles and unfinished. This was definitely not "voluntary"!

Which mathematical research fields have to be included in the discussion: logic and philosophy?

In a work on emigration of mathematicians it is a major methodological problem to decide which disciplines belong or do not belong to mathematics, how in particular one has to delimitate mathematical physics from mathematics. One wants to represent mathematics in as broad as possible a thematic variety, and, on the other hand, has to avoid an inappropriate inflation of the notion of "mathematician" which could disperse the historical focus.

Including logicians into the realm of mathematics does not seem to be too controversial, but things are getting tricky once one includes researchers on the foundations of mathematics and epistemologists, for instance the members of the Vienna Circle of Logical Positivism. The exclusion of some emigrants connected to the Vienna Circle such as Edgar Zilsel, Friedrich Waismann, and Felix Kaufmann is probably the most problematic choice made in the book under discussion and was in no small measure a subjective decision by the author. A towering figure and mathematically sophisticated man such as the logician Kurt Gödel had of course to be included. However in his case again the question occurs whether his emigration was "enforced" by the Nazis. Gödel was not Jewish and he hesitated to emigrate for quite a while, a fact which emigrants like Menger disliked. His decision to go to the Institute for Advanced Study (IAS) in Princeton as late as 1939 was influenced by economic rather than by political considerations. (See Dawson Jr.1997)

The effect of and the reactions to the annexation of Austria in March 1938

In retrospect the German mathematician-refugee Wolfgang Wasow saw in 1986 an amazing lack of prescience on the part of the Austrian Jews shortly before the occupation by the Nazis ["Anschluss"] in 1938:

"It was then - and still is now - a mystery to me that most Austrian Jews were just as unprepared for what happened as the Jews in Germany had been five years ear-

lier. Looking at the events in Germany, they should have taken as many of their possessions as possible abroad, while there still was time. Very few had done that. To get out with at least some of your money and to find a country that would let you in was much harder in 1938 than in 1933."

Among those who were prescient enough and saved their money was Richard von Mises, who transferred his assets from Vienna in time, but he had the first-hand experience of Berlin, where he had to leave in 1933. Austrian mathematicians within the German Reich often reacted quite differently, particularly if they were not affected by the racist laws. However, not many went to the extremes of the geometer of Hamburg, Wilhelm Blaschke, who had been born in Austrian Graz and welcomed the annexation of his country in 1938 as the fulfillment of a "dream from my younger years." In a review of a volume of the American Mathematical Society devoted to the 50th anniversary of the Society Blaschke criticized that the publication *"is shamefully silent about the national [völkisch] origin of the representatives of American scholarship."* On the same page Blaschke wrote, maybe not without feeling of envy and of anger about the flight of many talented emigrants from Germany, but certainly with unabashed anti-Semitic overtone (replacing Jews by fictitious Afro-Americans in Princeton):

"The most surprising thing is the mathematical large-scale enterprise [mathematische Großunternehmen] in the little Negro village of Princeton, where almost one hundred mathematical docents, with no students to speak of, are laying their golden eggs."

Jewish Austrians in the German "Altreich" such as the physicist Lise Meitner had to leave now. For the mathematicians in Austria the German racist laws came immediately into effect, which cost Adalbert Duschek, who was mentioned above, his job: he was dismissed both for political reasons and due to his marriage to a Jew.

Females among the Austrian refugees: Taussky and Geiringer

Among the fifteen women-mathematicians who emigrated from Nazi-oppression, the three most successful as researchers were probably Emmy Noether from Göttingen, Hilda Geiringer, and Olga Taussky,

the latter two Austrians. The last-named, as the youngest among them, had the relatively "easiest" fate as an early refugee from Austria and as a forced refugee from Göttingen; she soon won fellowships in England and the U.S. as a promising young mathematician.

Olga Taussky *(1906-1995): trained in mathematics in Vienna, Taussky left Göttingen and Vienna in 1934 for England and went after the war to the United States. She is best known for her work in matrix theory and number theory.*
Courtesy: Portrait Collection Mathematical Research Institute Oberwolfach

The hardest hit was apparently Hilda Geiringer, who was dismissed 1933 at Berlin University from her position in applied mathematics as an assistant to Richard von Mises.

Rightly recognizing that she was in a particularly disadvantaged position as a woman in the male profession of mathematics, Geiringer apparently felt the need to formally diminish her age in 1933 from 39 (i.e. nearly 40) to 37 in order to improve her chances of emigration.

She gave 1895 as her year of birth in all her correspondence with the *British Society for the Protection of Scientific Learning* (SPSL) and with other refugee organizations, only to return to the correct year of birth 1893 in her American marriage- and naturalization certificates of the mid-1940s. In spite of this very reasonable move, Geiringer fell nearly victim to the Nazis in October 1939 when desperately waiting for an American visa in Lisbon.

