ESI **The Erwin Schrödinger International Institute for Mathematical Physics**

Boltzmanngasse 9
A-1090 Wien, Austria

Scientific Report for the 5 Year Period 1993–1997 Including the Prehistory 1991–1992

Vienna, ESI-Report 1993-1997

March 5, 1998

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ERWIN SCHRÖDINGER INTERNATIONAL INSTITUTE OF MATHEMATICAL PHYSICS, SCIENTIFIC REPORT FOR THE 5 YEAR PERIOD 1993–1997 INCLUDING THE PREHISTORY 1991–1992

ESI, Boltzmanngasse 9, A-1090 Wien, Austria

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THE YEAR 1991 (Paleolithicum)

Report on the Workshop: Interfaces between Mathematics and Physics, 1991

Vienna, May 22 – 23, 1991, report written June 13, 1991, amended August 5, 1991. This report includes amendments by P. Budinich

This workshop was when ESI was conceived.

Participants.

P. Budinich (SISSA Trieste)
A. Connes (College de France – IHES)
J. Fröhlich (ETH Zürich)
L. M. Faddeev (Steklov Institute, Leningrad)
A. Galindo (Universidad Complutense, Madrid)
G. Marmo (Università di Napoli)
V. Souček (University of Prague)
A. Trautman (University of Warsaw)
I. Todorov (University of Sofia)
A. M. Vinogradov (University of Moscow)
J. Wess (Universität München)
W. Reiter (Ministry of Science)
W. Thirring
P. Michor
H. Narnhofer

ESI will be the short name for the Erwin Schrödinger International Institute of Mathematical Physics.

Wednesday morning. General and free discussion on organization, comparison of different research institutes.

Minister Busek greeted the participants: Austria was on the border of free Europe, now it is in the middle. Austria is willing to create a research institution of international impact, but scientists should say what they want and why. Some side condition already came to attention: near University, near the libraries, accommodation possibilities.

It was stressed very much, that the ESI should be near Universities to enable contacts, especially for graduate students (everybody). To build a library can take 15 years (Budinich). The MSRI in Berkeley worked very well as long as it was located on the campus, now it is too far away (Wess), it also has a mistake in concept, there is scientific circus all the time, visitors should not be viewed as consumers of a pre packed scientific program, the institute in Sta. Barbara is better (Fröhlich).

The ESI should also offer summer schools and conferences (Wess). In the Center in Trieste which is aimed towards developing countries the following system is applied: 2 weeks of course, 1 week of workshop, 1 week of a topical meeting where the best participants of the foregoing weeks also take part. (Budinich).

Connes: Working conditions and contact are very important. Counter examples are: IAS in Princeton, in former times the cafeteria was small and one could meet, now it is luxurious and split into small isolated tables where people tend to avoid contacts. It is too big, permanent members devote a lot of energy to choose visitors and post docs, which then come and do not have many contacts. In the MSRI (say: Misery) in Berkeley there is no lunch, doors are closed, and even the view is distracting. Also MIT is a place with closed doors. Good examples are IHES, in Harvard the building because all is intertwined, also Leningrad. The design of the building should help contact.

Trautman: The topic is well chosen, see Atiyah – Witten collaboration and the finding of exotic differential structures on $\mathbb{R}^4$. The interaction between mathematics and physics is traditionally more intense in England and USA than in middle Europe. The is a huge brain drain towards USA. An

axis Vienna Trieste could help to slow this. The political changes in the east had a lot to do with interactions between people; Poland and Hungary were first, where people could travel relatively free before. Mathematics and Physics is a small community, but very influential: now in Poland many rectors, also 3 in the senate (from 100). The greatest theoretical physicist of Poland, Marian Smolochovsky, was educated in Vienna and moved later to Poland, and Poland hopes for similar collaboration in the future.

Thirring: There are difficulties in the East, with libraries, budget, publications. What are the most urgent problems?

Todorov: It is not so important to educate students from the east in modern science, it is more important to preserve groups which are already good, but are in danger. Publication is now not a problem, there are no page charges in western Europe. One should help younger scientists to survive in their own places. Bulgaria and USSR feel the danger of brain drain most. Cuts in budget for academic institutions, in libraries; cut off from all western publications now. Cuts in personal, lately 10%, soon again 10%, more teaching. It is easy to destroy a scientific group but hard to recover, compare with the Nazi regime in Germany, it has not fully recovered till today. It is important to start ESI as soon as possible and work in directions that exist in eastern Europe, part time positions or temporary positions could help a lot.

Fröhlich: If people feel insecure, it will not help to invite them. Only if an excellent institution is there it would keep people in the neighborhood. It is less important to discuss scientific directions, more to get the best people as condensation center. The attraction should be scientific, not economic.

Wess: There is need for an institute of mathematical physics also in the West. It should be excellent in any case, otherwise it might be used just as a railway station to USA.

Vinogradov: Some political aspects in science: the ESI should be different from existing institutes, which tend to foster short wave kind of science, especially in mathematics; physics is in certain aspect more long wave science, because there is always nature pointing to the weak points of understanding. ESI should try to create a new type of scientist who combines mathematics and physics again in his thinking and is a long wave scientist: short wave science produces solvers of posed problems, not creators of new concepts. Sophus Lie could never have won a fields medal. In SU there exists a tradition of long wave science and one should try to keep, to keep some of best intellects here, although it is difficult to stop emigration. One should also organize a circulation of the best graduate students through Europe. (Idea of long wave science met approval)

Marmo: Picture of the situation in Europe is necessary of the attempts to hinder emigration, one should compare with other institutes, which compete for the same money. In Lecce Calogero is creating a new institute of nonlinear nuclear physics which is financed by the local government. In Torino Regge and Rasetti have the Institute of Scientific Interactions, which centers on solid state physics, organizes 6 months programs with 6-8 people and which will not enlarge. There is also the proposal for a European Institute for nuclear physics in Italy or in Copenhagen. One should try to push the proposal of the ESI as soon as possible. Post doc positions are very important, young people are easier to hinder on emigration.

Budinich: Center of Excellence is very important. The ICTP and SISSA in Trieste would be willing to establish collaboration. One should study instruments to hinder the brain drain: At SISSA (Trieste) a new kind of professor is created by a law: it can ask the minister to appoint a visiting professor for five years who has to stay in the lab only for 4 months per year, so he can keep contact with home in east and help there. Also some Italians from US can come back with this instrument and also SU $\rightarrow$ US $\rightarrow$ Italy $\rightarrow$ SU. A similar position in ESI could be helpful for the East.

Todorov: Invitation of a renowned institute would enhance the status at home.

Souček: In CSFR the support for universities has been cut by 20%, some people will loose jobs: how to find a place for talented young people: the young generation is in danger at this time.

Fröhlich: Now there is a good chance to get good people for part time. Strong connection with University is important, but there are mixed feelings about it in Zürich: J. Moser and Fröhlich are responsible for the visitor program of the ETH, there are a lot of visitors, but to organize this is too much work, especially since they have full duties at university and the administration is too heavy. Organizer should be free from the University, especially from the administration there, teach only every second semester. There is the general idea to create European network of post doc positions, (Atiyah proposed it, Wess). So applicant can be chosen centrally (no clear scheme yet) for three years, say, and then circulate through European institutes. To choose them is hard work, if it is only one

year they have to apply immediately for the next year, the effect is low.

Galindo: Enthusiastic support for the project of ESI, an institute like this is necessary, center of excellence also. Spain will be interested in ties with the institute, send people and receive people from there.

Marmo: CFNR will sign a contract with ESI, paying people to visit there and receive people from there. Also the Director of the University of Napoli will sign a contract, but ESI should have 'international' in its title for legal reasons in Italy.

Wess: Germany is occupied with reunification, a strong lobby is necessary there, Volkswagen stiftung is reluctant to support long term projects, so no direct financial support now.

Comparison with other institutes.

Fröhlich: IHES in Bures (he is external member of scientific council) This is a meeting place for mathematics and for physics. In the beginning only some excellent scientists there, visitors only to assist the members, best time when Grothendieck was there, ideal concept but not realistic, especially not for ESI. Now 6 permanent members, character has changed, more meeting place. Support staff is quite big: 6 secretaries, one for the director, one receiving visitors, 4 typing. 1 chief of administration, 2 accountants, 1 for printing, 1 driver, 1 housing supervisor, 1 computer support (for sparc cluster), 1 for the library. The library is bad. (original idea only to buy the good books, has worked out badly, since the change to find is low one is not even looking. Connes). Scientist should not be bothered, need help to find apartments, to send children to school, need help with visa regulations. There is the 'comité scientifique', containing all permanent members, the acting director, some outsiders, not more than permanent members. Then there is the 'conseil d'administration,, not containing the permanent members, but the directors and representatives from money givers. Money comes 75% from France, then from UK, Germany, Italy, Switzerland, Japan, etc, but these countries want profit so there are visitors sometimes, which do fit scientifically, only to repay the financial support. Outside money is not reliable, makes the project unstable. The director is full time, very (too) powerful, not supposed to do research. Relic from the private foundation time. (director is above science, impossible to choose him, much better to have a pair of directors, scientific, and administrative, Connes).

Connes: IAS in Princeton: The permanent members there devote a lot of time to selecting the post docs, but these later do not interact a lot, they a left alone, and there is a lot of tension between them. There are different ideas about work. In the US people have to produce results quickly, so they tend to follow general fashions and shift constantly according to the fashion. There seems to be a cultural difference between Europe and US. In France it is still possible for a scientist to do some work which goes against fashion. For the the ESI you should not follow the scheme of Princeton.

Trautman: Banach Center in Warsaw. It was meant as means for cooperation between Eastern countries only, fortunately it worked out otherwise. There is no permanent staff, The center organizes semesters devoted to special topics. Visitors come as lecturers or participants. A semester works reasonably well when it is thought out well. The host is the academy, and the idea is similar (and earlier) to that of the MSRI in Berkeley. It should not be taken as a model.

Wess: Max Planck institutes have an evaluation board meeting once a year, has lot weight on the finance. The Max Planck Institute for Mathematics in Bonn has only 1 or two permanenet members. One should at least start with few permanent positions. There is also new Sonderforschungsbereich in Berlin.

Budinich: The ICTP in Trieste is centered around the director, A. Salam, the faculty is 3–4 permanent members, scientific council does not discuss science, mainly administration. The ICTP devotes a lot of activity to courses and workshops for participants from developing countries. SISSA in Trieste is organizing courses, is subject to the laws regulating Universities in Italy but with larger authonomy and with some special privileges to recruit foreign visitors. institution.

Fröhlich: There is also the 'Forschungsinstitut Mathematik' at the ETH and a smaller scale Physics institute which he is heading. These are completely integrated into ETH, which has disadvantages. More independence is essential. The organizers do not get enough scientific profit, they only have a lot of work. The organizers should rotate.

For The ESI: Not all local peaople should be at all time on the board, but local people should have more weight than outsiders.

Marmo: Impact from outside peaople should be assured.

Budget of library: Thirring 5.000.000.- AS as for Zentralbibliothek of Physics? Marmo: Department of Physics in Napoli has the same. Budinich: Center has 10.000.000.-AS per year, more subjects

like biology, earth sciences, etc.

Finance and the question of national versus international money: one should not expect more than 20% of foreign money, even IHES has 75% of French money. A lot of foreign money makes the project unstable and prevents long range planning, which is essential to the quality of the project. A good idea is to cooperate in the European network of pst docs proposed by Atiyah and to get international money in this way.

Wednesday afternoon, scientific discussion.

Faddeev: Mathematical Physics is synthetic, it is a combination of different kinds of thinking, one should start with connections between Mathematics and Physics.

Connes proposes a 'tour de table'.

Wess: what is the aim of the discussion? To select a small number of topics (Connes), the program of the ESI for the next year (Thirring).

Connes: He recently changed minds on closed strings, which do gravity in the target space. There seems to be a close connection with Waldhausen algebraic K-theory, which tries to understand the homotopy of diffeomorphism groups of manifolds. String theory could lead to a better understanding of Waldhausen K-theory, but the profit of Physics might be small. Constructive Quantum field theory recently underwent developments leading to cohomological thinking, to cyclic cohomology and Floer cohomology. The prize in analysis is tremendous (very difficult), the profit for physics will be small. The combination between quantum groups and non commutative differential geometry could have an impact on Physics. A well posed problem is to construct the Chern-Weil homomorphism for principal bundles with structure group a quantum group. Do not forget functional analysis, it was the original roots for knot invariants (Jones), 3-manifold theory, non commutative differential geometry. It is part of the basic foundations of quantum mechanics, although the theory of Banach spaces probably became sterile. Do not give up the long range point of view: Jones was occupied in isolation for four years without visible results before he found his polynomial, for which he got the Fields medal.

Fröhlich: He grew up when Mathematics and Physics were separated, it was not a healthy situation. Mathematical Physics is not a field by itself, it needs input from both Mathematics and Physics and tries to make an impact back to the two fields. It is great, but its vitality depends on open communication channels. Particle Physics is the main source of inspiration for Mathematical Physics, but it is in a confusing state just now, it is better to listen to condensed matter physics just now. Pay attention to nonlinear quantum optics. Looking at the quantum Hall effect led me in 1985 to new insights.

Souček: Twistor theory is very important, there can be even higher dimensional analogues.

Todorov: Applications of non commutative differential geometry as developped by Alain Connes, Michel Dubois-Violette, Kerner, Coqueraux. They lead to more economical theories than the grand unified theory. Low dimensional quantum field theory models are related to quantum groups, see the chain: quantum Hall effect to Chern-Simons type of theory to completely integrable models to quantum groups by deformation.

Faddeev: Mathematical Physics is not a field in a certain sense. It is still well defined, but since it an interface, its contents also shift with time; nowadays it does not contain Maxwells equations any more - they are ripe. The division between Mathematics and Physics is not a happy one, where does quantisation belong to? It is part of non commutative differential geometry and deformation theory and quantisations is an important and open problem. Not so much for theoretical physicists, who are happy if they know how to write the Schrödinger equation. In opposition to Frölich he finds that particle physics should be looked at, since we want to understand nature, this is possible only from the fundamentals, and particle physics is the beginning of the study of matter, the fundamentals for us. In a certain sense Theoretical Physics is trying to use as little Mathematics as possible, and Mathematical Physics is trying to use as much as possible.

Galindo: Pay attention to fundamental theories, one should also know how to compute, but pay also attention to non perturbative aspects.

Trautman: Striking results coming from the interaction between Mathematics and Physics in the past: study of instantons, Yang Mills equations, via twistor theory showed that confinement in Physics did not work as expected, but it led via moduli space theory to exotic differential structures on $\mathbb{R}^4$. For the future he sees work to be done in classical differential geometry, interest in global Lorentzian geometry, Cauchy-Riemann structure, optical structures, spinors. Also the spectrum of the Dirac operator is not so well studied.

Marmo: Mathematical Physics is an interface between the two fields Mathematics and Physics, so it gets redefined from time to time. Open questions are in spin statistics, see the quantum Hall effect. The general problem of Quantisation is still open, Quantum Mechanics cannot be the ultimate theory, because its fundamentals are not understood. Constrained theory in quantisation and representation theory of infinite dimensional algebras will be important.

Wess: In former times one tried to understand nature by a small scheme. Then came periods with new physics, which helped to develop mathematics; now it is hard to find physics without being guided by mathematics already. Field theory = Physics. In particle physics one does not even understand the model. Open problems: Anomalies, Supersymmetries, path integrals, deformation concepts, quantum groups.

Thirring: In addition to the challenge to find a self contained quantum field theory, theoretical physics has to to explain concrete experiments in physics, and this explanation has to go beyond perturbation theory. But also long standing fundamental problems are still open: for instance mathematical physics has helped to understand stability (this turned out to be a first step for constructing dynamics for an infinite system), one of the fundaments of statistical physics. But a complete understanding of irreversibility and of the approach to equilibrium, the passage from microphysics to macrophysics, is still missing.

Vinogradov: Concrete proposals. 1. Algebraic geometry is the study of algebraic equations, but there is also the notion of an algebraic variety for nonlinear partial differential equations called diffiety, more complicated then algebraic geometry, having a lot of geometrical structures. See the chains: differential calculus to algebraic version of it to quantized calculus; higher symmetries of partial differential equations to quantized vector fields to conservation laws; characteristic classes to quantized differential forms to secondary objects. Cohomological theory can lead to a good mathematical theory for Feynman integrals. 2. Applications up: theory of diffieties. Applications down: propagation of singularities of PDE, classical limit. 3. n-ary mathematics (like n-ary Lie brackets) as a background to statistical Physics. But our mentality is a one particle mentality. 4. Computer support for this activity: a very special kind of symbolic computation.

Michor: I am fascinated by algebraic aspects of differential calculus and its deformations, and by multigraded Lie brackets which detect Lie algebras, their representations, their deformations, and their cohomologies. This will surely be important.

I was involved in the past twenty years with infinite dimensional differential geometry, manifolds of mappings and diffeomorphisms. This led to the theory of general fiber bundles with structure the diffeomorphism group, connections, holonomy, characteristic classes for it. This is tied with a revised calculus in infinite dimensions, developed by Frölicher and Kriegl, which also sheds new light on the theory of locally convex spaces and algebras.

Budinich: He has seen many fashions characterized by crowds producing useless papers mainly for career's reasons. ESI should encourage also young people who wish to deviate from fashions. Simple or pure spinor-geometry could be a good subject for study at ESI to deal with yet obscure corners of physics like global properties of fermions in conformal extensions of space time, unified or standard models, superconductivity.

Now followed an intensive discussion on the role of quantum groups in Mathematical Physics.

Wednesday evening, Heuriger.

Faddeev: In communist countries, Mathematics and Mathematical Physics was a sort of sheltered retreat for talented people to find independence. Thus the best intellects were drawn to it. This will change now, and emigration is going, but the ESI can still get some very good scientists. The quality/cost ratio for the ESI is the very best possible for any scientific enterprise which seems possible for Austria just now. But it is urgent to act quickly. Best quality will be assured.

Thursday morning, concrete proposal.

Some discussion: a theoretical physicist on the board (Souček, who is mathematician), lacks dynamical systems, condensed matter physics (Fröhlich), Hungary and Romania are lacking (Thirring).

Election of the chairman: Unanimously (13) for Thirring (Reiter abstained).

Scientific Council. The members of the workshop constitute themselves as scientific committee of the institute. Also V. Drinfeld is elected by acclaim in order to give more weight to mathematics.

Size. Recommendation of 40 Scientists. Up to 6 permanent positions besides directors, in the long range.

Administration. 1 Administrative director. 3 secretaries, one for the director, one for visitors, one for typing. 1 accountant. 1 computer support. 2 librarians. This excludes housekeeping and personal for the housing.

Directorate or advisory committee. Faddeev, Fröhlich, Connes; Thirring, Michor, Narnhofer as advisory committee, Thirring as director.

Conference. Faddeev proposes to meet again with a scientific conference 'Interfaces between Mathematics and Physics', not more than 30 active participants. Date March 1 – 8, 1992, at the university of Vienna. All present agree to come, more expository talks, program starting from names rather topics. Philosopher Alan Janik as introductory lecturer (Reiter).

Finale.

Trautman: The idea of this institute is so good that it may be stolen and such an institute wight be created elsewhere. It is essential to act quickly.

As name was adopted:

Erwin Schrödinger International Institute of Mathematical Physics

short **ESI**

Discussion after the end lead to the conviction that the ESI should be created immediately, its interim activities being the organization of workshops and conferences, until budget and location is found.

THE YEAR 1992 (Neolithicum)

Conference on Interfaces between Mathematics and Physics

Vienna, March 2–6, 1992, first public activity of the then projected Erwin Schrödinger Institute. Nine lectures were given, two full hours each, by two lecturers each day alternating, with generous intervals for discussions. A number of participants from Eastern Countries were financially supported. The lectures were:

A. Connes: Non-commutative Geometry.
L. Faddeev: Involution in Quantum groups and deformed affine algebras.
J. Fröhlich: Gauge Symmetry in Condensed Matter Physics.
K. Gawedzki: Conformal Field Theory and Black Holes.
P. Michor: Gauge theory for the Diffeomorphism Group.
I. Todorov: Conformal Quantum Field Theory.
A. Trautman: Geometric Aspects of Spinors.
A. Vinogradov: Geometry of Partial Differential Equations and Quantized Calculus.
J. Wess: Quantum Groups.

Conference '75 years of Radon transform'

Vienna, August 31 – September 4, 1992, second public activity of the then projected Erwin Schr"odinger Institute. Organized by Simon Gindikin and Peter W. Michor. This conference celebrated the 75th anniversary of the publication of Johann Radon's paper on the transform which later was named after him, and which set the mathematical background for computer tomography. The proceedings of this conference were published, with an (auto-) biographical section at the beginning:

75 Years of Radon Transform, S. Gindikin, P. Michor (eds.), International Press, Boston MA, 1994, ISBN 1-57146-008-X.

Programm.