Hilda Geiringer *(1893-1973): the able applied mathematician (statistics, plasticity) from Vienna, was dismissed in Berlin 1933 and followed Richard von Mises into Turkish and American emigration. They married in 1943.*
Courtesy: Magda Tisza (Boston)

The effect for the host countries and the specific conditions for the Austrian emigrants after 1938

Which conditions were specific for the emigration of Austrian mathematicians after 1938 as opposed to the previous emigration from Germany?

At least two things: Nazi enforced emigration occurred rather late compared to Germany, only after March 1938, and there were peculiarities of Austrian research traditions in mathematics (topology, statistics, logic, epistemology) compared to the German ones.

The first point implies that many positions abroad were already filled. Thus about 90 percent of the mathematicians expelled from Berlin and Göttingen were able to emigrate, while only two thirds of those from Vienna were able to flee after the occupation of Austria, and only one third of the dismissed were able to escape from Prague after the annexation of the Czech Republic.

The second point, however, the peculiarities of Austrian research topics, softened the effects of the late emigration, inasmuch as there was a demand abroad for the respective special disciplines.

In another somewhat contradictory way

the fates of the emigrants were affected by the particularities of the Nazi occupation of Austria: sometimes the immigrants were considered as Germans, and thus as enemy-aliens, sometimes, however, they counted as victims of the Nazis (and rightly so, unlike many Austrians back home) and were thus easier eligible for war research although not with the same priority as American citizens. However, the exigencies of war could also lead to early naturalization, as apparently in the case of the Austrian immigrant Abraham Wald,

Abraham Wald *(1902-1950) came from a Jewish family of Kolozsvár (Klausenburg/Cluj) in Hungary. He studied geometry under Menger in Vienna. After his emigration to the United States in 1938 Wald turned to statistics. His sequential analysis became famous and already part of the war effort.*
Courtesy: Portrait Collection Mathematical Research Institute Oberwolfach

whose statistical sequential analysis was of particular importance to the American war effort.

In terms of the impact of emigration of those disciplines which had been particularly cultivated in Austria one should remark:

The late immigration to the U.S. of the Austrians E. Helly, A. Wald, E. Lukacs contributed to the development of mathematical statistics in this country, although progress in this area had already been made due to the influence of British, Scandinavian and Polish research.

In mathematical logic (K. Gödel) and in topology (K. Menger) the more influential immigrants were again from Austria (compared to Germany); in topology they encountered a strong American tradition (O. Veblen, J. W. Alexander, R. L. Moore), which had already benefitted greatly before from the early immigration of non German-speaking countries (S. Lefschetz, E. R. van Kampen).

The rise of analytical philosophy of science in the U.S. occurred at the intersection of the theory of probability, foundations of mathematics and philosophical research. It was among others influenced by former members of the Vienna Circle, who, as outlined above, cannot generally be considered as mathematicians.

After the war

No general and official invitation was ever extended to the emigrants to return to Germany or to Austria after the war, nor was it always made easy for them to regain their German or Austrian citizenship. Only very few Germans or Austrians returned, among the latter the applied mathematician Albert Basch (1882-1958).

Quite to the contrary, some authorities used at least temporarily the argument of alleged ”voluntary“ emigration (as described above) to deny emigrants their compensation claims.

In several cases honorary doctorates (von Mises, Geiringer, Hempel etc.) were extended to emigrants by German and Austrian universities, and were accepted. However, invitations to join societies and Academies in Germany often received negative responses from former refugees, owing to old wounds and disappointments. According to Stadler Menger’s wish to return to Vienna ”failed miserably“, while several former Nazis continued to blossom in their careers at their original institutions after the war. (Reiter/Schurawitzki 2005)

Also on the level of disciplines and ideas, the re-import did not always work, as is clear in the case of the analytical philosophy of science in the tradition of the Vienna Circle. These traditions were re-incorporated in Austria too late to make up for the losses due to emigration.

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Reinhard Siegmund-Schultze is Professor for History of Mathematics at the Universitetet i Agder, Kristiansand, Norway.

New Appointment in Gravitational Physics at the University of Vienna: Piotr T. Chrusciel

Robert Beig and Wolfgang L. Reiter

Piotr T. Chrusciel had been appointed in April 2010 Professor of Gravitational Physics, Working Group of Gravitational Physics, Faculty of Physics at the University of Vienna.

Chrusciel, in the recent past was a frequent visitor at the ESI and co-organizer of programmes on gravitational physics and related topics together with Bobby Beig at the ESI.

Chrusciel is a leading researcher in the field of Mathematical General Relativity. He has made important contributions to several areas within that field, most notably Penrose's cosmic censorship hypothesis and the mathematical theory of black holes. He has been a participant in several ESI workshops and a co-organizer (with Robert Beig) of the 1993 workshop on 'Penrose Inequalities'. A Penrose inequality is a lower bound of the total mass of a balck hole spacetime in terms of the area of the black hole. By the time when the workshop took place, there had been several proofs of this inequality in an important special case. Progress on the general case, started at that workshop, is still happening, but no final proof has emerged so far. Chrusciel and Beig also collaborated on a number of other issues in the field of general relativity. An example is a paper introducing and studying the concept of 'KIDs' or 'Killing initial data', i.e. initial data for the Einstein equations having the property that the evolved spacetime has a continuous symmetry. This concept has been further studied by several other researchers in the field.

Curriculum vitae:
Born 1957, Zabrze, Poland;
1975 "Certificat de Maturité" (baccalauréat) at College Rousseau, Geneva, Switzerland;
1980 Graduated from the Department of Physics, Warsaw University;
1980-1985 PhD student, Institute for Theoretical Physics, Polish Academy of Sciences, Warsaw;
1983 Participant of the "Relativity, Groups and Topology II", Les Houches Summer School;
1984 French Gouvernement Scholarship at Université Paris VI;
1986 PhD in Physics, Institute for Theoretical Physics, Polish Academy of Sciences, Warsaw;
1985-1996 Research Position, Institute of Mathematics, Polish Academy of Sciences, Warsaw;
1987-1987 "Maitre de Conférence", Department of Mathematics, Université de Tours, France;
1987-1989 Research Associate Physicist, Physics Department, Yale University;
1988 Visiting Fellow, Center of Mathematical Analysis, Australian National University, Canberra;
1989 Visiting Member, Courant Institute of Mathematical Sciences, New York University;
1990 Visiting Fellow, Center for Mathematical Analysis, Australian National University, Canberra;
1991-1992 Australian Research Council Senior Research Associate position, Center for Mathematical Analysis, Australian National University, Canberra;
1992 "Professeur invité au contingent national", Department of Mathematics, Tours University, France
1992-1993 Alexander von Humboldt Fellowship, Max Planck Institut für Astrophysik, Garching;
1993 Habilitation Thesis: "Asymptotic problems in general relativity", Scientific Council of the Institute of Mathematics, Polish Academy of Sciences, Warsaw;
1993 Visiting Research Physicist, Institute for Theoretical Physics, University of California, Santa Barbara;
1993-1994 Alexander von Humboldt Fellowship, Max Planck Institut für Astrophysik, Garching;
since 1994 Professor of Mathematics at the Département of Mathematics, Université de Tours, France;
1998 Alexander von Humboldt Fellowship, Albert Einstein Institute for Gravitation, Potsdam;
2005 EPSRC Fellowship, Newton Institute for Mathematical Sciences, Cambridge;
2006 Research Fellowship at the Albert Einstein Institute for Gravitational Physics, Max Planck Institute, Golm;
2007 Fellow of Hertford College, Oxford, University lecturer with title of Professor at the Mathematical Institute, University of Oxford.

News from the ESI Community

Anton Zeilinger was affiliated as member of the **Académie des Sciences de l'Institut de France** together with the US-physicist **Curtis G. Callan** of Princeton University.

Anton Zeilinger was awarded the **Wolf Price** of the Wolf Foundation (Israel) for physics 2010 together with **Alain Aspect** (Laboratoire Charles Fabry de Institut d'Optique - Institut d'Optique-CNRS-Université Paris-Sud 11, France) und **John Clauser** (USA) The Wolf Prize is awarded to prominent researchers of the scientific community for their work. It is considered one of the most prestigious prizes in the scientific world.

Peter Zoller received the **Benjamin Franklin Medal** of the Franklin Institute for physics 2010 together with **Ignacio Cirac** (MPI, Munich) und **David Wineland** (Bolder, USA)

The 65th birthday of **Anton Zeilinger** was celebrated on May 20 with lectures by **Helmut Rauch** on *"From Neutron Research to Quantum Information"* and by **Jeffrey Bub** on *"How Can It Be*

Like That" at the Lise Meitner Lecture Hall. The lectures were followed by a reception at the premisses of the Faculty of Physics.

Maria Marouschek, nèe Windhager, one of our three most charming ladies at the ESI secretariat since many years, was married to **Christian Marouschek** in May. All our best wishes are with the newly married couple!

ANNOUNCEMENT

In commemoration of the 50th anniversary of Erwin Schrödinger's[2] death, ESI is organizing a Symposium on January 14 – 15, 2011 on

ERWIN SCHRÖDINGER – 50 YEARS AFTER

in cooperation with the Faculty of Physics, University of Vienna.