Plenary lectures:

A. Cormack (Tufts Univ., Nobel Price 1984). The Radon transform: A personal Odyssey.
S. Helgason (MIT). Radon transforms for Double Fibrations - Examples and Viewpoints.
E. Stein (Princeton). Estimates for Radon transform and singular Radon transform.
S. Gindikin (Rutgers Univ.). Radon transform from cohomological point of view.
A. Goncharov (Moscow). Integral geometry and varietes of minimal degree in $\mathbb{CP}(n)$.
G. Beylkin (Boulder). Inversion of the Generalized Radon Transform and its Applications.
J. Wolf (Berkeley). Uncertainty principles for symmetric spaces.
F. Natterer (Münster). Sampling the Radon transform.
E. Hlawka. Uniform distribution and Radon transform.
F. John. Reminiscences.
M. I. Graev. Radon transform and hypergeometric functions.
F. I. Karpelevich. Applications of Radon transform to random processes.

Lectures within workshops

D. H. Phong. Models of degenerate Fourier integral operators.
V. Palamodov. Radon transform on real algebraic varieties.
A. Greeanleaf. Microlocal analysis of the two-plane transform.
G. Mockenhaupt. On the circular maximal function.
A. Zaslavski. The Radon transform of discontinuous functions: the Legendre transform, the projective dual varieties, and envelopes.
L. Zalcman. Morera's theorem, 100 years after.
P. Kuchment. On the range and inversion of a Radon transform arising in tomography.
E. Casadio. Radon transform on trees.
Workshop: Integral geometry on homogeneous manifolds (organizer - S. Helgason).
M. Agranovsky. Radon-Pompeiu transform and CR-functions on the Siegel manifold .
C. Berenstein. Inverse conductivity problems and the hyperbolic Radon transform.

F. Gonzales. Range of the Radon transform on Grassmannians.
E. Grinberg. Radon transform for maximally curved spheres.
T. Kobayashi. Bounded domains and the zero set of Fourier transform.
K.-H. Neeb. Wiener-Hopf operators on symmetric spaces.
E. Opdam. Properties of Dunkl functions.
E. T. Quinto. Support theorems for generalized horocycle transforms on higher rank spaces.
F. Richter. Fundamental differential operators and range of the Radon transforms.
V. Soucek. The Penrose transform for the Dirac equation.
P. Michor. Curvature and the Radon transform.

THE YEAR 1993 (Start of history of ESI)

Erwin Schrödinger Institute opened

Established in January 1993, the official opening of the International Erwin Schrödinger Institute for Mathematical Physics (ESI) took place in April of that year, with the Austrian Minister for Science and Research, Vice Chancellor Dr. E. Busek performing the opening ceremony. The institute is housed in 3 flats near the Institutes of Mathematics and of Theoretical Physics of the University, in Pasteurgasse 4/7, 6/7, and 6/11, 1090 Wien, with premises encompassing $420m^2$. The first flat is just below the last residence of Erwin Schrödinger in Vienna. ESI was founded with the hope of achieving the following.

1. To provide continuing financial support combined with invitations to leading experts in the international scientific community, therefore providing an ideal centre of excellence in the heart of Europe, nurturing the exchange and development of ideas not only in the international arena but also on the home front with its affiliations with Austrian universities.

2. Though intellectually evenly matched with their western colleagues (also in Chess), scientists from the former Eastern Bloc countries, though well advanced and independent in theoretical studies, were then faced with shortages of scientific and practical resources and facilities resulting in the current massive migratory 'brain drain' to the West, from which the U.S.A. seems to be profiting the most. With the help of long and short term grants, ESI hopes to if not stop, then at least stem this migration, enabling scientists to remain firstly in Europe and hopefully, more importantly, in their own countries.

The scientific administration is run under the auspices of the International Scientific Administration Committee, comprising members from 11 states, who elect the directorship of ESI (at present W. Thirring, scientific director, P. Michor, acting director), initiate and supervise the scientific programmes and issue the long term invitations. ESI operates on a project and invitation basis with leading experts invited to the institute to continue and expand their research activities.

To date around 120 foreign scientists have visited ESI, contributing to (at time of writing) 76 preprints, many of which have been accepted for publication in top international scientific journals. Four specialized congresses have already been organized and held by ESI therefore producing and maintaining its own high standards of excellence.

Though a private organisation, the Society for the International Erwin Schrödinger Institute is subsidised by the Austrian Ministry for Science and Research, with its annual budget currently standing at 10 million Austrian Schillings, with further contributions from the Istituto Nazionale di Fisica Nucleare in Italy, the ETH in Zürich, the NSF in the U.S.A. and other scientific organisations.

The statutes of the society allow also for supporting members providing sponsorship for research, and donations to the society are, under Austrian law, tax-deductable. Organisations or persons wishing to support our institute in any way are asked to contact the administration director Mario Springnagel, ESI, Pasteurgasse 6/7, A-1090 Vienna, Tel. 3172047. For enquiries of a more scientific nature, please contact P. Michor at the insitute.

The Erwin Schrödinger Institute An Austrian Initiative for East-West-Collaboration

Walter Thirring

Contribution to the OECD-Seminars
"East-West-Mobility of Scientists and Engineers"

The downfall of communism in the eastern European countries confronts the scientific community with a solidarity problem of unprecedented scale. Whereas these governments has ruined their countries economically, ecologically and politically they had highly developed some fields like sports, musics or science. Their scientific institutes had far more staff than their western analogues and in natural sciences scientific qualification was useful for employment even without political engagement.

The only handicap for the scientific development was the restricted exchange with foreign scientists because foreign travel needed some party protection. As a consequence, in some new scientific developments eastern researches were absent and conversely some progress made by eastern scientists was scarcely appreciated in the west.

Today the new governments find that they need all the scarce resources for improving the living conditions and science cannot be supported on such a scale. Thus they have the choice either to effectively reduce the salaries of the scientists by a good fraction or to lay off this fraction of the number of scientists. Both alternatives have grave consequences. Since the living conditions were never very splendid a sizeable reduction comes close to the limit of starvation and the scientists are practically forced to seek employment elsewhere. On the other hand, since the number of excellent people is big, a reduction of positions means that some people of high scientific merit have to be fired. This has actually happened, for instance in eastern Germany, and had morally a very bad effect. Together with the living conditions also the conditions for work deteriorate since, for instance, the money for buying the scientific literature and other research needs is running low. Based on these facts I put forward the following three theses:

(1) In natural sciences the eastern countries do not so much face a problem of reconstruction but of preservation.
(2) These countries should not be deprived of their most qualified people lest they might fall back to the level of third world countries. After the last war Europe was materially destroyed but its recovery was effective only since qualified people were available.
(3) The western European countries should provide eastern scientists part time positions with adequate salaries and working conditions so that they can survive the coming difficult years. It would be a pity if this intellectual capital gets lost for Europe or may even be misused by other dictorial regimes.

The arguments put forward above were warmly approved by scientific circles. In addition, the Austrian government was susceptible to them and in a rather short time for this very purpose an international institute for mathematical physics was founded. It is named after the great Austrian scientist Erwin Schrödinger and is located in the house where he lived for his last years.

Reasons for the Foundation of ESI. The years 1989 and 1990 have seen revolutionary changes in Middle and Eastern Europe: After years of severe restrictions the original cultural, geographical, and political bonds between these countries and Western countries have reasserted themselves. The economic recovery is slow and painful, and a huge brain drain is taking the best scientists out of these countries; they are looking for acceptable working and living conditions. Due to its vast resources and the flexibility of its academic institutions the USA is the main beneficiary of this scientific migration. In view of the economic and political unification of Europe one should try to keep some of the best scientists in Europe and even in Middle Europe. ESI will try to do just that.

Some of the main scientific and cultural developments of this century have their origins in Middle and Eastern Europe: 12 tone music (Schoenberg, Berg, Webern), psycho analysis (Freud, Reich), literature (Musil, Roth, Schnitzler), philosophy (Wittgenstein), quantum mechanics (Schroedinger, Pauli), functional analysis (Hahn, Banach), homotopy theory (Cech, Hurewicz), measure theory (Radon, Nikodym). The political change and the fall of establishments in the wake of World War I was a very fertile ground for new ideas in science and art. This could happen again, and ESI could provide a focal point for similar developments in mathematical physics.

How would such an institute fit into the scientific landscape of Middle and Eastern Europe? The former communist countries suffer from severe economic problems. They have to decrease the sizes of their academic institutions and to rebuild parts of them (law, philosophy, economics). They are quickly loosing some of their best scientists, who are mainly attracted by the much better working conditions elsewhere. For theoretical sciences, these conditions are mainly possibilities of contact with collegues and good libraries. ESI can meet some of these demands and may help to retain some of the best minds in Europe.

The role of theoretical research institutes in the scientific life should not be underestimated: On the one hand they are a focal point or center for contact at highest levels of research for the scientists of a country. But they are also an aim for young talented scientists of the nation: they know where to apply to for temporary positions, where to look for help and opportunities. The flexible structure of such an institute makes it possible for a gifted researcher to start a career in science, which otherwise

depends upon the availability of open positions, overcoming the envy of established professors, and so on. In the long run the level of the whole scientific production in Mathematics and Theoretical Physics will rise.

Why exactly Mathematical Physics? There is no such institute anywhere. It blends very well with some of the best scientific traditions of Middle Europe. Mathematical Physics is very much alive just now. Three of the four Fields medals in Kyoto 1990 were given to Mathematical Physicists.

To guarantee the international character and the highest scientific level it was thought that an international advisory committee composed of leading scientists in this field should guide the activities of the institute. Fortunately indeed several eminent scientists were willing to serve and thus the institute has the following international advisory committee:

P. Budinich (SISSA, Trieste)
A. Connes (IHES, Bures-sur-Yvette)
V. Drinfeld (Academy of Sciences, Kharkov)
L.D. Faddeev (Steklov Mathematical Institute, St. Petersburg)
J. Fröhlich (ETH Zürich)
A. Galindo (Universidad Complutense, Madrid)
E. Lieb (Princeton, USA)
G. Marmo (Universitá di Napoli)
P. Michor (Universität Wien)
H. Narnhofer (Universität Wien)
W. Reiter (Bundesministerium für Wissenschaft und Forschung)
V. Souček (Charles University, Prague)
W. Thirring (Universität Wien)
I.T. Todorov (Academy of Sciences, Sofia)
A. Trautman (University of Warsaw)
A.M. Vinogradov (University of Moscow)
J. Wess (Universität München)

Many activities of the institute so far (workshops and conferences) had a very favourable response by the scientific community and have helped eastern researchers to take part in the mobility which western scientists have enjoyed so far.

ACTIVITIES IN 1993

Short overview

Two dimensional quantum field theory. The amount of 1.1 Mio. S. was spent, a workshop with 120 participants was held, 22 preprints were written.

Schrödinger Operators. The amount of 1.1 Mio. S. was spent, a workshop was held, 14 preprints were contributed.

Differential Geometry. The amount of 1.5 Mio. S. was spent, visitors supported from abroad contributed the equivalence of further 0.5 Mio. S. 41 preprints were contributed.

Visitors outside of programs. The amount of 0.4 Mio. S. was spent, 3 preprints were written.

Two dimensional quantum field theory

The amount of 1.1 Mio. S. was spent, a workshop with 120 participants was held, 22 preprints were written. This program was organized by H. Grosse.

In this program a very lively development set in and is still going on. This was reflected in a large number of seminars (two to three per week), which were presented at ESI. In addition, discussions

were numerous and very involved. Almost thirty papers were started and completed within this activity at ESI. They would not have been possible without the opportunity for the physicists from various countries to get together. Various discussions with the other groups at ESI have not only been appreciated, but led even to a number of common papers. Numbers to which we refer in the following short descriptions, refer to ESI preprints (1-76) which already exist, or to the list of forthcoming papers. We can divide these descriptions into three main subjects:

1. Integrable Models, Lattice Spin Models and Magnetic Field Models.

Integrable Models can be obtained through solutions of the Yang- Baxter relation. An infinite number of conserved quantities show up, and the transfer matrix can be diagonalized with the help of the algebraic Bethe Ansatz. This way it is possible to study the phase diagram of the model. All three contributions from Borovick [12,13,66], are of this type. In [12], vertex models defined on two layers which interact with each other are treated; in [13] and [66] integrable multicomponent models are dealt with. In Pasquier's paper [24], a Calogero-Sutherland model with spin is treated. Properties like degeneracies of the spectrum have been derived from a solution of the Yang-Baxter relation and from the underlying Yangian symmetry. In my own work with Raschhofer [26], we treated an $SU(3)$ type XXZ model which is integrable too; we were able to obtain the finite size corrections and determined the conformal charge which turned out to depend on the interaction. Although the 1-dimensional Hubbard model is integrable also, it is the 2-dimensional one which is the favourite model to explain super conductivity, which up until now has only been analyzed through approximate methods. A careful self-consistant mean field type analysis of the appearance of antiferromagnetic, ferromagnetic as well as superconducting phases, is given in the papers [31, 77], by Popov. Van Hove points play an essential role thereby.

In a common work with Popov [57], we found a way to relate the partition function of general spin systems to partition functions of fermion systems. For the latter, standard expansion methods can be applied. Spectra of Magnetic field problems are of interest, due to our interest in the quantum Hall effect. How the degenerate spectra of Landau levels split under the influence of nonconstant magnetic fields as well as under the influence of scalar potentials is analyzed in a common work together with Stubbe [71].

2. Models of Quantum Field Theory-External Field Problems. One of my own interests concerns cocycles which occur as central extensions of current algebra and the Virasoro algebra. They can be studied in external field problems within quasi-free second quantization. Together with Maderner and Reitberger, [8], we formulated these Schwinger terms as cyclic cocycles, respectively characters of a 2-summable Fredholm module. General states have been treated, and especially the independence of these cocycles on temperature has been formulated. We studied, in addition, anomalies between generators of translation and time evolution, within spin models for Kink-like states [22]. We compare our way of implementing the generators in finite temperature states to another method, which allows us to obtain temperature dependent anomalies. A further way to define symmetry generators for noncyclic states, together with a summary of the various approaches is given in [59]. Together with Maderner, we analyzed the classical origin of the fermionic Schwinger term in [58]. It turned out that the comomentum mapping is not a homomorphism of Lie algebras, and the algebra of charges can be recovered in an entirely classical context of smooth functions on the Grassmanian.

3. Algebraic Theories.

Chern-Simons Model. In discussions with Alekseev and Schomerus, we made attempts to obtain a lattice model which enjoys as a gauge symmetry, a quantum group. We therefore studied a lattice version of the Chern-Simons model. What results is a mathematically precise quantization of the Hamiltonian Chern-Simons model. We constructed the algebra of observables and formulated the model such that the lattice version already reproduces the results of the continuum model exactly.

Conformal Field Theory. This lively expanding subject was well represented by the Bulgarian group. Their method of obtaining local extensions of the chiral algebra of observables for conformal invariant models led to Stanev's publication [19]. He constructs all such extensions with the help of polynomial solutions of the Knizhnik-Zamolodchikov equation for SU_3 current algebra at level k. Discussions at ESI, between the Bulgarian and the Hamburg group, led to the understanding that there exist local extensions of the algebra of observables, which do not belong to the class considered

by Doplicher-Haag-Roberts. A summary of 'What we are learning from 2-dimensional conformal models?' is given by Todorov in his Beer Sheva Workshop contribution [52].

Noncommutative Manifolds. In my own attempts to relate models of QFT to noncommutative geometry, we studied, together with Prešnajder, the noncommutative analogs of homogeneous spaces using coherent states [23]. A one parameter family of algebras is obtained, which yields in the commutative limit the algebra of functions over a standard manifold. We apply this procedure to the Fuzzy sphere and to the Fuzzy hyperboloid. In a further contribution, we formulate the noncommutative analog of the Dirac operator on these algebras and find its spectra. This allows us to describe the analogs of the Thirring model in this noncommutative lattice.

Quantum Groups. Quantum Groups are, in a way, the central algebraic structure, which came out from studies of integrable models. This was also reflected in a number of seminars dealing with this new algebraic concept and also in a number of contributions.

Hadjiivanov studied the q-deformation of Bose parastatistics [20], and obtained a deformation of the algebra of para Bose-oscillators. The dynamics of a point particle moving on a 3-sphere was considered by Stanev and Todorov in [34]. They used an R-matrix which depends on a time parameter. It led to interesting discussions with the Hamburg group and might lead to a new concept: quasi Yang-Baxter equation for an R-matrix depending on a spectral parameter. Together with Prešnajder [45], we considered the classification of unitary representations of the q-oscillator algebra and showed the connection to explicitly known realizations.

The duality between deformations of the algebra of functions over a group to the deformations of the universal enveloping algebra of the Lie algebra, is worked out for Z_2-graded Hopf algebras by Pittner [69]. In the classical limit an interesting algebraic structure results.

Rehren worked out possible values which the index of subfactors can take in, [14].

Poisson Structures. Perelomov [17] joined visitors from the mathematics programme (Grabowski and Marmo), and worked out a classification of all possible Poisson structures in low dimensions.

The publication [33], by Alekseev and Todorov would not have been possible without the opportunity to combine the experience of Fadeev's group in St. Petersburg on quadratic brackets and Lie-Poisson groups, with the experience of the group in Sofia on matching the monodromy of chiral sector solutions of the Knizhnik-Zamolodchikov equation with a certain quantum group monodromy.

In summarizing, I may conclude, that we had very fruitful discussions, seminars and colloquiums during the project on 'two-dimensional Quantum Field Theory' at ESI. As a result I obtained, for example, a large number of applications for a post doc. position. There was a great interest to continue this programme in 1994 and for this purpose, up to ten visitors will join ESI in March and April 1994.

I. Todorov, Inst. f. Nucl. Research, Sofia, Bulgaria 15.2.-15.5.
V.N. Popov, Steklov Math. Inst., St. Petersburg, Russia 1.4.–30.6.
A.E. Borovick, Kharkov, Ukraine, 1.3.-31.3.
A. Perelomov, Univ. Bonn, 1.3.-15.3.
A. Alekseev, Dep. of Math. Physics St. Petersburg, Russia, 1.3.-30.6.
V. Schomerus, Univ. Hamburg, 1.3.-31.8.
L. Hadjiivanov, Inst. f. Nucl. Research, Sofia, Bulgaria, 15.2.-15.5.
V. Stanev, Inst. f. Nucl. Research, Sofia, Bulgaria, 15.2.-15.5.
K. Gawedzi, IHES Bures-sur-Yvette, 1.3.–31.3.
G. Mack, Univ. Hamburg, 3.5.–28.5.
K.H. Rehren, Univ. Hamburg, 1.3.–31.3.
K. Fredenhagen, Univ. Hamburg 15.2.–10.3.
V. Pasquier, Saclay, Paris, 1.3.–31.3.
P. Presnajder, Univ. Bratislava 1.6.–31.6.
Short invitations:
M. Havlicek, Prag,
V. Rittenberg, Universitaet Bonn,
J. Madore, Orsay, Paris,
R. Flume, Universität Bonn
G. Sotkov, Sofia
A. Schnizer, Tokyo

F. Nill, Berlin
W. Weich, Munich, Germany, July 7, 1993.

Workshop: Two dimensional quantum field theory. March 8–12, 1993.

Monday	Tuesday	Wednesday	Thursday	Friday
Conf. QFT	Conf. QFT	short contrib.	Int. Mod.	noncomm. DG
Todorov	Marchetti	CQFT-Anyons	Pasquier	Fröhlich
Nahm	Fredenhagen	and	Mussardo	Dubois-Violette
Schomerus	Rehren	Integrable mod.	Faddeev	Madore
Gravity	Conf. QFT	short contrib.	CS and top.QFT	
Jackiw	Onofri	quantum groups	Karowski	
Prešnajder	Alekseev	and	Itzykson	
Kummer	Seiler	gravity	Gaweḑski	

H. Grosse

Schrödinger Operators

The amount of 1.1 Mio. S. was spent, a workshop was held, 14 preprints were contributed.
T. Hofmann-Ostenhof

For over 65 years quantum mechanics and hence the Schrödinger equation has played a central rôle in the description and understanding of nature, in particular atoms and molecules. The questions raised and the answers given by quantum mechanics has led to many far reaching new developments not only in physics, but also in chemistry, mathematics and even philosophy.

There has always been a strong mutual influence between quantum mechanics and mathematics. Quantum mechanics prompted, even as early as in the 1930's, the development of some new areas in mathematics like the functional analysis of unbounded operators, and influenced with its new problems, many other fields of mathematics (representation theory, C^* algebras etc). On the other hand, new developments in various fields in mathematics (e.g. partial differntial equations, stochastic processes, pseudo differential operators etc), have played, and still play an increasingly important rôle in the progress in quantum physics, and especially in the investigation of the Schrödinger equation, leading us to a better understanding of this important part of physics.

The Schrödinger equation is a partial differential equation. The central objects one deals with are called 'Schrödinger operators'. Ever since the end of the 1960's, 'Schrödinger operators' is a very active field in mathematical physics and mathematics, with many probing results, and, naturally enough, still many open, challenging problems.