Organizing Commitee: Christoph Dellago, Wolfgang L. Reiter, Jakob Yngavason

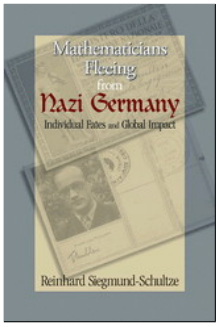
The Symposium will be accompanied by an exhibition organized by the Österreichische Zentralbibliothek für Physik on the "Life and Work of Erwin Schrödinger" at the premisses of the ESI.

The following speakers have accepted intivations to date: Roberto Car (Princeton), Olivier Darrigol (Paris), Jörg Fröhlich (Zürich), Helge Kragh (Aarhus), Jürgen Renn (Berlin), Walter Thirring (Wien), Anton Zeilinger (Wien) and Peter Zoller (Innsbruck).

[2]Erwin Schrödinger, 12 August 1887, Wien-Erdberg – 4 August, 1961, Wien

New Books

Reinhard Siegmund-Schultze: Mathematicians Fleeing from Nazi Germany: Individual Fates and Global Impact.



Princeton and Oxford: Princeton University Press 2009

The emigration of mathematicians from Europe during the Nazi era signaled an irrevocable and important historical shift for the international mathematics world. *Mathematicians Fleeing from Nazi Germany* is the first thoroughly documented account of this exodus.

In this greatly expanded translation of the 1998 German edition, Reinhard Siegmund-Schultze describes the flight of more than 140 mathematicians, their reasons for leaving, the political and economic issues involved, the reception of these emigrants by various countries, and the emigrants' continuing contributions to mathematics. The influx of these brilliant thinkers to other nations profoundly reconfigured the mathematics world and vaulted the United States into a new leadership role in mathematics research.

Based on archival sources that have never been examined before, the book discusses the preeminent emigrant mathematicians of the period, including Emmy Noether, John von Neumann, Hermann Weyl, and many others. The author explores the mechanisms of the expulsion of mathematicians from Germany, the emigrants' acculturation to their new host countries, and the fates of those mathematicians forced to stay behind.

The book reveals the alienation and solidarity of the emigrants, and investigates the global development of mathematics as a consequence of their radical migration.

An in-depth yet accessible look at mathematics both as a scientific enterprise and human endeavor, *Mathematicians Fleeing from Nazi Germany* provides a vivid picture of a critical chapter in the history of international science.

Content

Chapter 1: The Terms "German-Speaking Mathematician," "Forced," and "Voluntary Emigration";
Chapter 2: The Notion of "Mathematician" Plus Quantitative Figures on Persecution;
Chapter 3: Early Emigration;
Chapter 4: Pretexts, Forms, and the Extent of Emigration and Persecution;
Chapter 5: Obstacles to Emigration out of Germany after 1933, Failed Escape, and Death;
Chapter 6: Alternative (Non-American) Host Countries;
Chapter 7: Diminishing Ties with Germany and Self-Image of the Refugees;
Chapter 8: The American Reaction to Immigration: Help and Xenophobia;
Chapter 9: Acculturation, Political Adaptation, and the American Entrance into the War;
Chapter 10: The Impact of Immigration on American Mathematics;
Chapter 11: Epilogue: The Postwar Relationship of German and American Mathematicians.

Reinhard Siegmund-Schultze is Professor of the History of Mathematics at the University of Agder, Kristiansand, Norway.

New ESI Lectures in Mathematics and Physics

Emil J. Straube (Texas A+M University, College Station, USA)

Lectures on the $\mathcal{L}^2$-Sobolev Theory of the $\bar{\partial}$-Neumann problem

Zürich: European Mathematical Society Publishing House 2010.

This book provides a thorough and self-contained introduction to the $\bar{\partial}$-Neumann problem, leading up to current research, in the context of the $\mathcal{L}^2$-Sobolev theory on bounded pseudoconvex domains in $\mathbb{C}^n$. It grew out of courses for advanced graduate students and young researchers given by the author at the ESI and at Texas A+M University.

The introductory chapter provides an overview of the contents and puts them in historical perspective. The second chapter presents the basic $\mathcal{L}^2$-theory. Following is a chapter on the subelliptic estimates on strictly pseudoconvex domains. The two final chapters on compactness and on regularity in Sobolev spaces bring the reader to the frontiers of research. Prerequisites are a solid background in basic complex and functional analysis, including the elementary $\mathcal{L}^2$-Sobolev theory and distributions. Some knowledge in several complex variables is helpful. Concerning partial differential equations, not much is assumed. The elliptic regularity of the Dirichlet problem for the Laplacian is quoted a few times, but the ellipticity results needed for elliptic regularization in the third chapter are proved from scratch.

New Journal on Historical Perspectives on Contemporary Physics: The European Physical Journal H

Managing Editor: Wolfgang Beiglböck

A New Part of *The European Physical Journal* EPJ H:
Historical Perspectives on Contemporary Physics
was started in 2010.

For the first time a journal addressing the history of physics and for the discussions of its underlying concepts will become an integral part of a core physics publishing platform. Written primarily by physicists for physicists it signals that those issues are a necessary part of modern physics. The knowledge of the historic and philosophical background gives that kind of independence from prejudices of the highly specialized scientist and will keep active researchers open-minded. This is particularly true nowadays, where, alongside the reductionist approach championed over the centuries, the emerging paradigms of complexity and system sciences are providing new opportunities and frameworks for the natural sciences, physics in particular.

Researchers are interested in the struggles, accomplishments but also in the mistakes and false leads of the past as these may be instructive for their own work. Many of the old ideas, some of them abandoned long ago, could actually be of help in tackling open problems. Often the hyperactivity in creating fashionable theories and their new look at old problems brings with it the danger of hurtling into new dead ends. Here, the study of the history of physical thinking, and some of the philosophical reflections, may serve to alert active researchers to such dangers.

Therefore it is valuable for physicists with their deep insight into technical details to regularly analyze the development - also the rise and fall - of ideas and concepts, especially in the context of evolving physics research. As for any other scientific endeavour, this study and analysis will benefit from discussions on a regular basis in a modern physics forum such as The European Physical Journal.

A second purpose of the journal is to serve as a bridge between the working physicists and the professional historians and philosophers of science. In this sense, the periodical can be viewed as a place to trade ideas and exchange knowledge. In general, historians and philosophers of science know sufficient mathematics and physics to be able to write about classical physics, including relativity, in competent way. Likewise, the corresponding experimental setting is one they can easily grasp. This situation changes dramatically when it comes to modern quantum physics. Not only theory, but also experiments and observations now become so involved that a deeper understanding of the fundamental ideas requires the help of physicists who, through their own research - often as participant in a large collaboration - are familiar with the ramifications of quantum physics of the last half-century or with the highly technical mathematics needed for modern theory building. Hence, they will benefit from the physicists' own analysis of their quest for a better understanding of their field. Accordingly and importantly, the journal will not insist in a particular style of presentation: The physicists may write the way to which they are accustomed and, likewise, the historians and philosophers may apply the rules of their trade. Articles can be non-technical or as technical as need be, both in terms of their mathematical content and in relation to the technical jargon a community uses to convey precise meanings.

Given that the language of the journal is English, a third main feature will be the commented translation of articles, or other documents of interest to the readership of the journal, initially written in a different language. As well as making important and interesting texts more widely known, their contents will be put into context by careful annotations and, of course, archived.

EPJ H' s scope emphasizes themes from physics and astrophysics, in particular quantum field theory and particle physics, cosmology and quantum gravity; also statistical mechanics and nonlinear dynamics, particular in relation to complexity sciences and even applications outside core physics. It emphasizes modern physics but without explicitly excluding pre-twentieth-century physics.

As a whole then, EPJ H will help physicists to better understand their own culture, thereby improving present day research work: and at the same time it will pave the way for historians' and philosophers' future studies. EPJ H will also be glad to receive papers discussing experimental physics (including instrumentation where relevant), and demonstrating that the strong intertwining of theoretical and empirical work should be seen as the backbone of the entire endeavour of concept building. EPJ H is not a journal on the foundations of physics, in the sense of publishing new results or ideas at the forefront of research. Rather it attempts to explain and analyze progress in terms of the evolution of thinking and our past ideas about the physical world.

The purpose of this journal is to catalyse, foster, and disseminate an awareness and understanding of the historical development of ideas in contemporary physics, and more generally, ideas about –'how Nature works'.

The scope explicitly includes:

- Contributions addressing the history of physics and of physical ideas and concepts, the interplay of physics and mathematics as well as the natural sciences, and the history and philosophy of sciences, together with discussions of experimental ideas and designs - inasmuch as they clearly relate, and preferably add, to the understanding of modern physics.
- Annotated and/or contextual translations of relevant foreign-language texts.
- Careful characterisations of old and/or abandoned ideas including past mistakes and false leads, thereby helping working physicists to assess how compelling contemporary ideas may turn out to be in future, i.e. with hindsight.

The scope explicitly excludes:

- The publication of new results at the forefront of physics research.

EPJH addresses the history of physics primarily from the physics and physicists' perspective. Being an integral part of a core physics publishing platform, it will:

- Support physicists in any serious attempts to reflect, understand, and improve on the culture of their own discipline.
- Promote fruitful interaction between working physicists and historians of sciences.