The programme 'Schrödinger operators' was devoted to such problems. It started in spring and culminated at the beginning of December in a workshop with about 50 participants. Approximately 25 scientists visited the ESI during the year. 25 seminar talks and 37 talks at the workshop were given. The list of the talks, visitors etc. can be found below.

Up to now, 14 papers have been written (see in addition the list of ESI preprints), and about 10 are to be expected in the next few months. The research activities were devoted to the spectral theory of elliptic operators [27,29,43,62,64,67,71,74,75], to scattering theory [60,63], and to properties of the solutions of Schrödinger equations [35,36]. Schrödinger operators with magnetic fields were investigated very intensively and very successfully [27,67,71,74,75 and some work in preparation]. The analysis of Schrödinger operators with magnetic fields poses many new, physically important and challenging problems. Collaborations on such problems have been started and will be continued in the near future at ESI. Also other questions concerning the spectral theory of Schrödinger operators and scattering theory, as well as the Schrödinger equation considered as a partial differential equation, led to collaborations which will eventually be continued at ESI. The seminar talks were especially helpful in starting the exchange of ideas and discussions between the visiting scientists and some Austrian colleagues, but in particular between scientists from former Eastern Bloc countries and scientists from the West.

Naturally, a programme of this size cannot cover the enormously rich field of Schrödinger operators, and therefore has to focus around some specific problems. But the talks given at the workshop documented very well the progress made in other fields related to Schrödinger operators - in spectral

geometry, microlocal analysis, time dependent problems etc. Within the next few weeks a collection of abstracts of the talks given at the workshop will be available.

Finally, I should like to mention that the accomodation for the scientists, their salaries, and the sometimes difficult visa problems, was handled smoothly and efficiently by Mr. Springnagel, and the handwritten manuscripts were brought into their final form competently by Miss Haffner. My wife, Maria Hoffmann-Ostenhof helped me enormously with the scientific preparation of the workshop, while Mrs. Kroll took responsibility for a good deal of the organization of this conference, with Mr. Stöltzner also helping whenever possible. Most of the visiting scientists and myself made complete use of the PC facilities provided at ESI for writing papers, and especially for electronic mail which, thanks to the unstinting efforts and advice of Dr. Cap and Dipl.Ing. Schichl, never caused problems. Last but not least, I would like to mention that the good working atmosphere which also led to many interesting contacts with scientists participating in other programmes, has been nourished by the cooperative efforts of Professor Michor, Professor Thirring and other Viennese colleagues. All these individuals I want to thank heartily.

Visitors 1993.

Bach, Volker, TU Berlin, 11.10.-24.10.93
Combes, Jean Michel, University of Toulon, 22.11.-16.12.93
Derezinski, Jan, University of Warsaw, 22.9.-21.12.93
Erdös, Laszlo, Princeton University, 28.11.-18.12.93
Exner, Pavel, Nuclear Institute Prague, 18.10-12.12.93
Gerard, Christian, Ecole Polytechnique Palaiseau, 18.10.-29.10.93
Graf, Gian Michele, ETH Zürich, 11.10.-22.10.93
Harrell, Evans, University of Atlanta, 22.11.-17.12.93
Hempel, Rainer, University of Alabama, 4.12.-18.12.93
Herbst, Ira, University of Virginia, 1.6.-30.06.93
Hislop, Peter, University of Kentucky, 07.12.-20.12.93
Ivrii, Victor, University of Toronto, short visitor (December'93)
Kalf, Hubert, University of Munich, 26.09.-10.10.93
Karner, G. University of Virginia, short visit (June'93)
Korotyaev, Evgeni, Electrotechnical University of St. Petersburg, short visitor (December'93)
Loss, Michael, Georgia Technical School of Mathematics, 20.09.-20.12.93
Nadirashvili, Nicolai, University of Moscow, 01.03.-13.07.93
Nenciu, Gheorghe, University of Bucharest, 01.10.-31.12.93
Pavlov, Boris, University of St. Petersburg, 31.10.-19.12.93
Siedentop Heinz, University of Trondheim, 19.06.-02.07.93, 01.12.-16.12.93
I.M. Sigal, University of Toronto, January'93 (short visitor)
Skriganov, Maxim, University of St. Petersburg, 05.12.-19.12.93
Sobolev, Alexander, University of Nantes, 30.11.-12.12.93
Stubbe, Joachim, CERN Geneva, 11.10.-29.10.93
Thaller, Bernd, University of Graz, 11.11.-13.12.93
Vugalter, Simeon, Radiophysik Institute, Nishni Nogorod, 19.10.-19.12.93
Yafaev, Dimitri, University of Rennes, 30.09.-30.10.93, 29.11.-19.12.93
Zhislin, Gregory, Radiophysik Institute, Nishni Nogorod, 15.11.-15.12.93

Talks held at the Workshop on Schrödinger Operators.

M. S. Birman (St. Petersburg) A perturbation of a periodic Schrödinger operator by a modulated decaying potential
M. Bordoni (Rome) A method to compare operators. Applications to Schrödinger and Dirac operators
Y. Colin de Verdiere (Grenoble) Semi-classical analysis of tunneling and graph's embedding into surfaces
J. M. Combes (Toulon) Positive commutators and perturbation of the singular spectrum
M. Combescure (Paris) Localization versus diffusion for 'kicked' quantum systems
M. Demuth (Potsdam) Trace class criteria in stochastic spectral analysis
J. Derezinski (Warsaw) Long-range scattering theory for time-dependent potentials
P. Exner (Prague) Wannier-Stark ladder with unusual spectral properties

L. Erdoes (Princeton) Magnetic Lieb-Thirring inequalities
G. Goldstein (Baton Rouge) Spin polarized Thomas-Fermi theory with the Fermi-Amaldi correction
J. Goldstein (Baton Rouge) Obstacle scattering for elastic waves
E. Harrell (Atlanta) Some bounds on eigenvalues and spectral gaps of Schrödinger and Laplace operators
B. Helffer (Paris) On the Schrödinger equation in large dimensions
R. Hempel (Birmingham, USA) Strong magnetic fields, Dirichlet boundaries, and spectral gaps
A. Hinz (Munich) Selfadjointness of Schrödinger operators
P. Hislop (Lexington, USA) Localization for the scalar wave and Maxwell equations in random medias
M. Hoffmann-Ostenhof (Vienna) Regularity properties of the zero set of solutions to Schrödinger equations
V. Ivrii (Toronto) Accurate spectral asymptotics for operators with singularities and the Scott correction term
G. E. Karadzhov (Sofia) Spectral asymptotics for some Schrödinger opertors and applications
E. Korotyaev (St. Petersburg) The effective masses and conformal mapping
Y. Kuperin (St. Petersburg) Adiabatic Faddeev equations for three-body quantum scattering
M. Loss (Atlanta) Fluxes, Laplacians and Kasteleyn's theorem
A. Martinez (Paris) Non-linear Stark effect and molecular localization
E. Mitidieri (Trieste) Weakly coupled elliptic systems and positivity
G. Nenciu (Bucharest) Perturbation theory for time dependent Hamiltonians
H. Neidhardt (Berlin) On the Spectra of self adjoint extensions
B. Pavlov (St. Petersburg) Harmonic analysis on Riemann surfaces and the Lax-Philipps theory for lattices
D. Robert (Nantes) Statistics of level spacings and distributions of matrix elements for chaotic systems
R. Seiler (Berlin) Charge transport and the index of projectors
H. Siedentop (Oslo) Electronic densities of large atoms near the nucleus
M. Skriganov (St. Petersburg) Anomalies in spectral asymptotics
A. V. Sobolev (Nantes) The precise asymptotics for the discrete spectrum of the Schrödinger operator with Coulomb singularities in a homogeneous magnetic field
J. Stubbe (Geneva) A sum rule for the Schrödinger equation and applications
S. Vugal'ter (Nizhni Novgorod) Limits on stabiltity of positive molecular ions in a homogeneous magnetic field
D. Yafaev (Rennes) Eigenfunctions of the continuous spectrum for the N-particle Schrödinger operator
G. Zhislin (Nizhni Novgorod) On the localization of the essential spectrum of N-particle Hamiltonians with magnetic field

Amongst the participants of the conference not contributuing a talk were: B. Baumgartner (Vienna), P. Clement (Delft), M. Daumer (Munich), H. Grosse (Vienna), H. Kalf (Munich), P. Michor (Vienna), H. Narnhofer (Vienna), Walter Thirring (Vienna), and a few other Austrian colleagues.

Differential geometry

The amount of 1.5 Mio. S. was spent, visitors supported from abroad contributed the equivalence of further 0.5 Mio. S. 41 preprints were contributed. The progam was organized by Peter W. Michor.

The field of differential geometry has a long tradition of mutual scientific exchange with theoretical physics, and this exchange is even growing in importance now. Thus it fits well into ESI as a mathematical program.

By happy coincidence some very active groups found together, a lot of discussion also with members of other programs took place, and many beautiful results were published in the preprint series of ESI.

The following topics were worked on:

(1) Classical mechanics: here G. Marmo coordinated the discussion, G. Vilasi, G. Landi, J. Grabowski, D. Alekseevski, A. Perelomov (from 2-dim. QF program), T. Ratiu, I. Vaisman, A. Vinogradov and others contributed. Preprints 2, 5, 16, 17, 26, 28, 40, 46, 49, 66, 70, 72, 73 belong to this field.
(2) Geometry of nonlinear partial differential equations: A. Vinogradov coordinated this activity, A. Vinogradov, V. Lychagin, I. S. Krashilchik, V. V. Sokolov, V. N. Chetverikov. Preprints 9, 46, 47, 48, 51, 53, 54, 55, 61, 73.
(3) Infinite dimensional differential geometry: Here a topical series of lectures by D. Burghelea on Waldhausen algebraic K-theory and cohomomology of diffeomorphism groups was held in July. Preprints 4, 11, 26, 41.
(4) Riemannian differential geometry and related material: Here D. Alekseevski was most active, preprints 7, 11, 21, 30, 32, 38, 39, 65, 70.
(5) Spectral theory on manifolds. Here was some collaboration with the program on Schrödinger operators. D. Burghelea, L. Friedlander, F. Kamber, were active here, preprints 37, 44, 65.

The following 40 ESI Preprints were produced by the visitors and collaborators of this program: [1], [2], [4], [5], [6], [7], [9], [10], [11], [15], [16], [17], [21], [26], [28], [30], [32], [37], [38], [39], [40], [41], [44], [46], [47], [48], [49], [50], [51], [53], [54], [55], [56], [61], [65], [66], [68], [70], [72], [73].

Finally I want to thank all who have contributed to the success of ESI in 1993, to the nice athmosphere, and for a lot of work in the administration and at the computer system: Andreas Cap, Harald Grosse, Elisabeth Haffner, Thomas and Maria Hoffmann-Ostenhof, Hedwig Kroll, Hermann Schichl, Mario Springnagel, Michael Stöltzner, Walter Thirring.

List of visiting scientists.

D. Alekseevki, Center 'Sophus Lie', Krasnokazarmennaya 6, 111250 Moscow, USSR; January 18 -July 10,

Bogdan Bucicovschi, Dept. of Mathematics, Ohio State University, Columbus OH 43210, USA, supported by NSF, USA, July 14–July 31, 1993

D. Burghelea, Dept. of Mathematics, Ohio State University, Columbus OH 43210, USA, June 14 – August 14, 1993.

A. Cap, Institut f"ur Mathematik der Universität Wien, whole year, computer support and scientific collaboration.

Pierre Cartier, Institut des Hautes Études Scientifiques, 35, Route de Chartres, F-91440 Bures-sur-Yvettes, Frankreich 10 days, April 14–24.

Vladimir N. Chetverikov, ul. Ryleeva 6, korp. 1, Apt. 19, 121019 Moscow, Russland, September

L. Friedlander, Univ. of Arizona, USA, July 5 – July 31, 1993.

Thomas Friedrich, Fachbereich Mathematik, Humboldt Universit"at, PF 1297, D-10099 Berlin, June 19–25, 1993.

Olga Gil-Medrano, Universidad de Valencia, Dpto. de Geometria y Topologia, 46100 Burjassot, Spain; March 15–20, supported by Spain.

Janusz Grabowski, Institute of Mathematics, Warsaw University, ul. Banacha, P-02-097 Warszawa, Polen, 4 months, February 15 – July 14.

Dmitri Gurevich, MPI Bonn, Moscow, April 4–9.

Franz Kamber, Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green Street, Urbana IL 61801, USA; Salierstrasse 4, D-8000, Muenchen 90, Deutschland, July

Max Karoubi UFR de Mathematiques, Université de Paris VII, 2, Place Jussieu, F-75251 Paris, Frankreich; April 21–24.

I. S. Krashilchik, 1st Tversloy-Yamskoy per. 14, Apt. 45, 125047 Moscow B-279, Russland; September – October 1993

Gianni Landi, SISSA, Strada Costiera 11, I-34014 Trieste, January 17 – July 17, supported by Italy.

Fedele Lizzi, Universitá di Napoli, Dipartimento di Fisica, April 4 – May 7, supported by Italy.

M. Losik, ul. Chapaeva 28, kv. 8, 410056 Saratov, Russia; June – July

V. Lychagin, Center 'Sophus Lie', Krasnokazarmennaya 6, 111250 Moscow, USSR; September – October 1993

M. Markl, Mathematical Institute, Czech Academy of Sciences, Žitná 25, CZ-11567 Praha, June 11 – July 6, 1993.

G. Marmo, Dipartimento di Fisica, Universita di Napoli , Mostra d'Oltremare, Pad. 19-20, I-80125 Napoli, Italy; January 17 - May 20.

Giovanna Mendella, Dipartimento di Fisica, Universita di Napoli, Mostra d'Oltremare, Pad. 19-20, I-80125 Napoli, Italy; February 20–24; supported by Italy.

Giuseppe Morandi, Universitá di Bologna, Dipartimento di Fisica, 46 via Irnerio, I-40126 Italy; February 5–12; supported by Italy

A. L. Oniscik: Kolomenskaja nab. 10-153, 115 142 Moscow, Russland, January 10–April 10,

Emanuela Nicorestianu, Technical University Bucarest; May 20 – June 20; supported by an Austrian scholarship.

I. Penkov, Dept. of Mathematics, University of California, Riverside, CA 92521, September – October.

T. Ratiu, Dept. of Mathematics, University of California, Santa Cruz CA 95064, USA; June 21 – July 24

S. M. Salamon, Mathematical Institute, University of Oxford, 24–29 St. Giles, Oxford, UK; June 20–27, 1993.

Gaetano Scarpetta, Universitá di Salerno, Dipartimento di Fisica, I-84081 Baronissi - Salerno, Italy; March 7– 13, supported by Italy.

Herman Schichl, Institut f'ur Mathematik der Universität Wien, whole year, computer support and scientific collaboration.

Rudolf Schmid, Dept. of Mathematics, Emory University, Atlanta, GA-30322, USA, June 24–July 23, 1993.

Steven Shnider, Bar-Ilan University, Israel, June 24–30, supported by Israel

V. V. Sokolov, September – October 1993

Giovanni Sparano, Dipartimento di Fisica, Universita di Napoli, Mostra d'Oltremare, Pad. 19-20, I-80125 Napoli, Italy; February 24 – March 16; supported by Italy.

Andrea Spiro, Universitá di Ancona, Facoltá di Ingeneria, vial delle Brecce Bianche, Ancona, Italy; April 4 – 9; supported by Italy.

Wlodizimierz Tulczyjew, Universitá di Camerino, via Faverino, 26, I-62032 Camerino, Italy; April 13 – 20; supported by Italy.

I. Vaisman, Department of Mathematics, University of Haifa, Mount Carmel, Haifa 31999, Israel July 20 – September 15

J. Vanžura, Mathematical Institute, branch Brno, Czechoslovak Academy of Sciences, Mendlovo nám. 12A, CS-60300 BRNO, Tschechoslowakei 1 month, September

Gaetano Vilasi, Universitá di Salerno, Dipartimento di Fisica, I-84081 Baronissi - Salerno, Italy; January 18 – February 14 and March 7 – April 7; supported by Italy.

A. Vinogradov, Dipartimento di Matematica, Universitá di Salerno, Italien; private: vl. Republica 72, I-50019 Sesto Fiorentino (FI), Italien; Universitá di Salerno, Italy, Jan. 18 – March 19, and July 15– October 15

Patrizia Vitale, Dipartimento di Fisica, Universita di Napoli , Mostra d'Oltremare, Pad. 19-20, I-80125 Napoli, Italy; April 18 – May 7; supported by Italy.

Cornelia Vizman, University of Timişoara, Bul. V. Parvan 4, R-1900 Timişoara, Romania, May 20 – December 20; supported by an Austrian scholarship.

Visitors outside of specific activities

P. Bizon, Institute of Physics, Jagiellonian University Krackov, Poland, October 1, 1992 — September 30, 1993.

N. P. Ilieva-Litova, Institute of Nuclear Research and Nuclear Energy, 72, Tsagiradsko chaussee, 1784 Sofia, Bulgaria, February 1–28, 1993.

THE YEAR 1994

President of ESI and Scientific Director: Walter Thirring
Acting Director: Peter W. Michor

General remarks

In the year 1994 ESI was host to 185 visitors from 33 countries. There were 118 preprints contributed to the preprint series, and 133 seminar talks or ESI-Colloquia were given. 4 conferences were organized in Vienna:

International Symposium in Honour of Boltzmann's 150th Birthday, February 23 –26, 1994.

Mathematical Relativity, July 25 – 29, 1994.

Spinors, twistors and conformal invariants, September 19–23, 1994.

On the Ising Model and Around it in Eight Days, October 17–24, 1994.

ESI took part in the organization of two more conferences abroad.

14th Winter school on geometry and physics, January 15–22, 1994, Srni, Bohemian forest, Czech republic.

Quaternionic manifolds, September 1–6, Trieste, Italy.

The first book coming out of an ESI activity has just appeared:
75 years of Radon transforms, Proceedings of the conference held at the Erwin Schrödinger Institute for Mathematical Physics in Vienna, August 31–September 4, 1992, S. Gindikin, P. Michor, eds.; Conference Proceedings and Lecture Notes in Mathematical Physics, Vol. IV, International Press, Cambridge (USA), 1994.

ESI is a founding member of the association "International Mathematical Sciences Institutes (IMSI)", Peter Michor attended the founding meeting of IMSI just before the International Congress of Mathematicians in Zürich, August 2, 1994. The next meeting of IMSI is scheduled for the International Congress of Applied Mathematics in Hamburg, beginning of July 1995.

The budget of ESI for 1994 was 9.5 Mio. AS. Of these 4.7 Mio. were spent for scientific activities, and 4.3 Mio. for administration and infrastructure. 34 visitors supported from other (mainly non-Austrian) sources contributed the equivalent of further 0.75 Mio. AS.

ESI is now in the second year of full activity. It seems to be more successful than could have been reasonably expected. Many visitors expressed positive opinions: the good working conditions, the style of the premises, that all visitors are equal, the smoothness of the administrative processes, the quality of some of the preprints, the simplicity and ease of use of the computer system (but 2 visitors wished for a fully fledged system of SUN workstations which are professionally managed).

FTP-server for POSTSCRIPT-files of ESI-preprints available

After some discussions with visitors of ESI, and after seeing many requests of preprints after sending out the email version of ESINews 3, we decided to make available via anonymous FTP the POSTSCRIPT-files of those preprints produced at ESI, of which we have the TeX-files, a list of all preprints, the newsletters, and all abstracts in ASCII form. In the year 1994 there were 606 preprints retrieved from this server.

Use anonymous ftp or gopher `ftp ftp.esi.ac.at (131.130.25.2)`, or use the internet address `http://www.esi.ac.at/`

Note that the POSTSCRIPT-files are ASCII, they can be printed at every printer which can understand POSTSCRIPT with at least 300dpi or on UNIX systems using ghostscript.

Winter School in Geometry and Physics

The traditional winter school in geometry and physics which takes places for one week each January since 1980 in a picturesque village in the Czech parts of the Bohemian mountains will be a joint enterprise of the Czech society of mathematicians and physicists and ESI, from 1994 onwards. Usually there are proceedings, which are published as a supplement of the 'Rendiconti Matematici di Palermo'. The first conference with ESI-participation was in the period January 15–22, 1994, the proceedings for it are in preparation. The next winter school will take place in Srni, January 14–21, 1995.

ACTIVITIES IN 1994

International Symposium in Honour of Boltzmann's 150th Birthday

From February 23–26, 1994, ESI was a co–organizer of a symposium in honour of Boltzmann who was born 150 years ago. This was sponsored by AUA, BAWAG, CA, BMWF, etc. Apart from Schrödinger Boltzmann is considered to be the most outstanding physicist of Austria whose thinking still influences mathematics and physics.

International scientists of the highest rank participated in our meeting. On the first day the Creditanstalt offered a more festive atmosphere. Our purpose was to offer informative talks to international researchers as well as to the scientifically interested public of Vienna, and we believe that the symposium was well accepted and a real success. The following preprints are from talks of this symposium: [81], [83], [85], [95], [98], [125].

P. Schuster: *Die Prinzipien der biologischen Evolution und der Zweite Hauptsatz der Thermodynamik.*

Official Opening

W. Thirring: *Boltzmann's Legacy in the Thinking of Modern Physics*

J. Lebowitz: *Time Arrow and Boltzmann's Entropy*

T.D. Lee: *Vacuum as a Physical Medium (Relativistic Heavy Ion Collisions and the Boltzmann Equation)*

G. Gallavotti: *Ergodic Theory and Statistical Ensembles in Boltzmann's Work*

G.G. Emch: *Concepts from Statistical Mechanics in Relativity*

P. Schuster: *Statistics of Biopolymer Structures and the Boltzmann Distribution*

O.E. Lanford III: *Microscopic Mechanics, Probability and the Boltzmann Equation*

K. Schmidt: *Entropy for Mathematicians*

D. Szász: *Boltzmann's Ergodic Hypothesis, a Conjecture for Centuries?*

W. Stiller: *Ludwig Boltzmann und die Entwicklung der chemischen Kinetik*

H.A. Posch: *Numerische Simulation von Vielteilchensystemen im Gleichgewicht und Nichtgleichgewicht*

E. Oeser: *Boltzmann und die evolutionäre Erkenntnistheorie*

D. Flamm: *Leben und Werk Ludwig Boltzmanns*
R. Dobrushin: *A Mathematical Approach to Foundations of Statistical Mechanics*
G. Fasol: *The Boltzmann Equation and Its Limits in Solid State Physics*
A. Uhlmann: *Comparison of Probability Distributions*

Ergodicity in non-commutative algebras

Organized by Heide Narnhofer, Vienna. This activity produced 14 preprints up to now.

In the workshop on noncommutative ergodic theory our purpose was to transfer ideas of classical ergodic theory to dynamics of nonabelian algebras. We concentrated on the concepts of Lyapunov exponents and dynamical entropy.

In [103] we succeeded to find an appropriate definition for Lyapunov exponents for noncommutative algebras that provides the same consequences on the mixing behavior as in the classical case and does not depend on arbitrary choices.

For the dynamical theory for von Neumann algebras three definitions are now available (Connes-Stoermer-Narnhofer-Thirring, Alicki-Fannes, Voiculescu). They had to be compared and it turned out that they react very differently on commutativity properties [104,106,129,136]. Whether any of these dynamical entropies is related to Lyapunov exponents is at the moment not under control.

On the basis of C^* algebras a candidate for a topological dynamical entropy was proposed and examined in [93]. Also we examined the possibility to construct noncommutative systems with mixing dynamics. A natural possibility is to quantize classical Markov systems. But this quantization can be done in different ways. A comparison of these different possibilities with respect to the corresponding dynamical entropy should be finished in due time (seminar talk of Park, Benatti, Kümmerer, Narnhofer, Werner).

Another possibility to construct algebras with mixing automorphisms is based on the imbedding theory of algebras, where with a kind of mirroring process the imbedding can be enlarged to an automorphism group. This imbedding finds its counterpart in bipartite graphs. An essential step forward was done in [115] to single out those graphs that correspond to an imbedding.

Up to now we concentrated on an automorphism that can be extended to an automorphism group Z. Generalizations to other groups were treated in [86,97,108,109].

An essential tool for explicit calculations of the entropy seems to be an appropriate characterization of the state space over the algebra. [102] concentrates on this problem. Further research by Petz and Michor and by Benatti, Narnhofer and Uhlmann is in progress.

Finally the theory of deterministic chaos was enlarged in [119] where the deterministic time evolution of quantum mechanics was combined with a probabilistic evolution representing quantum measurement in a consistent way.

We organized a number of seminars where every visitor was invited to represent his research field. Nevertheless stronger emphasis was put on informal discussions. Here the atmosphere of the Schrödinger Institute turned out to be very stimulating. As a result spontaneous cooperations were started. Of course, not all discussions succeeded in finding concrete results. Many ideas are waiting to be attacked and examined again. Therefore we are looking forward to continuing the research activities of the Schrödinger Institute.

H. Narnhofer

Mathematical relativity

Organized by P. Aichelburg, R. Beig, Vienna. 1 July – 15 September 1994. Conference: 25 – 29 July 1994. In this activity 11 preprints were produced in 1994.

The field of Classical General Relativity (G.R.) has recently seen a significant upward swing, both in the quality and the number of published results. There seem to be three main reasons for the current renaissance of classical G.R.

One is the refined observations of effects where general relativity is essential, such as the Hulse-Taylor pulsar or the prospect of direct experimental detection of gravitational waves. The most notable effort in the latter direction is the LIGO project in the US, the construction of a system of

earth-bound Laser Interferometric Detectors — at present the largest project funded by NSF. The correct interpretation of experimental results requires a solid understanding of the underlying theory.

A second factor is that G.R. is "becoming of age" in the sense that the theory has reached a degree of maturity where many physically relevant questions can be given a rigorous mathematical formulation, typically at the geometry-analysis interface. There is moreover an increasing number of researchers with, not only a good command of the available mathematical machinery, but also the ability to further develop these techniques according to the requirements of the problems at hand.

A third element in the recent uprise of activity in Mathematical Relativity is that, with the power reached by current electronic computers, particularly when combined with insights coming from the analytical side, one can study problems which would have been considered out of reach a couple of years ago.

The Workshop on Mathematical Relativity which ran from 1 July through 15 September, set itself the task of studying global existence and uniqueness questions for the Einstein Equations (EE's).The Einstein Equations with reasonable matter sources form a system of partial differential equations which give rise to a well-defined initial-value problem. In the initial-value formulation the EE's split into two sets: the constraint equations, an elliptic system which determines the set of allowable initial data, i.e. the phase space of G.R. and the hyperbolic system of evolution equations. The singularity theorems of Penrose and Hawking show that solutions with large data are necessarily singular in the sense of having incomplete causal geodesics. A major (perhaps 'the') open question in classical G.R. concerns the precise nature of the singularities developed by the maximal solution to the Cauchy problem, e.g. whether the maximal solution can be extended across a Cauchy horizon. That this should, for generic data, be impossible, is one version of the cosmic censorship conjecture. Another version states that, for many forms of matter, the maximal Cauchy evolution of asymptotically flat initial data will either approach flat spacetime or settle down to a stationary black hole state. For some matter sources one knows that these black hole states are characterized just by the gravitational mass, the angular momentum and the global charges of the matter sources ('no-hair property'). But recently Bartnik, McKinnon, Bizon and others have found non-abelian soliton-like and black hole solutions to the Einstein-Yang-Mills system which violate the above stated no-hair property. Since then such non-linear matter couplings to gravity have attracted much attention from physicists and mathematicians.The existence of regular non-abelian finite energy configurations in equilibrium with gravity results from a cancellation of gauge and gravitational singularities. This is a typical non-perturbative effect which shows that gravity can regularize divergences present in flat space theories. Another aspect is that the time development of perturbed soliton configurations may shed new light on the above mentioned cosmic censorship hypothesis. Furthermore, in the spherically symmetric case the static Einstein equations with non-linear field sources reduce to dynamical systems for which, it seems, modern methods of bifurcation and critical point theories may successfully be applied.

The work performed at the workshop concentrated on the following topics :

(1) Gravity coupled to nonlinear matter sources (Aichelburg, Bartnik, Bizon, Chmaj, Choptuik, Forgacs, Gibbons, Maison, Smoller, Straumann, Wald.)
(2) Black-Hole physics, No-Hair theorems (Chrusciel, Gibbons, Israel, Racz, Schmidt, Simon, Temple, Tod, Wald, Weinstein.)
(3) Constraint Equations and Hamiltonian Reduction: Andersson, Bartnik, Beig, Fischer, Hajicek, Iriondo, Isenberg, Malec, Moncrief, O Murchadha.)
(4) Evolution problems and Cosmic Censorship (Choptuik, Chrusciel, Friedrich, Hübner, Isenberg, Moncrief, Rein, Rendall.)

There were lively interactions between people working on these different topics and, whenever possible, with ESI visitors outside the Relativity program (examples: C.LeBrun, N.S.Nadirashvili). Up until now 11 ESI preprints have resulted from the workshop, and there are more to come. The workshop culminated in a Conference on Mathematical Relativity from 25-30 July, which was attended by roughly 100 people, many of whom were from former communist countries.

Program of the conference, July 25–30:

Monday, 25 July

G. Gibbons: *Gravitating Solitons and Hairy Black Holes.*

R. Wald: *Classical Thermodynamics of Black Holes in Arbitrary Lagrangian Theories of Gravity Coupled to Matter.*

P. Chrusciel: *Strong Cosmic Censorship in Vacuum Spacetimes with Compact, Locally Homogeneous Cauchy Surfaces.*
N. O Murchadha: *Spherical Gravitational Collapse.*

Tuesday, 26 July

Y. Choquet-Bruhat: *Non-Abelian Relativistic Fluids.*
M. Choptuik: *Critical Phenomena in Gravitational Collapse.*
P. Brady: *Self-Similar Scalar Field Collapse: Naked Singularities and Critical Behavior.*
A. Rendall: *Crushing Singularities in Spacetimes with Spherical or Plane Symmetry.*
G. Rein: *On the Spherically Symmetric Vlasov-Einstein System.*

Wednesday, 27 July

R. Bartnik: *Solutions of the Einstein-Kaluza-Klein Equations.*
P. Bizon: *Gravitating Solitons and Hairy Black Holes.*
B. Temple: *An Astrophysical Shock-Wave Solution of the Einstein Equations Modeling an Explosion.*
H. Friedrich: *Boundary Conditions for Anti-de-Sitter Spacetimes.*
K. Newman: *The Structure of Conformal Singularities.*

Thursday, 28 July

W. Israel: *Effect on Radiative Wave Tails on Black Hole Interiors.*
D. Brill: *Testing Cosmic Censorship with Black Hole Collisions.*
H. Pfister: *Dirichlet Problem for the Stationary Einstein Equation with Applications to Stability Limits of Rotating Stars.*
N. Straumann: *On Einstein-Yang-Mills System for Arbitrary Gauge Groups.*
D. Maison: *Analytical and Numerical Methods for Einstein- Yang-Mills and Related systems.*

Friday, 29 July

V. Moncrief: *Analytical and Numerical Studies of Spacetime Singularities.*
A. Fischer: *Classical and Conformal Superspace.*
M. Iriondo: *Existence and Regularity of CMC Hypersurfaces in Asymptotically Flat Spacetimes.*
G. Weinstein: *N-Black Hole Stationary Axially Symmetric Solutions of the Einstein-Maxwell System.*
B. Schmidt: *The Newtonian Limit of Einstein's Equations of Gravity.*

P. Aichelburg, R. Beig.

Quaternionic and hyper Kähler manifolds,

A conference on quaternionic and hyper-Kähler manifolds was be organized in Trieste in the period September 5–9, 1994, by St. Marchiafava, S. Salamon, M. Pontecorve, and D. Alekseevsky; it was the precursor of this program.

This program ran from September to December 1994, and was organized by D. Alekseevsky and S. Salamon. 9 preprints were produced in 1994. The following persons participated:

Physicists: Ch. Devchand, E. Ivanov, O. Ogievetsky, V. Ogievetsky, A. Perelomov, A. Van Proeyen.

Mathematicians: D. Alekseevsky, F. Battaglia, E. Bonan, C. Boyer, V. Cortes, I. Dotti-Miatello, K. Galicki, G. Gentili, P. Kobak, C. LeBrun, S. Marchiafava, Y. Nagatomo, T. Nitta, H. Pedersen, P. Piccinni, F. Podestà, M. Pontecorvo, Y-S. Poon, S. Salamon, U. Semmelmann, A. Spiro, A. Swann, T. Taniguchi.

There were a number of younger participants, including Battaglia, Cortes, Devchand, Kobak, Nagatomo, Semmelmann, Swann, Taniguchi.

The main technical achievements are described below, and take into account (i) ESI preprints produced or in preparation, (ii) lectures given at ESI, and (iii) additional discussions or informal talks of relevant problems that are not covered by the preprint or lecture information. There is no doubt that the program was a great success in terms of the volume of work which it encouraged, and the on-going research advances that have been accomplished. The organizers wish to thank the Institute on behalf of all the participants.

Outline of work.

The problems for investigation fell under one of the following headings:

1. Four-dimensional Riemannian and conformal geometry. A quaternionic structure on a real 4-manifold is the same as an oriented conformal structure, and a Riemannian 4-manifold has two compatible quaternionic structures. Quaternionic geometry may thus be viewed as an extension of the 4-dimensional theory.

2. The geometry of quaternionic structures on higher-dimensional manifolds. This included studies of the various types of quaternionic manifolds and their associated twistor and other spaces. Work was done both on the construction of explicit classes of examples and on the general theory. Many classification issues remain open in eight and more dimensions, and this is likely to be a fruitful avenue for future research.

3. Quaternion-Kähler and hyper-Kähler structures in physics. The latter has provided independent approaches of great value to determining examples and their classification.

4. Other topics. This included work on areas not covered above but involving similar techniques.

1. Four-dimensional Riemannian and quaternionic geometry.

Preprints 156, 174, and in preparation: Riemannian 4-manifolds with two Hermitian structures (Kobak)

Lectures (dates are in the form day/month): 4-dimensional integrable systems (V. Ogievetsky) 11/10; Conformally invariant Einstein geometry (Pedersen) 17/10; Twistor spaces of 4-manifolds (Pontecorvo) 9/12; Symmetry of self-dual manifolds (Poon) 9/12;

Additional discussions: Hermitian structures on 4-manifolds (Kobak, Nurowski, Pontecorvo, Salamon); T^2-actions on selfdual 4-manifolds (Pontecorvo, Poon); Einstein metrics on 4-manifolds (Cortes, Alekseevsky, Marchiafava); Moduli spaces of hyper-complex structures on 4-manifolds (Alekseevsky, Boyer, Nitta)

2. The geometry of quaternionic structures on higher-dimensional manifolds

Preprints 138, 142, 148, 150, 154 and in preparation: The Betti numbers of 3-Sasakian manifolds (Galicki, Salamon); Quaternionic transformations of non-positive quaternion-Kähler manifolds Alekseevsky, Marchiafava); Hyper-complex manifolds foliated by Hopf surfaces (Pedersen, Poon, Swann); Infinitesimal Einstein-Weyl deformations (Pedersen, Swann); The isometry group of the homogeneous quaternion-Kähler manifolds (Alekseevsky, Cortes)

Lectures: On quaternion-Kähler manifolds, (LeBrun) 1/9; Weyl structures in quaternionic geometry (Piccinni) 16/9; Hyper-complex structures on solvable Lie groups (Dotti-Miatello) 28/9; Einstein metric and 3-Sasakian geometry (Galicki) 28/9; An explicit construction of hyper-Kähler metrics (Devchand) 12/10; Deformation of quaternionic structures (Nitta) 14/10; Hyper-Kähler manifolds associated to quaternion-Kähler manifolds (Swann) 17/10; Hyper-complex structures on Stiefel manifolds (Boyer) 19/10; Twistor construction for some Grassmann structures (Alekseevsky) 20/10; Decomposition of the exterior algebra of hyper-Kähler manifolds (Bonan) 23/11

Additional discussions: Invariant complex and hyper-complex structures on Lie groups (Dotti-Miatello, Salamon); torus actions on quaternion-Kähler manifolds, and divisors on twistor spaces and the classification of quaternionic structures (Battaglia, Pontecorvo, Poon)

3. Quaternion-Kähler and hyper-Kähler structures in physics.

Preprints 134, 153, and in preparation: Gap phenomena for quaternionic Yang-Mills connections (Taniguchi)

Lectures: Complex and quaternionic geometries in supersymmetry and self-duality, informal talk and discussion, (V. Ogievetsky) 11/10; Gap phenomena for quaternionic Yang-Mills connections (Taniguchi) 20/10; Harmonic space description of quaternionic manifolds (Ivanov) 27/10; Instantons on quaternion-Kähler manifolds (Nagatomo) 7/11; Holonomy groups and extended supersymmetry in topological Yang-Mills theory (O. Ogievetsky) 14/11

Additional discussions: Geometrical meaning and formulation of harmonic space description of hyper-Kähler and quaternion-Kähler manifolds and its generalizations (Alekseevsky, Devchand, Ivanov, V. Ogievetsky); Dimensional reduction of supergravity and the relationship between special quaternionic-Kähler, special Kähler, and special Riemannian manifolds (informal talk by Van Proeyen); Lie group approach to the classification of homogeneous special Kähler manifolds (Alekseevsky, Cortes, Van Proeyen)

4. Other topics. Preprints in preparation: Homogeneous non compact Einstein 5-manifolds (Alekseevsky, Dotti-Miatello); Invariant Poisson structures on semisimple Lie groups and symplectic structures on Borel subalgebras, (Alekseevsky, Perelomov)

Lectures: Integrable systems of classical mechanics: integration of equations of motion (Perelomov) 18/10; Compact quotients of negatively curved manifolds with large isometry group (Podestà) 19/12.

Additional discussions: Kostant's generalization of the Borel-Weil theorem and its applications (informal talk by Nagatomo); Groups of automorphisms of CR structures (Alekseevsky and Spiro); Differential invariants of conformal and quaternionic structures (Alekseevsky, Slovak, Souček); Cohomology of cohomogeneity one compact manifolds (Alekseevsky, Losik); Relations between different diffeologies of some quotient spaces (Alekseevsky, Losik, Michor)

A few words about working at ESI. In spite of the relatively short time that it has been running, the Institute has managed to develop its own style and it has already acquired traditions which have positively influenced the scientific activities. It has become common practice for the scientists, also ones from different projects, to interact actively. This they do by participating in numerous seminars and improvised informal discussions which often bear fruit either during the stay itself or after the scientists have returned to their home institutions.

The technical side of ESI is well organised and efficiently managed, and any problems are settled with the minimum of fuss. As in other institutes of its type, visitors expect ready access to computer networks, and facilities are more than adequate to cope with the average number of visitors, and include an informative manual on the local system. The fact that the majority of both short and longer-term visitors are now housed in Hotel Kaiser Franz Josef encourages collaborations to continue in the evenings. The social life is quite active, and the proximity of the city centre makes it easy for ESI scientists to unwind and attend cultural events.

The open and warm atmosphere of the Institute is certainly influenced by the unique spirit and style of Vienna: a city of art and music, in which organization of work harmonizes with a relaxed way of life.

Dimitry Alekseevsky, Simon Salamon

Spinors, twistors and conformal invariants

Organized by A. Trautman, V. Soucek, H. Urbantke (local organizer). September and October 1994. 9 preprints were produced in 1994.

1. Organization. The activity was a joint project on two topics: Spinor fields and Dirac operators; Twistors and conformal invariants. The activity took place in September and October 1994. The main concentration of participants was achieved around the conference "Spinors, twistors and conformal invariants" organized at ESI during the week Sept 19 - Sept 23. The were 6 longer stays (2 stays for 8 weeks, 4 stays for 4 weeks) and 17 stays shorter than a month. The activity had a well balanced proportion of visitors coming from west and east.

There was another activity (Quaternionic and hyper-Kähler manifolds) organized at ESI during the same period, and there was a substantial interaction among participants of both activities. Lectures at the conference were attractive for participants of both activities, and the same was true for seminars of both activities as well. This made it possible to start a fruitful cooperation (e.g. on eigenvalues of Dirac operators on hyper-Kähler manifolds - A.Moroianu, U.Semmelmann; invariant operators on quaternionic and hypercomplex manifolds - D.Alekseevski, A.Čap, J.Slovák, V.Souček).

The organization of the conference was quite smooth due to very efficient work by the administration (Mr. Mario Springnagel, Ms. Hedwig Kroll, Ms. Lilla Hathanyi, Ms. E. Haffner); all practical problems concerning computer network were easily solved due to the very kind and efficient help of Andreas Čap. Sincere thanks are due to all of them.

2. The conference. There were 23 invited lectures and 8 shorter lectures. The main subjects discussed at the conference were the Penrose transform, conformal and CR invariants, Dirac operators and bounds on its lowest eigenvalues, twistor spaces and the twistor equation, deformations of twistor spaces, spinors and spinor fields in space-times, optical geometry, self-dual Yang-Mills fields and their relations to integrable systems.

The general impression felt from reactions of participants of the activity as well as from people coming to lectures was very positive. There were a lot of interesting lectures and several groups of people working in distinct but related fields (who usually do not meet) were brought together with a

fruitful interaction coming as a result. The list of all speakers and titles of their talks is enclosed at the end.

3. Main topics discussed during the activity. There were several different topics, some of them more mathematical, other ones more in mathematical physics. The topics were not always very close to each other, but there was a substantial interaction among participants working on different topics.