Articles may therefore vary significantly as regards the type, level and amount of technical discussion that is required to convey precise meaning to the respective communities. However, the editors will insist that comprehensive and lucid non-technical introductions and summaries are provided for every contribution.

All papers will be published in English. Both regular articles and reviews will be considered.

More information: **epj.org**

Current and Future Activities of the ESI

Thematic Programmes 2010

Quantitative Studies of Nonlinear Wave Phenomena, January 7 - February 28, 2010

Organizers: P.C. Aichelburg, P. Bizon, W. Schlag

Quantum field theory on curved space-times and curved target-spaces, March 1 – April 30, 2010, Workshop March 22 – 26, 2010

Organizers: M. Gaberdiel, S. Hollands, V. Schomerus, J. Yngvason

ESI May Seminar 2010 in Number Theory, May 2 - 9, 2010

Organizer: J. Schwermer

Matter and radiation, May 3 - July 30, 2010

Organizers: V. Bach, J. Fröhlich, J. Yngvason

Topological String Theory, Modularity and Non-Perturbative Physics, June 7 - August 15, 2010

Organizers: L. Katzarkov, A. Klemm, M. Kreuzer, D. Zagier

Anti - de Sitter holography and the quark-gluon plasma: analytical and numerical aspects, August 2 - October 29, 2010

Organizers: A. Rebhan, K. Landsteiner, S. Husa

Higher Structures in Mathematics and Physics, September 1 - November 7, 2010

Organizers: A. Alekseev, H. Bursztyn, T. Strobl

Thematic Programmes 2011

Bialgebras in free Probability, February 1 - April 22, 2011

Organizers: M. Aguiar, F. Lehner, R. Speicher, D. Voiculescu

Nonlinear Waves, April 4 - June 30, 2011

Organizers: A. Constantin, J. Escher, D. Lannes, W. Strauss

Dynamics of General Relativity: Numerical and Analytical Approaches, July 4 - September 2, 2011

Organizers: L. Andersson, R. Beig, M. Heinzle, S. Husa

Combinatorics, Number theory, and Dynamical Systems, October 1 - November 30, 2011

Organizers: M. Einsiedler, P. Grabner, C. Krattenthaler, T. Ziegler

Thematic Programmes 2012

Automorphic Forms: Arithmetic and Geometry, January 1 - February 29, 2012

Organizers: James W. Cogdell, Colette Moeglin, Goran Muic, Joachim Schwermer

Selected Topics in Spectral Theory II, January 17 - Januar 27, 2012

Organizers: B. Helffer, T. Hoffmann-Ostenhof, A. Laptev

K-Theory and Quantum Fields, May 21 - July 27, 2012

Organizers: Matthew Ando, Alan Carey, Harald Grosse, Jouko Mickelsson

Modern Methods of Time-Frequency Analysis II, September 3 - December 9, 2012

Organizers: Hans Georg Feichtinger, Karlheinz Gröchenig

Other Scientific Activities in 2010

Discrete Mathematics, May 14 – May 15, 2010

Organizer: C. Krattenthaler

Meeting on Optical Response of Extended Systems, November 3 – November 5, 2010

Organizer: K. Hummer

Follow-up workshop to the 2009 ESI programme on "The dbar-Neumann Problem: Analysis, Geometry and Potential Theory", December 13 – December 22, 2010

Organizers: F. Haslinger, B. Lamel, E. Straube

7th Vienna Central European Seminar on Particle Physics and Quantum Field Theory.

The topic and date of the Seminar: *tba*.

This Semininar, organized by the Faculty of Physics, University of Vienna, is supported by the ESI.

Organizer: H. Hüffel

ESI May Seminar 2010 in Number Theory

The aim of this workshop was to introduce young researchers at the PhD and post doc level to exciting recent developements of current research at the crossroads of number theory and related fields. Several mini-courses and invited research talks on a variety of topics ranging from number theory proper over automorphic forms and arithmetic quantum chaos were given by leading experts. The seminar took place at the Erwin SchrŽdinger Institute from May 2nd to May 9th, and was organized by Joachim Schwermer (University of Vienna, ESI). Graduate students and post docs from various countries attended the seminar. Informal discussions between the students from Princeton, Zürich, Bonn, Essen Tel Aviv, Austin among others and the students of the Vienna based mathematical community took place right away from the start of this enterprise. This also lead to a fruitful interaction between the participants and the lecturers through all the week.