(1) Invariants of conformal (more generally almost Hermitian symmetric) and CR structures: D. Alekseevski (quaternionic activity), T. Branson, J. Bureš, A. Čap, M. Eastwood, R. Graham, J. Slovák, V. Souček
(2) Optical geometry, CR-structures and the Kerr theorem, and related topics: R. Graham, J. Lewandowski, P. Nurowski, L. Mason, S. Salamon, A. Trautman, (P. Tod - by e-mail), H. Urbantke,
(3) Dirac operators and spin structures on manifolds: A. Trautman, M. Cahen, S. Gutt, W. Kopczynski, J. Rawnsley
(4) twistor spaces, deformation theory: M. Eastwood, S. Huggett, L. Mason, S. Merkulov, J. Rawnsley,
(5) The Penrose transform: T. Bailey, J. Bureš, M. Eastwood, L. Mason, V. Souček
(6) Dirac operator and twistor operator on Riemannian manifolds and its spectral properties: H. Baum, T. Friedrich, O. Hijazi, A. Moroianu, U. Semmelmann (quaternionic activity)

4. Preprints. The discussions and the work done during the activity has brought nice results; 9 preprints have already appeared in the ESI series: [135], [140], [148], [149], [158], [159], [172], [173], [186].

A broader project for the study of invariant operators on manifolds with almost Hermitian symmetric structures from the point of view of natural operators was started by A. Čap, J. Slovák and V. Souček. One preprint [186] of a longer series is already finished, several more are in preparation.

A. Trautman, V. Soucek, H. Urbantke

Gibbsian random fields

Organized by R. Dobrushin (Moscow). August – December 1994. The theory of Gibbsian fields is a quickly developing branch of science lying on the boundary between probability theory and statistical mechanics. The notion of Gibbsian random field having the origin in statistical mechanics turns out to be a very general way to describe random functions of many variables, and so found many applications in different sciences, including engineering, biology, and so on. Difficult mathematical problems arose in the study of properties of Gibbsian fields, especially in connection with the problem of phase transition.

For a longer period R. Dobrushin, S. Shlosman, O. Hryniv visited ESI, other scientists came for the workshop. The following preprints were produced in this activity: [125], [176], [179].

Seminar: On the Ising Model and Around it in Eight Days. October 17–24, 1994. Abstracts of all talks given are collected in preprint [183].

A. van Enter, Groningen: *Ill-defined renormalization group maps: some new results,*
A. Messager, Marseille: *The Falicov-Kimball model is an Ising model,*
R. Dobrushin, Vienna - Moscow: *Estimates of semi-invariants for the Ising model at low temperatures.*
R. Kotecky, Praha: *The staggered charge order phase of the extended Hubbard model in the atomic limit,*
R. Schonmann, Los Angeles: *A study of the metastable behavior of the Ising model in the joint limit of small h and T,* 1994 10 19
O. Hryniv, Vienna - Lviv: *Fluctuations of the 2D Ising model droplet around the Wulff shape,*
S. Shlosman, Vienna - Moscow - Irvine: *Restricted variational problem and the Ising model,*
Ch. Pfister, Lausanne: *Conditional Limit Theorems and Equivalence of Ensembles,*
M. Zahradnik, Praha: *Stratified Gibbs states of 3D Ising type models,*
E. Olivieri, Rome: *Ising model and renormalization group pathologies,*
Ch. Maes, Leuven: *Percolation techniques in disordered spin systems,*

R. Dobrushin

CONTINUATION OF 1993 PROGRAMS

The three programs of 1993 had a continuation on a smaller scale in 1994 in order to finish scientific activities which were started in these programs.

Two-dimensional quantum field theory

Organized by H. Grosse. 16 preprints were produced in 1994, namely [69], [71], [77], [79], [80], [82], [90], [91], [95], [105], [110], [113], [118], [121], [132], [143].

After the development of quantum mechanics the line spectra of atoms and molecules, the periodic system as well as macroscopic properties of condensed matter have been explained. Although the quantum mechanics of atoms and molecules is well understood, the many-body effects offer, on the contrary, new challenging problems. The most prominent recent examples are high Tc superconductivity materials as well as the recent discovered quantum Hall effect. (To both subjects a Nobel prize has been awarded). Models describing these phenomena have been dealt with in our program. Various properties of spin systems related to superconductivity have been analyzed. The new technique of almost solvable models has been applied. Within the description of the quantum Hall effect geometrical and analytical methods have to be combined. It was a great surprise, when it was first observed experimentally, that the Hall conductivity at low temperatures and at high magnetic fields shows flat plateaus in 2-dimensional structures at well-described values of the filling factor. Models explaining the so-called fractional effect are still under debate. The precision of the plateaus compares with the most accurate measurements in nature.

The third kind of models dealt with in that program describes conductivity along one-dimensional systems, so called quantum wires. There exist new experimental methods in semiconductor technology, which allow to prepare almost one dimensional structures. Within the new subject, which is called mesoscopic physics, a number of elder ideas of quantum mechanics have been experimentally verified. A number of new phenomena are expected to show up in the near future.

H. Grosse

Differential Geometry

Organized by Peter Michor.

Nearly half the available resources were devoted to invite D. Alekseevsky, who organized the program on quaternionic manifolds. Some East European Scientists were invited in order to help their research.

There was an intensive collaboration between Michor and M. Dubois-Violette (who visited only 1 week) on the Frölicher-Nijenhuis bracket and non-commutative geometry, see preprints [70], [111], [133]. Preprint [72] on Poisson structures on the cotangent bundle of a Lie group or a principal bundle and their reductions came out of a collaboration in 1993 at ESI, where some participants did not even know each other before coming to ESI, and it was ignited by a talk by A. Alekseev (preprint [33]). Preprint [73] is an important contribution, connected with the stay of Tudor Ratiu and J. Marsden, another preprint by them is in preparation. Shan Majid contributed preprints [120], [130], [131] on quantum geometry, and he had influence on the preprint [163]. Alekseevsky contributed preprints [72], [138], [150], and some more are in preparation. Izu Vaisman spent one month, worked mainly on Poisson manifolds, and contributed [122], [123]. Perelomov, who was invited jointly with H. Grosse, contributed [143]. D. Juriev spent one month and contributed [167], [170]. From Timisoara I invited M. Craioveanu and M. Puta, who are working in some isolation in Rumania for 6 weeks each, and they contributed [164], [165], [177], and [178], on classical mechanics and Hamiltonian geometry. All together there were 29 preprints in this program.

P. Michor

Schrödinger Operators

Organized by T. Hoffmann-Ostenhof.

The activity in Schrödinger operators in 1994 was mainly the continuation of the 1993-program. It was more specialized in the sense that the problem of understanding Schrödinger operators with magnetic fields was the central topic to which about half of the activity was devoted. Consideration of magnetic Hamiltonians lead to new and challenging problems and many of the questions which have been answered satisfactorily for operators without magnetic fields await still answers for the case with magnetic fields.

There were 15 visitors, 20 preprints were written, 10 of which are devoted to the magnetic case (preprint 71, 74, 75, 78, 155, 162, 180, 181, 182, 184). These works address problems in solid state physics (74, 155, 162), spectral theory (71, 75, 78, 180, 181) and properties of magnetic eigenfunctions (184).

The other work includes scattering theory (100, 139) spectral theory (124, 137) inverse spectral theory (151, 152, 161) and properties of solutions of Schrödinger operators (99). With some ideas stemming from Schrödinger operators techniques a problem in hydrodynamics was solved (160).

Perhaps I should mention the work of Hempel and Herbst on the Hamiltonians without potential but with special magnetic fields which give rise to spectral behavior typical for solids (band structure), (74 and 162). Fefferman and Seco considered the spin of a large atom in its ground state (137) and Nadirashvili et al consider the regularity of the zeros of solutions to Schrödinger equations (99).

There were many seminars given about various topics, I just want to mention two interesting seminars on Ginzburg Landau models by Loss and by Struwe as well as a seminar on resonances given by Agmon.

Finally I should remark that some of the preprints produced during the activity in 93 already appeared or are about to appear. For instance the seminal result of N. Nadirashvili (29) who proved a 115 year old conjecture of Lord Raleigh concerning the fundamental frequency of vibrating plates is about to appear in Archive of Rational Mathematics.

T. Hoffmann-Ostenhof.

THE YEAR 1995

President of ESI: Walter Thirring
Scientific Director: Walter Thirring till August 1995
Acting Director: Peter W. Michor till August 1995
Director: Klaus Schmidt, from September 1995
Deputy Director: Peter W. Michor, from September 1995

General remarks

The directors of ESI changed. From the beginning of September 1995 onwards the director of ESI is Klaus Schmidt, and deputy director is Peter Michor. In thi year also fell the decision that ESI should change its location. It will occupy $840m^2$, half of the second floor, in Boltzmanngasse 9, A-1090 Wien. The new location is twice as large and nearer to the institutes of Theoretical Physics and Mathematics. A famous architect (proposed by the Minister of Science and Arts, Dr. Rudolf Scholten) is planning and supervising the adaptation of the site. We hope that ESI will be relocated in mid-1996.

In the first half of the year 1995 ESI was host to 216 visitors. There were 108 preprints contributed to the preprint series, many of them still belong to programs from 1994, and 89 seminar talks or ESI-Colloquia were given. A conference was organized in Vienna, on Complex Analysis, and ESI took part in the organization of two more conferences abroad. The program on condensed matter theory included 4 workshops of 2 weeks each.

15th Winter school on geometry and physics, January 14–21, 1995 Srni, Bohemian forest, Czech republic.

Noncommutative differential geometry, Czech Republic, Castle Třešť, May 7 – 13, 1995

Gibbs random fields and phase transitions; this program started with a small workshop with 26 participants in Churáňov (Czech Republic).

Winter School in Geometry and Physics

The traditional winter school in geometry and physics which takes places for one week each January since 1980 in a picturesque village in the Czech parts of the Bohemian mountains will be a joint enterprise of the Czech society of mathematicians and physicists and ESI, from 1994 onwards. Usually there are proceedings, which are published as a supplement of the 'Rendiconti Matematici di Palermo'. The first conference with ESI-participation was in the period January 15–22, 1994, the proceedings for

it are in preparation. The second winter school took place in Srni, January 14–21, 1995, proceedings will be published again as a supplement of the 'Rendiconti Matematici di Palermo'.

ACTIVITIES IN 1995

Two-dimensional quantum field theory

The lively developments in this field were reflected also in the continuation of this programme (which started in 1993 and had a continuation on a small scale in 1994). This time altogether ten visitors spent around two to four weeks at ESI.

The main subjects treated were Integrable Lattice Spin Models and Quantum Groups (Faddeev, Scheunert, Jurco, Kulish), Conformal Quantum Field Theory (Todorov, Niemi, Wipf) and Noncommutative Geometry (Coquereaux, Presnajder). For all three subjects, papers were delivered and seminars held. Some papers are still in preparation. During a one-day visit, Kuchar reported on the latest news concerning the Quantum Hall effect.

Quantum groups are still of great interest, and the recent developments around the reflection equation and applications to q-deformed Minkowski spaces were treated. The problem of quantizing the Liouville equation has been dealt with also.

New soluble models of conformal quantum field theory are obtained through the study of the Khizhnik-Zamolodchikov equation. Various versions of the WZNW-model led to a publication by the Bulgarian group.

We used the ideas of noncommutative geometry to obtain a cut-off procedure for quantum field theory. Scalar fields, gauge fields and spinor fields in two dimensions can be handled. Most surprisingly our method allows to handle supersymmetry without breaking it.

After finishing this project it is a pleasure for me to thank all people involved (visitors and staff) for providing an excellent atmosphere, so that scientific exchange on this high level was possible. Since four of our guests lectured this year also at the Schladming Winter school, the whole Austrian physics community, as well as 140 participants profitted from the activity in Vienna.

H. Grosse

The following preprints were contributed in this program: [214], [217], [225], [233], [234], [244]

Complex Analysis

Organized by F. Haslinger.

The activities of this program were spread over the months January, February and March 1995. The main topics were CR-manifolds and functions, geometric aspects of complex analysis, application of functional analysis to complex analysis and partial differential equations, $\overline{\partial}-$ equations, Bergman and Szegö kernels.

Some collegues stayed for a longer period at the ESI (Daryl Geller, Takeo Ohsawa, Peter Greiner , John Wermer, David Tartakoff) most of the participants concentrated their visit around the week Feb. 20 - Feb. 24, where a workshop took place with 20 interesting 45 minutes lectures (see the following list):

B. Berndtsson, Sweden: Some problems connected with interpolation and sampling of analytic functions.

J. Bros, France: Transformations of Fourier-Laplace type and related holomorphy domains on the complex hyperboloid.

R. Dwilewicz, Canada: Type functions for CR manifolds.

Ch. Epstein, IHES, France: A relative index for CR-structures.

Laura Geatti, Italia: Complex symmetric spaces.

D. Geller, USA: Partial differential equations on the Heisenberg group.

P. C. Greiner, Canada: Hamiltonian mechanics and fundamental solutions for subelliptic operators.

A. Iordan, France: Compactness of the Neumann operator for piece-wise smoothly bounded strictly pseudoconvex domains.

M. Langenbruch, Deutschland: Splitting of the $\overline{\partial}$-complex.

L. Lempert, USA: Algebraic approximations in analytic geometry.

J. McNeal, USA: The Bergman and Szegö projections on convex domains.
R. Meise, Deutschland: Extension and lacunas of solutions of linear partial differential equations.
S. Momm, Deutschland: Partial differential equations for analytic functions on compact convex sets in $\mathbb{C}^N$.
P. Müller, Austria: The Banachspace $H^1(X, d, \mu)$ (isomorphic classification).
T. Ohsawa, Japan: On the variation of the density and an application to interpolation problems.
H.S. Shapiro, Sweden: Partial differential equations and analytic continuation.
R. Szöke, Ungarn: Hypercomplex structures on the tangent bundles of hermitian symmetric spaces.
D. Tartakoff, USA: The smoothness of solutions to the $\overline{\partial}$-equation and applications.
H. Upmeier, Deutschland: Toeplitz operators and geometric quantization in several complex variables.
V. Vâjâitu, Romania: On Levi q-convexity.
D. Vogt, Deutschland: Solution operators for linear partial differential operators of second order and fundamental solutions with support in a half space.
J. Wermer, USA: Interpolation bodies in $\mathbb{C}^n$.

There were many further informal seminars combining various special fields of the visitors.
Contributions to the ESI preprint series: [195], [199], [203], [215], [216], [232], [253]

Noncommutative Differential Geometry

Organized by Alain Connes and Michel Dubois-Violette, local responsible P. Michor.

Central part of this program was a conference in the Czech Republic, in the castle of Třešt, May 8 – 13, which was organized by the Union of Czech Mathematicians and Physicists, the Erwin Schrödinger Institute of Mathematical Physics in Vienna, together with the Institute of Mathematics and Institute of Physics of Czech Academy of Sciences and the Faculty of Mathematics and Physics of Charles University. The most exciting event at the conference was a new noncommutative representation of the standard model by A. Connes, which restricts some of the free parameters more tightly than the old one. The program of this conference was as follows:

PLENARY LECTURES:

Chamseddine A.: Unification, gravity and supersymmetry in NG
Connes A.: Geometry from the spectral point of wiev
Coquereaux R.: Fractal triangular dissections, Jones algebras and NG
Doplicher S.: The small scale structure of spacetime, gravitational stability and quantum field theory
Dubois-Violette M.: Connections on certain classes of bimodules and reality conditions in NG
Gawedzki K.: Conformal field theory and NG
Karoubi M.: Algebres graduees mixtes
Kastler D.: Constraints of the standard model a la Connes-Lott
Kerner R.: Z-3 graded differential calculus and new gauge theories
Klimcik C.: NG and supersymmetry
Madore J.: Linear connections in NG
Michor P.: Derivation based constructions on central bimodules
Rieffel M.: Deformation quantization
Roberts J.: Physical and mathematical aspects of spacetime
Todorov I.: Non-commutative configuration space in WZNW model
Connes A.: Geometry from the spectral point of wiev, II

AFTERNOON LECTURES:

Bona Pavel: On Lie-Poisson structure on quantum states
Borowiec Andrzej: Constructive approach to non-commutative differential calculi
Brodzki Jacek: Supertraces and entire cyclic cohomology
Brzezinski Tomasz: Geometric aspects of the quantum group gauge theory
Cap Andreas: On twisted tensor products of algebras
Ferretti Gabriele: Schwinger terms and cohomology of pseudodifferential operators
Friedlander Leonid: L^2 - analytic torsion and L^2 - Reidemeister torsion
Gracia-Bondia J.M.: Connes' interpretation of the standard model and massive neutrinos
Iochum Bruno: Yang-Mills-Higgs versus Connes-Lott
Kalau Wolfgang: Supersymmetric Connes-Lott models
Kaviani Kamran: Chiral perturbation theory in the framework of NG
Kopf Tomas: The evolution of spacetime encode into a scalar field algebra
Lee Chang-Yeong: BRST and anti-BRST symmetry in noncommutative geometric gauge theory: matrix derivative approach
Martin C. P.: Quantum corrections and the stability of the ngc constraints on the parameters of the standard model
Presnajder Peter: Finite gauge model in non-commutative geometry
Schucker Thomas: Yang-Mills-Higgs versus Connes-Lott
Sitarz Andrzej: Problems with metric and linear connections in NG

POSTERS:

Drabant Bernhard: Quasitriangular structures in braided tensor categories

Le Roy Bertrand: Hypermatrices: a Z-3 graded matrix algebra

Lizzi Fedele: Noncommutative Lattices as Finite Approximation of Topological Spaces

Post Gerhard: Differential calculus on Universal Enveloping Algebras

Moreover there was scientific activity in ESI in the month of May, and the following preprints were contributed: [210], [228], [235], [269], [285], [290], [296], [299] (the authors of the last preprint were guests from the program on field theory).

Field theory and differential geometry

Organized by Guiseppe Marmo and P. Michor, it took place from May 15 till July 31, 1995.

The program developed along the following lines:

Differential geometry and its applications. Asorey, Ibort, Grabowski, Marmo, Michor, Perelomov, Simoni, Tulczyjew, Vilasi.

Spectral Geometry and Torsion. Burghelea, Friedlander. Their theory was explained in an interesting series of lectures.

Infinite dimensional Lie algebras and Lie groups. Borodin, Grabowski, Kirillov, Michor, Mickelsson, Rozhkovskaya. Here a very interesting series of lectures by A. Kirillov and infinite dimensional Lie algebras and their representations is to be mentioned. Borodin and Rozhkovskaya are young graduate student of A. A. Kirillov who were still in Moskau at the time of the program.

Gauge theories and current algebras. Langmann, Mickelsson, Rajeev, Stern, Vitale

Finite approximations to quantum physics. Balachandrian, Bimonte, Landi, Lizzi, Sparano, Teotonio-Sobrinho

The following preprints were contributed: [200], [218], [224], [229], [231], [236], [239], [240], [241], [242], [243], [245], [246], [247], [248], [254], [255], [256], [261], [277], [279], [282], [289], [293], [299].

Geometry of nonlinear partial differential equations

In this small program, organized by Vinogradov, he and Krasil'shchik spent one month each at ESI. The following preprints were produced: [202], [257], [260],

Gibbs random fields and phase transitions

Organized by R. Dobrushin and R. Kotecký.

The semester was overshadowed by the sad news of passing away of Roland L. Dobrushin (12th November 1995 in Moscow) who was the main organizer. Even though his deterioating health did not allow him to come, many discussions were influenced by his recent proposals and his thinking.

First steps toward organizing a conference devoted to the memory of Roland L. Dobrushin next September in Vienna were made during the semester.

The following colleagues participated in the program of the semester in Vienna:
Marek Biskup (1 week), Anton Bovier (2), Lincoln Chayes (8), Filippo Cesi (2), Efim Dinanburg (6), Roberto Fernandez (2), Roman Kotecký (10), Christian Maes (4), Vadim Malyshev (2), Fabio Martinelli (3), Igor Melicherčík (1), Boris Nakhapetjan (8), Enzo Olivieri (3), Senya Shlosman (1), Daniel Ueltschi (2), Miloš Zahradník (8).

We started with a workshop in Churáňov (Czech Republic) attended by:
M. Biskup, C. Borgs, A. Bovier, L. Chayes, J.-D. Deuschel, E. Dinanburg, R. Fernández, F. Hollander, P. Holický, O. Hryniv, D. Ioffe, M. Janžura, P. Kotalík, R. Kotecký, P. Marchetti, A. Martin-Löf, J. Miękisz, S. Miracle-Solé, B. Nakhapetian, C. Pfister, J. Ruiz, F. Slanina, D. Ueltschi, A. van Enter, M. Winnink, M. Zahradník.

In addition to (and as an extension of) numerous seminars, several topics were discussed in small groups. Some discussions already lead to finishing a paper (three ESI preprints were issued during the semmester); a number of papers and preprints is under preparation.

Among the topics discussed were:

Dobrushin's program for defining relative energies for weakly non-Gibbsian measures
C. Maes, L. Chayes, R. Kotecký, E. Olivieri, M. Zahradník

A proposal made by R. Dobrushin at a workshop in Renkum (in September) has been discussed. Certain pathologies in transformations of Gibbs measures can be for some models treated analogously to the so called Griffiths' singularities in disordered systems.

Kac Model
A. Bovier, M. Zahradník

Low temperature phase of the d-dimensional Kac Model was discussed. The aim is to prove that the critical temperature T_c is greater or equal to $1 - \gamma^x$ for some $x > 0$ where γ is the inverse of the range of the interaction. The validity of the Peierls argument was investigated for these models.

Ising model with alternating field
E. Olivieri, L. Chayes, M. Zahradník

The problem of its low temperature phase diagram was almost solved. In general we are dfealing with the structure of low temperature phases of two dimensional models whose contours do not satisfy the ordinary Peierls condition but a weaker property: the energy of such contours is the sum of the "corner energy"which has a high density and the "segment energy" having a small density. The possibility of extending the Pirogov-Sinai theory to these cases was established.

The spin flip dynamics of disordered systems
F. Cesi, C. Maes, F. Martinelli, M. Zahradník

We started working on the glassy dynamics for randomly diluted magnets. Both upper and lower bounds for the relaxation of the disordered system to equilibrium were derived.

Diluted models with continuum spins
L. Chayes, R. Kotecký, S. Shlosman

We discussed the existence of "entropic" intermediate phases for lattice models with continuous spin and annealed dilution.

Intermediate phase for a continuum model
L. Chayes, R. Kotecký

A continuum four component model of Widom-Rowlinson type with an Ashkin-Teller symmetry was discussed. This model has two phase transitions with four distinct phases at high fugacity and two distinct phases in an intermediate fugacity regime.

A Potts model with transition between two disordered states
M. Biskup, L. Chayes, R. Kotecký

We investigated a possibility to use reflection possibility for a class of random cluster models and an application to a particular class of Potts models.

Pirogov-Sinai theory for quantum models
R. Fernández, R. Kotecký, D. Ueltschi, E. Dinanburg

Different aspects of this problem were discussed including fermi and bose systems as well as corresponding degenerated models.

Dynamics of non Hopfield neural networks
V. Malyshev

General methods which were developped earlier for telecommunication networks were applied to neural networks introduced by M.Cottrell. Strong properties of the dynamics were proved: convergence to the patterns starting from noisy patterns.

Some other topics discussed:

Lifshitz law for the life-time of a droplet in the low temperature Ising model *L.Chayes , F. Martinelli*

Asymptotical behaviour for 1D symmetric exclusion with moving boundaries *O. Hryniv, L. Chayes*

Invariant measures for 1D asymmetric exclusion process *O. Hryniv, V. Malyshev*

Mixing properties and limit theorems for random fields *O. Hryniv, B. Nahapetian*

The question of the completeness of the phase picture constructed by the P.S. theory *M. Zahradník, I. Melicherčík*

Generalized Gibbs distributions *V. Malyshev, B.Nahapetian*

Dynamics for Hopfield networks with Small Number of Patterns *V. Malyshev, L. Pastur, M. Scherbina*

Roman Kotecký

Contributions to the ESI preprint series: [281], [283],

Reaction-diffusion Equations in Biological Context

This program was run from September 1 to November 15, 1995, and used nine man-months. The local organizers were Karl Sigmund, Reinhard Bürger and Josef Hofbauer from the Institute of Mathematics, the visitors Pavol Brunovsky, Konstantin Mischaikov, Thomas Nagylaki and Vivian Hutson.

Reaction-diffusion equation have been studied (in the context of population genetics) since 1937, but only recently has one studied the effect of different diffusion rates (biological motivation: diffusion rates are evolutionary variables, and subject to selection). The central question discussed during the workshop was: if different diffusion rates carry no selective advantage per se (i.e. all have the same fitness) will there still be selection for some particular rate? We assume, for instance, a one-dimensional distribution of the population along an axis, and a carrying capacity which is not constant and can even be negative in some spots. Under the assumption of asexual replication, and only two different diffusion rates, it turned out that there was always selection for the smaller one. This could be proved analytically, using the theory of monton flows, even in the case of adding small mutation rates to the equation. For more than two rates, the result is probably true, but its proof has still a gap (even for the no mutation case). Considerable effort has been made to develop more sophisticated models including sexual replication, recombination, and drift. Among the problems still at an exploratory stage, we mention: what happens if there is a cost attached to diffusion rates that are too small, or too large? Is there a selective advantage for higher diffusion rates if the carrying capacity oscillates periodically?

Another center of gravity for the discussions was the theory of travelling waves for frequency-dependent selection. This can be studied using evolutionary games (more precisely, reaction-diffusion variants of the replicator equation). The bistable situation was of particular interest. It was shown that under certain circumstances bistable waves exist (with a change of sign for the velocity of the density of one of the two competing types). This was applied to the study of the iterated Prisoner's Dilemma, with special emphasis on the invasability of a population of defectors by strict retaliators.

It is expected that during the next few months, several papers will result from our collaboration.

In particular, Nagylaki is finishing a paper with the title 'Multinominal-sampling models for random genetic drift', and a further work by Brunovsky-Hofbauer and Nagylaki with the title: 'Convergence of Multilocus systems under weak epistassis or weak selection' is in preparation.

Karl Sigmund

Condensed Matter Physics

In this program which is still runing at present almost 70 scientists visited the Erwin Schroedinger institute. In the year 1995 3 workshops were held. The first one in August was about "Transport Phenomena and Chaos". The second one in September war devoted to the "Heisenberg and Hubbard Model" and the third one in Octobre to "Singular Spectra". The first two workshops lasted two weeks each and the third one just one week. Up to now about 15 preprints were writen by the participents of this special semester on "Condensed Matter Physics - Dynamics, Geometry and Spectral Theory." Since this activity is still going on until the end of February 1996 the final account will be given in the report this year.

Contributions to the ESI preprint series: [259], [264], [270], [271], [272], [275], [276], [280], [291], [294], [295], [297], [302]

Semi-Classical Limits and Kinetic Equations

This was a small workshop, organized by C. Schmeisser as a preparation for a program for 1997, in the period November 27 - November 28, 1995. The following talks were presented:

W. Thirring (Wien): Derivation of the Thomas-Fermi theory from the Schrödinger Equation
T. Paul (Paris): Semiclassical methods using coherent states
H. Narnhofer (Wien): Vlasov hydrodynamics for a quantum mechanical model
A. Arnold (Berlin): The relaxation-time von Neumann-Poisson equation: existence, uniqueness, large time behaviour
B. Perthame (Paris): Time Decay in Kinetic Equations, Relations with Schrödinger and Fluid Cases
M. Pulvirenti (Roma): On the Enskog equation: Derivability from particle systems
I. Gasser (Berlin): The classical limit of Hartree-Fock systems
N. Mauser (Berlin): Wigner transforms and homogenization limits
R. Illner (Victoria): Global weak solutions of the Boltzmann equation in a slab with stochasitc boundary conditions
F. Poupard (Nice): Semiclassical limits and effective mass theorems
P. Gérard (Paris): Wigner measures and Concentration Effects
A. Unterreiter (Berlin): The stationary quantum drift-diffusion model
C. Ringhofer (Tempe): Approximate equilibria of quantum mechanical systems and applications to quantum kinetic and quantum hydrodynamic models
P. Degond (Toulouse): Macroscopic models for semi conductors
A. Zwirchmayr (Wien): Convergence of moment expansions for the semiconductor Boltzmann equation

Guests of Walter Thirring

Contributions to the ESI preprint series: [187], [199], [209], [220], [221], [222], [223], [226], [265], [267], [286], [287], [288], [292],

Guests of Klaus Schmidt

Contributions to the ESI preprint series: [268], [273], [300], [301],

Guest of Wolfgang Kummer

Existing treatments of $2d$-dimensional models largely ignore a careful stydy of global questions. During the first visit of Dr. Katanaev we showed that nonvanishing torsion may be eliminated in $2d$-dimensional models of gravity. The equivalent generalized dilation theory, nevertheless, acquires a 'geometric' justification by this procedure. The global structure of that theory is shown to be obtained by cutting Penrose diagrams of the theory with torsion. The resulting structures turn out to to be much closer to the genuine Schwarzschild black hole of General Relativity ([278]).

During his second stay we prepared a paper (preliminary draft: 'On the completeness of the black hole singularity in $2d$ dilaton theories, prep. TUW95-24). It critically analyses the properties of Witten's black hole in relation to the genuine one. All known soluble models in the presence of matter are found to differ crucially from the genuine black hole, a fact to be suspected already from qualitative differences, e.g. in the Hawking temperature.

W. Kummer

Contributions to the ESI preprint series: [252], [278].

CONTINUATIONS OF ACTIVITIES FROM 1994

Continuation Operator algebras

Contributions to the ESI preprint series: [204], [226], [267], [274].

Continuation Schrödinger Operators

Contributions to the ESI preprint series: [190], [193], [262], [208], [211], [212], [237], [238], [249], [250], [258], [262], [263].

Continuation Mathematical Relativity

Contributions to the ESI preprint series: [190], [266], [267], [206], [207], [251], [266],

Continuation Quaternionic manifolds

Contributions to the ESI preprint series: [188], [191], [196], [197], [198], [205], [213], [219], [230], [247],

Continuation Spinor - and twistor theory

Contributions to the ESI preprint series: [192], [194], [201], [219], [227], [284],

THE YEAR 1996

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General remarks

End of July 1996 ESI moved into its new premises, part of the second floor of the building in Boltzmanngasse 9, 1090 Wien. The adaptation of the rooms was planned and supervised by 'Eichinger oder Knechtl', architects. There are $840m^2$, a decent lecture hall and a good common room, all with enough headroom of $5.20m$ high. The building is over 200 years old, it was built as an orphanage during the rule of the emperor Joseph II.

In the year 1996 ESI was host to 258 visitors. There were 120 preprints contributed to the preprint series, some of them still belong to programs from 1995, and 202 seminar talks or ESI-Colloquia were given. Three conferences were organized in Vienna:

(1) 'Statistical mechanics as a branch of probability theory', September 16-20, 1996, dedicated to the memory of Roland L. Dobrushin.
(2) Satellite conference of the European Mathematical Congress: Aspects of Spectral Theory.
(3) Workshop, organized jointly by ESI and the 'Internationales Institut f"ur Kulturwissenschaften in Wien': The changing Metaphysics of Science.

ESI took part in the organization of one conferences abroad, 'The 16th Winter school on geometry and physics', January 14–21, 1996, Srni, a small village in the Bohemian forest, Czech republic.

ESI has spent AS 4.55 Mio for science, 4.6 Mio for administrative costs, and 5.4 Mio for the adapting the new premises.

Conference: Statistical mechanics as a branch of probability theory

Vienna, September 16-20, 1996.
Preprints contributed: 346, 347, 355, 360, 384,
Money spent: 195.000.– (ESI)
This Conference was dedicated to the memory of Roland L. Dobrushin, who spent a significant part of his last years at ESI. The following lectures were given:

Opening: Walter THIRRING, Robert MINLOS
Raghu VARADHAN: On the diffusive behavior of a tagged particle in the asymmetric simple exclusion models
Konstantin KHANIN: Ground States for Random Burgers Equation
Peter MAJOR: Existence and non-existence of phase transition in Dyson hierarchical model with continuous symmetry
Alessandro PELLEGRINOTTI: Random walk in random environment
Leonid BUNIMOVICH: Transport Coefficients from Dynamics
Henk van BEIJEREN: Dynamical properties of disordered billiards
József FRITZ: Ergodicity of infinite Hamiltonian systems with weak noise
Yury SUHOV: Polygonal billiards with point obstacles

Frank den HOLLANDER: Localization transition for a polymer near an interface.
Salvador MIRACLE–SOLE: Statistical mechanics of interface models
Charles PFISTER: Wetting Phenomenon in the 2D Ising Model
Miloš ZAHRADNÍK: A remark on the shape of the three dimensional Ising contours
Lincoln CHAYES: Graphical representation
Bogusław ZEGARLINSKI: Coercive Inequalities for Kawasaki dynamics
Nobuo YOSHIDA: Relaxed criteria of Dobrushin-Shlosman mixing condition
Enzo OLIVIERI: Renormalization-group at criticality and Dobrushin-Shlosman conditions
Geoffrey GRIMMETT: Exponential decay for Potts and random-cluster models
Hans-Otto GEORGII: Phase Transition for Continuum Potts Models
Aernout van ENTER: Robustness of the non-Gibbsian property
Eugene PECHERSKY: On applications of Gibbs fields in image processing
Raphael LEFEVERE: Gibbs description of some non-Gibbs fields
Herbert SPOHN: Stochastic particle systems (the one-dimensional asymmetric exclusion process)
Carlo BOLDRIGHINI: Navier-Stokes corrections for one-dimensional hard rods
Alain MESSAGER: On the rigidity of the 1-1-1 interface in the Falicov-Kimball model
Wolfgang SPITZER: On hydrodynamics of quantum hard rods
Abel KLEIN: Griffiths singularity
Christian MAES: Relaxation to equilibrium for glassy dynamics in the Griffiths' regime
Fabio MARTINELLI: Relaxation of 2D disordered magnets in the Griffiths phase
Arthur JAFFE: Hidden Symmetry
Anatoly VERSHIK: Limit shapes in algebra & geometry and large deviations.
Boris GUREVICH: Thermodynamic formalism in the theory of infinite nonnegative matrices
Robert MINLOS: Absence of phase transitions in quantum anharmonic crystal with light particles
Valentin ZAGREBNOV: Quantum Fluctuations Can Suppress Structural Phase Transition
Walter THIRRING: Spontaneously broken symmetries

Satellite conference of the European Mathematical Congress Aspects of Spectral Theory

ESI contributed AS 50.000.– to this conference. It was organized by M. Hoffmann-Ostenhof, Th. Hoffmann-Ostenhof, H. Langer, R. Menniken. The following talks were given:

Heinz Siedentop (Oslo, Norway) Counting Eigenvalues Using Coherent States with an Application to Dirac and Schrödinger Operators in the Semi-Classical Limit
Fritz Gesztesy (Columbia, Missouri, USA) Trace Formulas and Inverse Spectral Problems
Michael Solomyak (Rehovot, Israel) Rozenblum-Lieb-Cwikel estimate for Markov generators
Bernd Thaller (Graz, Austria) Optimal Norm Estimates for the Schrödinger Semigroup with a Magnetic Field in Two Dimensions
Evgeni Korotyaev (St. Petersburg, Russia) The estimates and the inverse problem for the Hill operator
Gunther Karner (Blacksburg, USA) The Schroedinger Equation on Time-Dependent Domains
Andrea Sacchetti (Modena, Italy) Lifetime of Wannier-Stark resonance
Y.M. Arlinskii (Lugansk, Ukraine) Closed sectorial sesquilinear forms and one-parameter contractive semigroups
Zdzislaw Brzeźniak (Hull, Great Britain) Asymptotic Behaviour for Contraction Semigroups with Countable Unitary Spectrum
Boris Pavlov (Auckland, New Zealand) Semigroup approach for Szegö-Kac determinants
V. Kondratiev (Moskow, Russia/Potsdam, Germany) On estimate of the first eigenvalue of the elliptic operator
Jürgen Voigt (Dresden, Germany) Schrödinger operators with singular complex potentials
Serguei Naboko (St. Petersburg, Russia) On the absolutely continuous spectrum of the weighted discrete Schrödinger operators
Lev A. Sakhnovich (Odessa, Ukraine) Spectral Problems (direct and inverse) for Canonical Systems
Yaroslav Kurylev (Loughborough, Great Britain) Multidimensional Gelfand Inverse Problem with Complete and Incomplete Spectral Data
Vyacheslav Pivovarchik (Odessa, Ukraine) Direct and inverse problems for an inhomogeneous string vibrating with damping and associated operator pencils
Bernard Helffer (Paris, France) Witten's Laplacians and decay of correlations
László Erd"os (New York, USA) Semiclassics and Lieb-Thirring inequality for the Pauli operator in a strong nonhomogeneous magnetic field
Ira Herbst (Charlottesville, USA) Title to be announced
A. Sobolev (Brighton, Great Britain) Quasi-classical asymptotics for the Pauli operator
Mikhail Agranovich (Moscow, Russia) Nonsmooth elliptic boundary problems, transmission problems, and boundary problems with indefinite weight
Rudi Weikard (Birmingham, USA) On Hill's Equation with a Singular Potential
Simeon Vugalter (Nizhny Novgorod, Russia) Asymptotic estimates for bound states in quantum waveguides coupled laterally through a narrow window

Grigorii M. Zhislin (Nizhny Novgorod, Russia) On the bound states of N-particle systems with large N in magnetic fields

Andreas Fleige (Essen, Germany) A Counterexample to Completeness Properties for Indefinite Sturm-Liouville Problems

Mel Faierman (Witwatersrand, South Africa) On a problem in fluid dynamics

Alexander Kozhevnikov (Haifa, Israel) Spectral problems for differential operators of mixed order

Georgi D. Raikov (Sofia, Bulgaria) Strong magnetic field spectral asymptotics for the Schrödinger operator

József Benkö (Budapest, Hungary) Schrödinger equation of the hydrogen atom in strong magnetic fields

Mark Michael Malamud (Donetsk, Ukraine) On the Gohberg and Krein's conjecture about cyclicity and unicellularity of Volterra operators

Henk de Snoo (Groningen, The Netherlands) On a subdivision of Nevanlinna functions

Sergei G. Pyatkov (Novosibirsk, Russia) Interpolation of some function spaces and indefinite Sturm-Liouville problems

A. Sakhnovich (Odessa, Ukraine/Amsterdam, The Netherlands) Generalized Bäcklund-Darboux transform and tranfer matrix function. Spectral and bispectral properties

Aad Dijksma (Groningen, The Netherlands) Selfadjoint differential operators and one-dimensional form perturbations

Robert Seeley (Newton, USA) Spectral asymptotics on a manifold with conic singular stratum

Vladimir Mikhailets (Warsaw, Polen) Spectral Analysis of the One-Dimensional Schrödinger Operators with Point Interactions

Pavel Kurasov (Bochum, Germany) Finite rank perturbations and selfadjoint extensions

Branko Najman (Zagreb, Croatia) Singular perturbation of dynamical boundary value problems

Vadim Adamyan (Odessa, Ukraine) Spectral Decomposition of Schroedinger Operator with Pauli Constraints

Manfred Möller (Witwatersrand, South Africa) Differentiable dependence of eigenvalues of operators in Banach spaces

Konstantin Makarov (Bochum, Germany) Three-body problem with point interactions: To Fall or not to Fall to the Center?

Franciszek H. Szafraniec (Kracaw, Polen) Limit procedures within the quantum harmonic oscillator

Peter Stollmann (Frankfurt, Germany) Localization for random perturbations of periodic anisotropic media

Mikhail A. Antonets (Nizhny Novgorod, Russia) Initial-boundary-value problems for hyperbolic systems with transmission and impedance conditions

Yuri Tomilov (Kiev, Ukraine) On local and global asymptotic behavior of C_0-semigroup

Nikolay D. Kopachevsky (Simfereopol, Ukraine) Hydrodynamical boundary eigenvalue problems with spectral parameter in an equation and boundary conditions

Leonid Volevich (Moscow, Russia) Newton's polygon and the resolvent of a system elliptic in the sense of Douglis-Nirenberg

Alexander Lifschitz (Chicago, USA) Preliminary results on the generalized Poincar'e problem

Yurij M. Berezansky (Lublin, Poland) Infinite-dimensional non-Gaussian analysis and its applications to the operators of Schroedinger type

Andrei A. Shkalikov (Moscow, Russia) Invariant Subspaces of Operator Matrices and Applications

Christiane Tretter (Regensburg, Germany) Spectral Properties of the Orr-Sommerfeld Problem

Reinhard Mennicken (Regensburg, Germany) Spectral decomposition of symmetric operator matrices and applications

Vladimir Derkach (Donetsk, Ukraine) On generalized resolvents of symmetric relations in Krein spaces

Seppo Hassi (Helsinki, Finland) Rank one perturbation of selfadjoint operators

Michael Kaltenbäck (Vienna, Austria) A characterization of semibounded selfadjoint operators

Abdelkader Intissar (Corte, France) Some New Properties of Regularity of the Shape Memory Alloys Operator

Alexander Markus (Beer Sheva, Israel) On some properties of factorisation indices

Peter Jonas (Berlin, Germany) On the spectral theory of operator matrices and riggins

Miroslav L. und Valentina I. Gorbachuk (Kiev, Ukraine) On entire Hermitian operators which admit a representation by partial differential operators

Henrik Winkler (Dresden, Germany) Spectral problems for canonical systems and associated strings

Jakov and Inna Roitberg (Chernigov, Ukraine) Green's formula for general systems of equations; Sobolev's problem in complete scale of Banach spaces

Winter School in Geometry and Physics

The traditional winter school in geometry and physics which takes places for one week each January since 1980 in a picturesque village in the Czech parts of the Bohemian mountains will be a joint enterprise of the Czech society of mathematicians and physicists and ESI, from 1994 onwards. Usually there are proceedings, which are published as a supplement of the 'Rendiconti Matematici di Palermo'. The first conference with ESI-participation was in the period January 15–22, 1994, the proceedings for it are in preparation. The winter school took place in Srni, January 14–21, 1995, proceedings will be published again as a supplement of the 'Rendiconti Matematici di Palermo'.