Emanuel Kowalski (ETH Zuerich) gave a series of lectures on **Sieve methods and some recent applications**. Sieve methods have been used for more than a century to extract information about the distribution of prime numbers. There are now many variants available, and recent years have seen striking successes and developments of sieve principles, sometimes in surprising areas. The lecturer gave a survey of some of the techniques and results, emphasizing the recent and more surprising applications (for instance, sieving in the context of discrete groups, the work of Holowinsky and Soundararajan on Arithmetic Quantum Unique Ergodicity, and that of Goldston, Pintz and Yildirim on gaps between primes)

Zeev Rudnick discussed **Topics in arithmetic quantum chaos** in his minicourse. He gave an introduction to a collection of recent results and conjectures on the spectrum and the eigenfunctions of the Laplacian, with emphasis on arithmetic models. In particular, he discussed

- The universality conjectures for spectral statistics and relations with the classical subjects of uniform distribution and lattice point problems, zeros of zeta functions and Random Matrix Theory.
- Nodal lines of eigenfunctions of the Laplacian and lattice points on circles and spheres.

David Masser, University Basel, presented in his talks recent results on **Unlikely intersections**. Solving polynomial equations in integers or algebraic integers $x, y, \ldots$ is far too hard, so one might try to solve for example with x a power of 2, y a power of $3, \ldots$ This problem when suitably generalized is associated with the names of Mordell-Lang. Or one might try to solve in roots of unity, a problem similarly associated with Manin-Mumford. Both of these topics are fairly well understood. Independently Zilber in 2002 and Pink in 2005 used a concept of unlikely intersections to create a common generalization going far beyond the union of both topics. In fact some related work started already in 1999 and since then there has been enormous progress, particularly in the last two years.

Neven Grbac, University Rijeka, a Senior Research Fellow at the ESI in the summer term 2010, gave a minicourse entitled **Eisenstein series in arithmetic and geometry**. He dealt with the spectral decomposition of the space of square-integrable automorphic forms, an important problem in the arithmetic theory of automorphic forms on the adelic points of a (connected) reductive algebraic group defined over a number field. The geometric importance of the space of all automorphic forms is seen from their relation to the cohomology of arithmetic (congruence) subgroups. In approaching both problems the Eisenstein series play one of the key roles. Grbac explained here recent results in both directions. Although essentially of different nature, the common ground for these results is the study of analytic properties of Eisenstein series.

Robert Tichy, Graz, lectured on **Metric Discrepancy Theory** among other topics. He presented recent probabilistic results in number theory and in the theory of point distributions. This work combined methods from Fourier analysis as well as martingale inequalities and combinatorial techniques. The main results were limit theorems for discrepancies and related counting functions.

Unfortunately, **Alan Reid (U Texas, Austin)** had to cancel his envisaged course **The Geometry and Topology of Arithmetic Hyperbolic 3-Manifolds** on short notice.

The lecture **Arithmetic formulas for topological invariants of modular varieties** by **J. Rohlfs** discussed the notion of Lefschetz numbers for arithmetically defined locally symmetric spaces and presented some methods to derive arithmetic formulas for them. These encode important number theoretical information on the underlying varieties. **J. Schwermer** pursued this topic in his lecture **On the cohomology of arithmetically defined groups and automorphic forms**. Starting of from the case of arithmetically defined hyperbolic 3-manifolds he explained the close relation between the cohomology of these spaces and the theory of automorphic forms, in particular, Eisenstein series. With this frame work in place he discussed some recent results regarding the construction of non-vanishing cohomology classes for arithmetically defined groups.

Erwin Schrödinger Lectures

Spring Term 2010

The Erwin Schrödinger Lectures are directed towards a general audience of mathematicians and physicists. In particular it is an intention of these lectures to inform non-specialists and graduate students about recent developments and results in some area of mathematics or mathematical physics.

These lectures take place in the Boltzmann Lecture Room of the ESI.

Each lecture will be followed by an informal reception at the Common Room of the ESI.

Zeev Rudnick (Tel-Aviv University, Israel): *Arithmetic Quantum Chaos.* May 4, 2010

George Ellis (University of Cape Town, South Africa): *The Crystallizing Block Universe.* June 10, 2010

Senior Research Fellows Lecture Courses

Spring Term 2010

To stimulate the interaction with the local scientific community, the ESI offers lecture courses on an advanced graduate level. These courses are taught by Senior Fellows of the ESI, whose stays in Vienna are financed by the University of Vienna, the Vienna University of Technology, and the Austrian Federal Ministry for Science and Research.
These courses take place in the Erwin-Schrödinger Lecture Room of the ESI.