Workshop: The changing Metaphysics of Science

This workshop was organized jointly by ESI and the 'Internationales Institut f"ur Kulturwissenschaften in Wien'. ESI supported the stay of all physicists at this workshop, AS 80.000.–. These were: John Ziman, Anton Zeillinger, John L. Heilbron, Lee Smolin, Sam Schweber, Carlo Rizutto, J"urgen Renn, Paul Forman. The program did not follow the usual scheme of ESI conferences.

PROGRAMS IN 1996

Condensed Matter Physics – Dynamics, Geometry, and Spectral Theory

ESI, August 6, 1995 – February 24, 1996

Preprints contributed: 22

Money spent: AS 1.780.100.- (ESI), AS 182.000.– (foreign)

Starting from August 6, 1995 and ending on February 24, 1996, a special semester on **Condensed Matter Physics – Dynamics, Geometry, and Spectral Theory** took place at ESI. The main objective of this program was to bring scientists together from active areas of mathematics and physics, ranging from applied mathematics and mathematical physics to theoretical condensed matter physics, and to give them the opportunity to talk to each other - people who probably would not have met otherwise.

Throughout the program, as many young postdoctoral scientists were present as established senior scientists. The participants came from all over the world, in particular from Europe, from overseas and the eastern countries. This reflects the strong interest the scientific community had in this program at ESI which went far beyond the invitation letters that were sent out. Altogether, more than a hundred physicists and mathematicians participated in the program. Notably many long-term visitors were among them, the average staying length amounted to twenty days, approximately. All participants and the organizers enjoyed the pleasant atmosphere at ESI and benefitted from the good working conditions ESI provides.

Scientifically, the program was centered around five workshops that were held during the program,

(CT) Workshop on *Transport Phenomena and Chaos*, August 13 – 26, 1995;
(HH) Workshop on the *Hubbard and Heisenberg Model*, August 27 – September 9, 1995;
(SiS) Workshop on *Singular Spectra*, October 23 – 28, 1995; a collection of the abstracts of the seminars is available as ESI-Preprint no. 280.
(FFT) Workshop on *Field Theoretic Methods for Fermion Systems*, January 21 – February 3, 1996;
(DG) Workshop on *Condensed Matter Physics and Discrete Geometry*, January 21 – February 3, 1996;

In each of these workshops, between twenty and forty participants attended the seminars on a rather diverse collection of topics and continued the discussions afterwards in the offices of ESI in Pasteurgasse.

All participants in this program have much enjoyed the pleasant facilities and the good working conditions ESI provides. Besides, the atmosphere at ESI is rather stimulating for starting new or continuing existing collaborations. If this was the aim to be met then we succeeded, as many replies from the participants from all over the world show.

The scientific "spin-off" of this program may be best illustrated by the preprints that its participants have contributed to the ESI preprint series. Among them are very prominent authors, and we are happy that ESI possibly takes part in a new exciting development in theoretical physics.

The 21 ESI preprints that have been submitted during or after the program by its participants are:

1995: 259, 264, 270, 271, 272, 275, 276, 280, 291, 294,
1996: 295, 297, 302, 306, 308, 313, 330, 331, 339, 352, 380, 383.

Volker Bach (TU Berlin), Ruedi Seiler (TU Berlin),

Topological, Conformal and Integrable Field Theory

February 15 till May 14, 1996
Preprints contributed: 21,
Money spent: AS 794.000.– (ESI), 8.000.– (foreign).

The aim of the activity was to bring together a number of specialists in the three interrelated domains in order to stimulate the research on their front lines. A special stress was put on the development of methods applicable in more than one of the three fields. The ESI created ideal conditions for such exchanges which took form of official (almost every day) seminars and unofficial discussions between the participants in the comfortable surrounding of the (former) Institute's site. Special thanks are due to the permanent stuff of the Institute which assured much needed flexibility in organization of the activity and more than smooth handling of all practical problems.

An important part of the program dealt with conformal field theories. These are theories describing critical phenomena in 2-dimensional statistical-mechanical systems and vacua of string theory. One of the main open problems of conformal field theory is that of classification of the rational models. The research in this direction was conducted by Ganchev, Ganon, Petkova Schroer and Stanev. Ganon has pursued the work on the classification of modular invariant partition functions of theories with Kac-Moody symmetries by methods based on the Galois symmetries inherent in the action of the modular group whereas the Bulgarian group studied the fusion algebras related to rational level Kac-Moody algebras and constructed correlation functions out of the corresponding solutions of the Knizhnik-Zamolodchikov equations (in the joint preprint with Furlan). Schroer pursed his approach to the classification based on algebraic field theory methods. It has become more and more evident that the three methods, based on the study of monodromies of correlators, are closely related and involve interesting number theory aspects of quantum fields deseving further investigation.

The applications of conformal field theories to quantum Hall effect were studied by Cappelli and by Todorov (in a joint preprint of the latter with V. Kac). The idea is to search for new families of conformal models with W-algebra symmetries which may describe the Hall boundary currents. Not too surprisingly, it appeared that this program is strongly related to the classification problem of rational models of conformal field theory. The work conducted at ESI has permitted to put forward a new list of conformal models for Hall fluids.

The analysis of differential equations satisfied by the conformal field correlators has been one of the principal tools of conformal field theory. Alekseev-Recknagel-Schomerus in a joint work have shown how to obtain and analyze equations generalizing the Knizhnik-Zamolodchikov ones for a large class of conformal field theories. This work opens a possibility to directly apply the methods used in the analysis of WZW models to other models of conformal field theory.

The appearance of structures typical for integrable models in conformal field theories has been a subject of an intense study. One of such relations is that between the integral formulae for the conformal blocs (solutions of the KZ equations) and the Bethe Ansatz for spin chains. The topic which, as indicated by recent works of Beilinson, Drinfeld Feigin and Frenkel exposed by the latter in a series of seminars at ESI, is related to the geometric Langlands program. It has been analyzed in the case of genus 1 in the joint work of Falceto and Gawedzki where the Bethe-Ansatz formulae for general group where obtained by exact calculation of field theory functional integrals and were shown to encode hermitian structures on the bundles of non-abelian theta functions.

The connections of the Knizhnik-Zamolodchikov equations and integrable models were also studied by Felder, Varchenko and Veselov. On one hand side the KZ equations may be considered as a quantization of the Hitchin integrable system and in the genus one case they lead to a quantum elliptic Calogero-Moser system or its spin versions. On the other hand, the deformation of the equations to a finite difference ones, gives rise to new integrable models based on elliptic quantum groups whose intricate representation theory has been studied by Felder and Varchenko.

Another application of conformal field theory techniques to integrable systems was developed by Bonora who has generalized the Drinfeld-Sokolov construction of integrable hierarchies to the N=2 supersymmetric case and by Olshanetsky who has obtained a novel description of Hitchin systems.

One of the main directions in the theory of integrable two-dimensional field theories has been the work on exact formulae for form-factors, started by Smirnov. Musardo exposed the application of this methods to a series of deformations of minimal conformal theories. Al. Zamolodchikov analyzed

its relation with the thermodynamical Bethe Ansatz. Bernard and Babelon (in a joint paper with Smirnov, completed at ESI) have found an interpretation of the form-factor formulae as a semiclassical description of the soliton scattering. A fundamental role in their work has been played by a new quantum deformation of Riemann surfaces which deserves further studies.

The inclusion of the ideas of non-commutative geometry into field theory has been a subject of work of Grosse Klimcik and Presnajder who, in a series of ESI preprints, developed quantum field theories on non-commutative spaces and constructed theories with two-dimensional fermions (using supersymmetry), with non-trivial topological sectors and first four-dimensional models. Their constructions provide a new type of cutoffs for field theory which preserve the essential symmetries, but may also play a more fundamental role. In another attempt to marry non-commutative geometry with field theory, Alekseev Faddeev and Schomerus (with Fröhlich) made progress in the study of lattice 1+1 dimensional models with fields taking values in quantum groups. Such models possessing lattice versions of Kac-Moody and conformal symmetries may be constructed from representation theory of discretized Kac-Moody algebras developed by the authors.

The conformal field theory ideas (more concretely, the geometric analysis of WZW models) found also an application in the work of Assorey and Falceto who analyzed the vacuum nodes of the ground state of three-dimensional gauge theory, confirming Feynman's conjecture that the node structure is related to the confinement mechanism. An attempt to extend the geometric construction of the WZW model of conformal field theory to four dimensions was described in a series of brilliant seminars by Nekrasov, summarizing his work with Losev, Moore and Shatashvili and its relation to the recent developments in supersymmetric Yang-Mills theory and to the Seiberg-Witten invariants. The recent duality ideas in gauge field theories were discussed in talks by Olive (a general exposition) and by Schwimmer (on his work on the generalizations to higher rank groups). The mysterious occurence of integrable models in the low energy effective actions of supersymmetric gauge theories was studied by Morozow and by Dubrovin who developed a unified approach to low energy prepotentials based on the Witham hierarchies. The relation between the Seiberg-Witten and Donaldson invariants was the subject of the research of Stora who exploited the relations between the topological field theories and the equivariant and BRST cohomologies.

Finally, although the string theory and quantum gravity did not belong to the main subjects of the program, their relations with conformal and topological field theories were the topics of research by Pawelczyk (who found new topological instanton configurations for a model of rigid string), of Schimmrigk and Theisen (mirror symmetry of string vacua) and of Durhuus and Jonson who pursued their analysis of phase transitions in discrete models of random surfaces.

In summary, the program has resulted in numerous advances in topological, conformal and integrable field theories. Even if most of the large number of participants did not spend at ESI a long enough period to complete a closed research project (an average length of stay was about 2 weeks), the possibility of intensive exchanges with a wide spectrum of specialists, also the ones taking part in the parallel representation theory activity, was unanimously appreciated by the participants and had a stimulating effect on their research which is difficult to overestimate. One should also stress that several of more general talks gathered an audience from outside ESI extending the profit to the local community from the Institute's activity beyond Grosse's group directly involved in the program. We have to admit, however, that more could have been done in this direction by, for example, organizing a systematic series of lectures accessible to students on the topics of the program. One should maybe consider the possibility of making such courses a permanent companion of longer activities at ESI.

Krzysztof Gawedzki, Harald Grosse

Preprints contributed: 315, 316, 317, 318, 319, 320, 321, 322, 323, 327, 335, 336, 350, 362, 370, 371, 378, 386, 389, 391, 407.

Representation Theory with Applications to Mathematical Physics

April - June, 1996

Preprints contributed: 24

Money spent: AS 1.246.800.– (ESI), 331.000.– (foreign)

The program was coorganized by Ivan Penkov (University of California at Riverside) and Joseph A. Wolf (University of California at Berkeley). Peter Michor served as local organizer. The main

idea was to present today's Representation Theory in all its diversity. Another idea was to foster active interaction between three major schools in Representation Theory: the American, the Western European, and the Russian. Along with the about 35 senior participants, the program hosted about 20 graduate students of US Universities sponsored jointly by ESI and the NSF (via a special NSF grant of US$24000). Another feature was the considerable interaction with the Mathematical Physics program organized by K. Gawedski.

The following areas of Representation Theory were most active in the program:

- representations of real Lie groups: analytic and geometric methods;
- structure theory of Lie algebra representations;
- structure theory of quantum groups;
- Lie superalgebras, Lie supergroups, and their representations;
- invariant theory;
- (co)homology of Lie algebras and applications;
- infinite-dimensional Lie groups and differential operators;
- applications of Representation Theory to Mathematical Physics and to Geometry.

Here is a list of talks presented in the program:

D. Alekseevsky, Sophus Lie Centre, Moscow, Classification of n-extended Poincare Lie algebras and Lie superalgebras.

A. Astashkevich, UC Davis, On the Fedosov quantization of semisimple coadjoint orbits.

L. Barchini, Temple University, Unitary representations and harmonic forms (collaboration with Roger Zierau).

M. Eastwood, University of Adelaide, Zero energy fields on real projective space.

A. Fialowski, UC Davis, Deformations of the vector field Lie algebra L1.

M. Flato, University of Bourgogne, Deformation quantization: deforming Nambu mechanics.

I. Frenkel, Yale University, Four-dimensional realizations of two-dimensional current groups.

D. Fuchs, UC Davis, Massey products.

V. Futorny, University of Kiev, Alpha-stratified weight modules for finite-dimensional Lie algebras.

V. Futorny, University of Kiev, Representations of affine Lie algebras.

S. Gindikin, Rutgers University, $\bar{\delta}$-cohomology at nonconvex tubes.

M. Golinshcheva-Kutuzova, Institute of Nonlinear Sciences, Intertwining operators and integrable hierarchies of soliton equations.

V. Kac, MIT, Quantum orbifolds.

A.A. Kirillov, Jr., MIT, Cohomology of local systems and canonical basis.

A.A. Kirillov, Sr., University of Pennsylvania, Tame algebras of differential operators.

B. Kostant, MIT, Quantum cohomology of the flag manifold, the Toda lattice and the representation of highest weight rho.

G. Litvinov, Institute of New Technologies, Moscow, Lie hypergroups and their representations.

G. Litvinov, Institute of New Technologies, Moscow, Non-unitary representations of the Heisenberg group in details.

G. Lusztig, MIT, Asymptotic properties of Hecke algebras and quantum groups.

F. Malikov, University of Southern California, Singular support of g-modules and an attempt to build GFT using admissible representations.

O. Mathieu, University of Strasburg, Canonical operations in symplectic geometry.

O. Mathieu, University of Strasburg, Obstructions for Hodge theory on symplectic manifolds.

P. Michor, ESI, Basic differential forms for actions of Lie groups.

P. Michor, ESI, Choosing roots of polynomials smoothly alias lifting of curves over invariants.

D. Milicic, University of Utah, On the classification of irreducible Harish-Chandra Modules.

M. Nazarov, University of Swansea, Yangians and Capelli identities.

Y. Neretin, Moscow Institute of Electronics and Mathematics, Boundary values of holomorphic functions and singular unitary representations of groups O(p,q).

J. Novak, Ball State University, USA, Explicit realizations of certain representations of Sp(n,R) via the Penrose transform.

A. Onishchik, Yaroslavl University, Supermanifolds associated with Symmetric spaces.

I. Penkov, UC Riverside, Representations of arbitrary finite-dimensional Lie superalgebras.

V. Popov, Moscow State Technical University, An analogue of M. Artin's conjecture on invariants for non-associative algebras.

V. Protsak, Yale University, On a geometric approach to vertex operator algebras.

M. Rosso, University of Strasburg, Quantum groups and quantum shuffles.

A. Rudakov, Russian Academy of Sciences, Representation-like properties of vector bundles.

V. Serganova, UC Berkeley, Representations of the Lie superalgebra q(n).

J. Simon, University of Bourgogne, Global solutions of the Maxwell-Dirac equations.

E. Sommers, MIT, A family of representations of a Weyl group, and applications.

E. Stern, UC Berkeley and University of Pennsylvania, Semi-infinite wedges and combinatorics.

D. Sternheimer, CNRS, France, Recent developments in deformation quantization and quantum groups.

T. Takebe, UC Berkeley and University of Tokyo, A system of difference equations with elliptic coefficients and Bethe vectors.
A. Vershik, Russian Academy of Sciences, St. Petersburg, Inductive construction of Coxeter group representations.
E. Vinberg, Moscow State University, On invariants of a set of matrices.
J.A. Wolf, UC Berkeley, Linear cycle spaces and double fibration transforms.
S. Woronowicz, University of Warsaw, Remarks on quantum SU(1,1).
D. Zhelobenko, Independent University, Moscow, Hypersymmetries on extremal equations.
R. Zierau, Oklahoma State University, Unitary representations and harmonic forms (collaboration with Leticia Barchini).
G.J. Zuckerman, Yale University, Lie superalgebras in Poisson and complex geometry.

Preprints contributed: 324, 325, 328, 332, 333, 334, 338, 340, 341, 342, 344, 345, 348, 349, 353, 354, 357, 361, 375, 376, 381, 398, 404, 407,

Mathematical Problems of Quantum Gravity

July – August 1996
Preprints contributed: 20
Money spent: AS 678.000.–(ESI)

Abhay Ashtekar & Peter C. Aichelburg

A 2-month workshop was held at the Erwin Schrödinger International Institute for Mathematical Physics in Vienna during July and August, '96. There were 23 participants from outside Austria, mostly young physicists who have been working on various aspects of quantum gravity. In addition, about a dozen faculty and students from Vienna actively participated in the seminars and discussions. While the focus of this effort was on non-perturbative quantum general relativity, there were several experts from string theory, supergravity, quantum cosmology, quantum field theory, as well as mathematical physics in a broad sense of the term. There were two weekly "official seminars" which were widely announced –one entitled "fundamental issues", and the other,"advanced topics". They enhanced the scientific interaction between workshop participants and the local physics and mathematics community. In addition, there were "discussion seminars" (the remaining) three days a week. The afternoons were left open for further informal discussions (and real work!). On the scientific front, the workshop elevated the subject to a new level of maturity. It enabled the participants to take stock of a number of areas to obtain a global picture of issues that are now well-understood and also opened new directions for several other key issues.The following main topics were discussed during the workshop (the names in parenthesis refer to people who contributed to the specific topic):

- *Quantum Hamiltonian constraint.* (Hans-Jürgen Matschull, Jorge Pullin, Carlo Rovelli, Thomas Thiemann)
- *Quantum geometry.* (A.Ashtekar, J.Lewandowksi, R.Loll, T.Thiemann)
- *Lattice methods and skeletonization in loop quantum gravity.* (R.Loll, M.Reisenberger)
- *Super-selection rules in quantum gravity.* (A.Ashtekar,J. Lewandowski, D.Marolf, J.Mourao, T.Thiemann)
- *Degenerate metrics: extensions of GR.* (T.Jacobson, J.Lewandowski, H.-J.Matschull)
- *Global issues, Hamiltonian formulations.* (F.Barbero, D.Giuilini)
- *Mathematical issues in quantum field theory and quantum gravity.* (J.Baez, M.Blau, H.Balasin, R.Gambini, J,Mourao, D.Marolf)
- *Exactly soluble midisuperspaces.* (A.Ashtekar, H.Nicolai)
- *Lessons from low dimensional gravity.* (A.Ashtekar, D.Giuilini, J.Lewandowski, D.Marolf, J.Mourao, T.Thiemann, T.Strobl).
- *Black-hole entropy.* (T.Jacobson, K.Krasnov, D.Marolf, R.Myers, C.Rovelli)
- *Topological quantum field theories* (J.Baez, M.Reisenberger)
- *String duality, conformal field theories* (J.Fuchs, K.Meissner, R.Myers, T.Strobl)
- *Foundations of quantum mechanics and quantum cosmology* (A.Ashtekar, D.Giulini, J.Halliwell, F.Embacher)

If participants were to single out one topic that generated most excitement, it would probably be the regularization of the Hamiltonian constraint by Thiemann. This has significantly deepened our understanding of the mathematical problems underlying quantum dynamics of general relativity. However, a number of important problems remain. In particular, during the workshop it was realized that these

regularized quantum constraints have the feature that they strongly commute not only on diffeomorphism invariant states (which is to be expected physically) but also on a rather large class of states which are not diffeomorphism invariant (which is alarming from a physical viewpoint). A related potential difficulty is with the semi-classical limit: it is not clear if all the quantum constraints, taken together, admit a sufficient number of semi-classical states. Analogous calculations in 2+1 dimensions indicate that the appropriate semi-classical sector *does* exist. In 3+1 dimensions, further work is needed. This will no doubt be an area of much research and new effort in the coming year.

Preprints contributed: 307, 327, 351, 363, 364, 365, 366, 367, 368, 369, 373, 379, 390, 392, 393, 394, 397, 417, 418, 420.

Among these the following preprints belong to the Gravity program of 1995 (Aichelburg-Beig) 307, 329, 351, 394.

Hyperbolic Systems with Singularities

September – December 1996

Preprints contributed: 12

Money spent: AS 711.700.– (ESI), 192.000.– (foreign).

The workshop has focused on a broad range of problems connected with hyperbolic systems. Particular emphasis has been given to the relation between dynamical systems and statistical mechanics. This was achieved thanks, in particular, to the composition of the participants of the workshop: a blend of mathematicians and theoretical physicists. In fact, the interaction among mathematicians and physicists was one of the main tasks of our activity. Another aim was to compare several new techniques recently put forward for studying dynamical systems, in the conviction that a synthesis and new insights were at hand.

In order to favor interaction among the participants we reduced officially scheduled talks to a minimum (one two-hour key-lecture per week) and asked people to otherwise self-organize talks and discussions. The intense activity and the wide involvement in interdisciplinary and specialistic discussions has rewarded such an approach.