Neven Grbac (University of Rijeka)

Eisenstein Series, March 17 - May 6, 2010, Lectures: Wednesday and Thursday: 09:00 - 11:00, Seminar: Thursday: 16:00 - 17:00

Eisenstein series play an important role in the spectral decomposition of the space of square-integrable automorphic forms on the adelic points of a reductive algebraic group defined over a number field. In particular, the continuous part of the spectrum can be described using direct integrals of Eisenstein series, while the non-cuspidal part of the discrete spectrum is spanned by certain residues of Eisenstein series. Their importance goes beyond square-integrability in view of the fact that the space of all automorphic forms can be described using the residues and principal values of the derivatives of Eisenstein series. This course is ment to be an introductory course to Eisenstein series at the graduate level. Hence, it sticks most of the time to the example of the split general linear group, and, in particular, to GL_2. Main results concerning analytic properties of Eisenstein series are considered in that case. The course covers also the Langlands-Shahidi method for normalization of interwining operators, as well as the application of Eisenstein series to the spectral decomposition.

Stefan Hollands (Cardiff University, UK)

Quantum Field Theory on Curved Spacetimes, March 19 - June 1, 2010, Lectures: Friday: 09:00 - 11:00, Seminar: Thursday: 16:00 - 17:00

In this series of lectures, I will describe the theory of quantized fields on curved spacetime backgrounds. The two main topics of the course are (a) the physical effects that this theory is able to describe and (b) the mathematical foundations of this formalism. In (a) I will describe in some detail the Hawking Effect (black hole radiance), the Unruh effect, the generation of primordial fluctuations in the context of Early Universe cosmology, including–time permitting–the effects of nonlinearities which give rise to the much talked about "Non-Gaussianities" in the CMB spectrum. In part (b) I am going to describe in detail the formalism that is necessary in order to describe composite quantum fields ("Wick powers"), and the prescription for constructing an interacting (non-linear) quantum field theory from an underlying linear one. This discussion will include mathematical topics such as renormalization procedure, and the necessary tools from microlocal analysis. I will also discuss in detail recent developments concerning the "Operator Product Expansion" in interacting quantum field theory models, the underlying algebraic and cohomological structures, and its calculation in renormalized perturbation theory. I will finish off the course with some fundamental, model independent physical theorems in QFT on curved spacetimes that can be proven with the help of this construction, namely the Parity-Time-Charge theorem, and spin-statistics theorem. The course is aimed at students with an interest in quantum aspects of relativity, and QFT. A knowledge of quantum mechanics/special relativity is assumed, and it is also to have a basic knowledge in QFT on Minkowski spacetime. The level of presenation can be adapted if necessary to the demands of the audience.

Peter West (King's College, London, UK)

E Theory, June 2 - 22, 2010, Lectures: Wednesday: 15:00 - 17:00, Seminar: tba

After reviewing the theory of finite dimensional semi-simple Lie algebras and then Kac-Moody algebras, I will present the evidence for an E_{11} symmetry of an underlying theory of strings and branes.

Lectures on Physical and Mathematical Sciences in Historical Context

No lectures are currently scheduled for spring term 2010.
***Anne Kox**, University of Amsterdam, will give a lecture on "The Correspondence between H. A. Lorentz and E. Schrödinger" in January 2011.*

Previous lectures:

2005:

Leo Corry (The Cohn Institute for History and Philosophy of Science and Ideas, Tel-Aviv University):
Hilbert's Axiomatic Approach to the General Theory of Relativity: From "Grundlagen der Geometrie" to "Grundlagen der Physik"

Jeremy Gray (Centre for the History of the Mathematical Sciences, Faculty of Mathematics, Open University, Milton Keynes, U.K.):
Poincaré and Fundamental Physics

2006:

Catherine Goldstein (CNRS, Paris, Institut mathèmatique de Jussieu):
Geometry and Nature according to A. N. Whitehead

2007:

Dieter Hoffmann (Max Planck Institut für Wissenschaftsgeschichte, Berlin):
Zwischen Autonomie und Anpassung. Die Deutsche Physikalische Gesellschaft im Dritten Reich.

Moritz Epple (Universität Frankfurt):
Beyond Metaphysics and Intuition: Felix Hausdorff's View on Geometry

2008:

Scott Walter (Archives Henri Poincare, Nancy):
Hermann Minkowski and the Scandal of Spacetime

Jacques Bouveresse (Collège de France, Paris):
Ludwig Boltzmann und das Problem der Erklärung in der Wissenschaft

2009:

Scott Walter (Archives Henri Poincare, Nancy)
Hermann Minkowski and theoretical physics in Göttingen

Samuel J. Patterson (Göttingen)
The number theorist Hermann Minkowski

Nevena Ilieva-Litova (Bulgarian Academy of Sciences)
Pauli and the non-Abelian gauge theories: between physical intuition and mathematical logic

Stobaios, an early 5^{th}-century anthologist reports about **Euklid**: *Somebody, who started to study geometry with Euklid did ask him about the first theorem: "What is it good for me to learn all these things." Euklid called his slave and said: "Give him a token coin for he has to gain some asset from his learnings".*

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