The main fields of activity were: decay of correlations; ergodicity in infinite systems; dynamical problems in non-equilibrium statistical mechanics and ergodicity of hyperbolic systems with singularities.

The estimation of the rate of decay of correlations is not only interesting in itself but it has relevant physical implications for non-equilibrium statistical mechanics (e.g. Green-Kubo formulae). For long time it was known that smooth hyperbolic maps enjoy exponential decay of correlations for sufficiently smooth (Hölder) observables; yet, little was known beyond that (with the notable exception of one–dimensional systems and some partial results for billiards). Only recently substantial progress has been made: efficient techniques have been developed to treat systems with discontinuities (Liverani, Young, Benedicks), new ideas have been put forward to investigate the case of flows (Chernov, Dolgopyat'), and some progress has been made in extending the Ruelle zeta–function formalism (Baladi, Keller, Rugh). Since almost all the above mentioned persons were present at the workshop it is not surprising that a lot of effort was put into comparing different points of view. Some of this effort has already produced concrete results ([413], [409]) but many of the projects and discussions initiated in Vienna are quite ample and ambitious, therefore not likely to crystalize in the very short term. Nevertheless, a very tight network of connections has materialized and it is bound to yield results for a long time.

Ergodicity in infinite systems is at the core of statistical mechanics but very few rigorous results are available. Yet, recently Bunimovich and Sinai proposed a model of coupled interacting maps that not only has been widely investigated numerically but has proven susceptible for rigorous analysis (Keller, Bricmont–Kupianen, Pesin-Sinai, Jiang, ...). Quite a lot of attention was dedicated to such a model during our workshop. Up to now [388] is the only finished result but many new ideas have been advanced and, hopefully, new results are forthcoming.

A field in which the treatment of infinite systems is, at the moment, a prohibitive task, but a lot of progress have been made, is the case of hard balls interacting with elastic collisions. This has also been the subject of many discussions expecially in view of the results of Simányi and Szász [337] that have made an important progress toward the understanding of the ergodicity of systems of hard spheres [98]. In fact, by using algebraic methods for complexified billiard dynamics, they could show

that hard ball systems are fully hyperbolic for almost every parameters (masses, radii) of the model. This is a model in the domain of dynamical systems with singularities. On this subject many more arguments were discussed: e.g. Markov partitions [Krüger, Troubetzkoy], general billiards [Chernov, Markarian], one dimensional systems of balls [Wojtkowski], multidimensional billiards with convex boundary components [Bunimovich-Rehacek], bounds for the total number of collisions for hard ball systems in the euclidean space [Burago-Ferleger-Kononenko], ..., that we hope will yield fruit in the near future.

Finally, a lot of effort was devoted to the study of the Lyapunov exponents both in Hamiltonian Systems [410] and in a class of systems that, presently, are receiving a great deal of attention: particles subject to an external force and in contact with a "Gaussian thermostat" [414]. In this respect, it is interesting to notice that such systems have been recognized as Conformally Hamiltonian (on this subject a paper is in preparation) also thanks to discussions with some visitors of ESI (e.g. D.Alexeevski) not participating in our workshop. One of the many circumstances that underline the importance of the environment provided by ESI and the fruitfulness of bringing together scientists from seemingly unrelated fields.

Non-equilibrium statistical mechanics has been the main field of interest in the physics part of the programme. Typical subjects dealt with in individual research, group discussions, seminars — both spontaneous and officials — have been: Liapunov spectrum of the FPU-beta model in the infinite N limit(S.Ruffo); Kolmogorov-Sinai entropy and Liapunov spectrum of the Sinai model (H.van Beyeren), of the hard disk (R.van Zon) and hard sphere gas (H.Posch), of the low density field driven Lorentz gas (H.van Beyeren, J.R.Dorfman et all.); Gaspard-Nicolis escape-rate-formulas for transport coefficients (J.R.Dorfman), Liapunov exponents and transport coefficients (D.Evans); electric fields on a surface of constant negative curvature (F.Bonetto); thermostated systems (Ph.Choquard, H.Posch); dynamical systems and statistical mechanics (E.G.D.Cohen). Related problems connected with non-equilibrium statistical mechanics are the so called escape rates, either in finite systems [412] or in spatially extended systems [382]. This is one of the fields in which the interaction among physicists and mathematicians was especially lively.

The atmosphere of the workshop was much pleasant and very fruitful through a lot of interaction among the participants, both mathematicians and physicists, which was definitely facilitated through the opening of new premises of ESI.

The organizers of the workshop, which extended to two four-week periods, were Heide Narnhofer (local organizer), Philippe Choquard (Lausanne), Carlangelo Liverani (Rome) and Domokos Szász (chairman, Budapest). The list of invitees and the program was prepared during two meetings of the organizers in Vienna, and one in Florence.

The following preprints were contributed to this program:

415 S. Ruffo *Lyapunov Spectra in Spatially Extended systems*
414 Ph. Choquard *Lagrangian Formulation of Nosé-Hoover and of Isokinetic Dynamics*
413 Carlangelo Liverani, Benoit Saussol, Sandro Vaienti *Conformal Measure and Decay of Correlation for Covering Weighted Systems*
412 N. Chernov, R. Markarian, S. Troubetzkoy *Conditionally Invariant Measures for Anosov Maps with Small Holes*
410 Nicolai Chernov *Entropy, Lyapunov Exponents and Mean Free Path for Billiards*
409 Carlangelo Liverani *Flows, Random Perturbations and Rate of Mixing*
388 Gerhard Keller *Mixing for Finite Systems of Coupled Tent Maps*
387 József Fritz, Carlangelo Liverani, Stefano Olla *Reversibility in Infinite Hamiltonian Systems with Conservative Noise*
385 V. Gerasimenko, D. Petrina *Rigorous Derivation of Generalized Kinetic Equation*
382 Pierre Gaspard *Entropy Production in Open Volume-Preserving Systems*
337 Nándor Simányi, Domokos Szász *The Boltzmann-Sinai Ergodic Hypothesis for Hard Ball Systems*
298 Carlangelo Liverani *Central Limit Theorem for Deterministic Systems*
98 Domokos Szász *Boltzmann's Ergodic Hypothesis, a Conjecture for Centuries?*

Guests of Walter Thirring

Preprints contributed: 303, 312, 343
Money spent: 104.000.– (ESI), 55.000.– (foreign)

Guests of Klaus Schmidt

Preprints contributed: 300, 301, 374, 377, 396, 400, 401, 411
Money spent: 87.000.– (ESI), 253.000.– (foreign)

Guests of Peter Michor

Here also the continuation of the the program 'field theory and differential geometry, 1995' is included.

Preprints contributed: 296, 299, 304, 309, 310, 311, 314, 326, 356, 365, 395, 402, 403, 404, (405), 406, 419
Money spent: 144.000.– (ESI), 66.000.– (foreign)

Guests of Hoffman-Ostenhof

Preprints contributed: 305, 358, 359, 383, 421
Money spent: 79.000.– (ESI)

Guests of Wolfgang Kummer

Preprints contributed: 0
Money spent: 30.000.– (ESI)

THE YEAR 1997

President: Walter Thirring
Director: Klaus Schmidt till August 1997; Peter W. Michor from September 1997.
Deputy Director: Peter Michor till August 1997; Jakob Yngvason from September 1997.
Administration: Mario Springnagel till October 1997; Lilla Hartyani, Anna Maria Ojeda
Computer group: Andreas Cap, Hermann Schichl.
International Scientific Advisory board:
Jean-Pierre Bourguignon (Paris),
Krzysztof Gawedzki (Paris),
Elliott Lieb (Princeton),
Vaughan Jones (Berkeley),
Alexander Kirillov (Pennsylvania),
Othmar Loos (Innsbruck),
Domokos Szasz (Budapest),
Klaus Schmidt (Wien).

General remarks

In the year 1997 ESI was host to 293 visitors. There were 106 preprints contributed to the preprint series (116 till beginning of February), some of them still belong to programs from 1996, and 162 seminar talks or ESI-Colloquia were given. Three conferences were organized in Vienna:

(1) Conference in ergodic theory, geometry and arithmetic. This was part of the program on ergodic theory and will be reported on there.
(2) Formal power series and algebraic combinatorics 97
(3) Workshop in local quantum physics. This was part of the program on local quantum physics and details are geven in the report on the program.

ESI took part in the organization of one conferences abroad, 'The 17th Winter school on geometry and physics', January 11–17, 1997, in Srni, a small village in the Bohemian forest, Czech republic.

ESI has spent AS 3,78 Mio for science which was supplemented by AS 1.12 Mio of foreign support; AS 5,92 Mio were spent for administrative costs including some open bills for the adapting the new premises.

Winter School in Geometry and Physics

The traditional winter school in geometry and physics which takes places for one week each January since 1980 in a picturesque village in the Czech parts of the Bohemian mountains is a joint enterprise of the Czech society of mathematicians and physicists and ESI, from 1994 onwards. Usually there are proceedings, which are published as a supplement of the 'Rendiconti Matematici di Palermo'.

In this year, the 17th Winter school on Geometry and Physics took place in the week January 11–18, 1997. ESI has contributed AS 10.000.– The former conferences with ESI-participation are published in the proceedings volumes:

The proceedings of the Winter school 'Geometry and Physics', Srní, January 1994. Suppl. Rend. Circ. Mat. Palermo, II. Ser. **39** (1996), 9–148
Contents:
J. Huebschmann: Poisson geometry of certain moduli spaces 15
A. Biś: Geometrical directions and ends of a manifold, points of accumulationof a direction of a group in the hyperbolic space H^2 37
A. Cap, H. Schichl: Characteristic classes for A-bundles 57
M. Doupovec, A. Vondra: Some natural operations between connections on fibred manifolds 73
J. Korbaş, P. Zvengrowski: On sectioning tangent bundles and other vector bundles 85
W.M. Mikulski: Natural operator s lifting vector fields on manifolds to the bundles of covelocities 105
J. Rogowski: Some integral formulas for a Riemannian 3-mqanifold equipped with a system of orthogonal foliations 117

J. Slovák: The principal prolongation of first order G-structures . . . 123
V. Studeny: General Nijenhuis tensor, an example of a secondary invariant . . . 133
M. Znojil: Circular vectors and toroidal matrices . . . 143

The proceedings of the 15th Winter school 'Geometry and Physics', Srní, January 14–21, 1995.
Suppl. Rend. Circ. Mat. Palermo, II. Ser. **43** (1996), 9–228
Contents:

V.K. Dobrev: q-difference conformal invariant operators and equations . . . 15
M. Eastwood: Notes on conformal differential geometry . . . 57
L. Mason: Twistor theory, self-duality and integrability . . . 77
P.M. Akhmetiev: A high-order helicity invariant and the Rokhlin theorem . . . 85
A. Cap, J. Slovak: On local flatness of manifolds with AHS-structures . . . 95
J. Eichhorn, J. Fricke, A. Lang: Metrics conformally equivalent to bounded geometry . . . 103
M. Doupovec, J.Kurek: Liftings of convariant $(0,2)$-tensor fields to the bundle of K-dimensional 1-velocities . . . 111
C. Gross: Cohomology and connections on S^1-bundles . . . 123
J. Hruby: On the Q-deformed Heisenberg uncertainty relations and discrete time . . . 133
J. Janyska: Natural symplectic structures on the tangent bundle of a space-time . . . 153
I. Kolar, G. Virsik: Connections in first principal prolongations . . . 163
L. Kozma: On Finsler-Weyl manifolds amd connections . . . 173
M. Kures: Natural lifts of classical linear connections to the cotangent bundle . . . 181
M. Luedde: Yang-Baxter deformations of complex simple Lie algebras . . . 189
W.M. Mikulski: Natural operators lifting functions to cotangent bundles of linear higher order tangent bundles 199
J. Sobczyk: Quantum deformation of relativistic supersymmetry . . . 207
A. Vanzurova: Special connections on smooth 3-web manifolds . . . 217

The proceedings of the 16th Winter school 'Geometry and Physics', Srní, January 13–20, 1996.
Suppl. Rend. Circ. Mat. Palermo, II. Ser. **46** (1997), 9–176
Contents:

K. Beidar, Y. Fong, A. Stolin: Symmtric algebras and Yang-Baxter equation . . . 15
T. Branson: Spectral theory of invariant operators, sharp inequalities, and representation theory . . . 29
M. Eastwood: Complex methods in real integral geometry . . . 55
V.K. Dobrev, P. Moylan: Singleton representations of $U_q(\mathfrak{so}(3,1))$ . . . 73
V.K. Doupovec, J. Kurek: Natural operations of Hamiltonian type on the contangent bundle . . . 81
C. Gross: Equivariant cohomology of the Skyrmion bundle . . . 87
F. Hinterleitner: Local and global aspects of separating coordinates for the Klein-Gordon equation . . . 97
M. Kraus: BRS-Transformations in a finite dimensional setting . . . 107
M. Lüdde: A unified construction of the Alexander- and the Jones-invariant . . . 117
J. Mikeš, G.A. Starko / K-concircular vector fields and holomorphically projective mappings on Kählerian spaces 123
J. Rataj: The iterated version of a translative integral formula for sets of positive reach . . . 129
T. Rybicki: On admissible groups of diffeomorphisms . . . 139
A. Schmitt: Existence of Skyrmions . . . 147
T. Schmitt: Symplectic solution supermanifolds in field theory . . . 153
P. Tiller: The approximate symmetries of vacuum Einstein equations . . . 163
A. Vanžurová: Connections for non-holonomic 3-webs . . . 169

Conference: Formal power series and algebraic combinatorics 97

The 9th conference of this series of organized by Christian Krattenthaler at the University of Vienna, July 14–18, 1997. ESI has contributed 50.000.- to this conference. The proceeding will be published as a special volume in 'Discrete Mathematics'.

Lectures given:

Sergei Abramov: Solutions of linear differential equations in the class of sparse power series
Martin Aigner: Geometric representations of graphs and the four–color theorem
Eric Babson, Anders Björner, Svante Linusson, John Shareshian*, and Volkmar Welker: Complexes of not i-connected graphs
Frédérique Bassino: Distributions de longeurs des codes circulaires
Nantel Bergeron and Frank Sottile*: Identities of structure constants for Schubert polynomials and orders on S_n
Miklos Bona: P-recursiveness for pattern avoidance
Jonathan Borwein: Three adventures: Symbolically discovered identities for $\zeta(4n+3)$ and like matters
Richard Brak: Osculating lattice paths and alternating sign matrices
Will Brockman* and Mark Haiman: Nilpotent orbit varieties and the atomic decomposition of the q-Kostka polynomials
E. Rodney Canfield, Sylvie Corteel* and Carla D. Savage: Durfee polynomials
Christophe Carré and Sébastien Veigneau*: HUB, un concentrateur de ressources distribuées en combinatoire algébrique
Carol Chang: The $n!$ conjecture and an algebraic vector bundle on the Hilbert scheme of n points in the plane
Frédéric Chyzak: An extension of Zeilberger's fast algorithm to general holonomic functions

Mihai Ciucu: No feedback card guessing for dovetail shuffles
Robert Cori, B. Jacquard and Gilles Schaeffer*: Description trees for some families of planar maps
Vesselin Gasharov: Green and Gotzmann theorems for polynomial rings with restricted powers of the variables
Tom Halverson*, Robert Leduc and Arun Ram: Iwahori-Hecke algebras of type A, bitraces and symmetric functions
Philippe Jacquet* and Wojciech Szpankowski: Analytical depoissonization and its applications to combinatorics and analysis of algorithms
Anatol N. Kirillov and Toshiaki Maeno*: Quantum double Schubert polynomials, quantum Schubert polynomials and Vafa-Intriligator formula
Ulrich Kortenkamp and Jürgen Richter-Gebert*: Cinderella's Café — Interactive geometry on your computer
Daniel Krob* and Jean-Yves Thibon: A crystalizable version of $U_q(gl_N)$
Sévéverine Leidwanger: A relation between Schur P- and S-functions
Cristian Lenart: Symmetric functions, formal group laws, and Lazard's theorem
Nicolas Magot and Alexander Zvonkin*: Belyi functions for Archimedian solids
David K. Maslen: The computation of Fourier transforms on the symmetric group
Michel Mendes-France: The ultra divergent series $\sum_{n=0}^{\infty} \frac{1}{0^{2^n}}$
Stephen C. Milne: New infinite families of exact sums of squares formulas, Jacobi elliptic functions, and Ramanujan's tau function
Jean-Christophe Novelli: On the hypoplactic monoid
Andrei Okounkov: Binomial formula for Macdonald polynomials and applications
Yuval Roichman: Murnaghan-Nakayama and Littlewood-Richardson type rules for Kazhdan-Lusztig representations of Coxeter groups
Abdus Salam: Using the software EBENMASS for the symmetric groups and symmetric functions
Bruno Salvy: The combinatorics library of the project 'algorithms' at INRIA
Rodica Simion: Noncrossing partitions
Sheila Sundaram: Homotopy and homology of non-modular partitions and related posets
Brian Taylor: Straightening laws for row-convex tableaux

PROGRAMS IN 1997

Ergodic theory and dynamical systems

Organized by A. Katok, K. Schmidt, Margulis, January 1 – August 30.
10 Preprints contributed: [424], [425], [428], [433], [439], [484], [494], [497], [503], [519],
Money spent: AS 994.748.- (ESI), AS 549.928.– (foreign)

This program was devoted to the study of Dynamical Systems, with special emphasis on multidimensional dynamics and the new phenomena encountered there, as well as on the interaction between Dynamical Systems and Number Theory, Geometry and Statistical Mechanics.

The program started in January 1997 with a series of lectures by D. Rudolph on *Entropy theory and restricted orbit equivalence for discrete amenable group actions*, in which he presented recent joint work with J. Kammeyer on entropy as a complete invariant of (suitably) restricted orbit equivalence. K. Park lectured on her work on *Subdynamics of $\mathbb{Z}^d$-actions*, J.-P. Thouvenot and E. Glasner presented results on the *Pinsker algebra of product actions and joinings*, and Ya. Pesin gave two lectures on *Spatio-temporal chaos in coupled map lattices* (a class of $\mathbb{Z}^2$-actions arising in statistical mechanics). Amongst the topics of further lectures in January were *Notions of complexity of dynamical systems* (S. Ferenczi) and *Recent progress in billiards* (A. Stepin). Lectures by A. Katok on *Conjugacy rigidity of hyperbolic maps with sufficiently large commutants* and K. Schmidt on *Homoclinic points and Markov partitions of algebraic $\mathbb{Z}^d$-actions* served as an introduction to one of the main topics of the February Conference on *Ergodic Theory, Geometry and Arithmetic*: the rigidity properties of higher rank abelian group actions.

February was dominated by the two-week **Conference on Ergodic Theory, Geometry and Arithmetic**, February 3-14, 1997, organised by A. Katok and G. Margulis. The main theme of this very intensive meeting was the comparison of 'arithmetical' rigidity properties of actions of 'large' groups, like Kazhdan groups, and the 'geometrical' rigidity properties appearing in actions of higher-rank abelian groups, like $\mathbb{R}^d$ and $\mathbb{Z}^d$, or, for example, in the geometric structure at infinity of Riemannian manifolds of negative and non-positive curvature.

In addition to almost thirty research talks (listed below) there were five major survey lecture series:

(1) Eskin, Kleinbock, Margulis, and Shah gave six lectures on flows on homogeneous spaces and number theory, in which they presented connections between arithmetical results connected with the Raghunathan conjecture and its solution, and striking new results on diophantine approximation and related questions.
(2) Katok and Schmidt gabe a series of four lectures on actions of higher-rank abelian groups and rigidity, in which they presented a variety of rigidity results (such as cohomological rigidity, isomorphism rigidity, perturbation rigidity and scarcity of invariant measures) for geometric and algebraic actions of $\mathbb{Z}^d$ and $\mathbb{R}^d$ with $d \geq 2$.
(3) Burger and Mozes gave three lectures on lattices in the automorphism group of a product of trees in which they presented new results and examples both in the theory of infinite groups and in multidimensional shifts of finite type.
(4) Besson and Courtois described their landmark results on the geometry of manifolds with geodesic flows of minimal entropy in three lectures.
(5) Feres gave three lectures on topological superrigidity which centered around his joint work with Labourie on cocycle superrigidity in the absence of invariant measures.

The conference was attended by most of the active reasearchers in the subject, both at senior and at junior level.

After mid-February things quietened down a little. G. Margulis and A. Katok gave surveys of *Flows on homogeneous spaces and Diophantine approximation on manifolds* and *Hyperbolic measures*, respectively, M. Lemanczyk presented current work on *Gaussian processes*, and T. Ward gave an account of recent work on *S-integer dynamical systems* which again show a remarkable interplay between arithmetic and dynamics. One should also mention C. Radin's visit in May, during which he spoke on the symmetry properties of some of the remarkable planar tilings he and others have constructed. Research on *Voronoi tilings* was presented by N. Priebe.

With the beginning of June the number of visitors increased again and the emphasis of the programme shifted towards symbolic dynamics. Although the classification of automorphisms and homomorphisms of shifts of finite type is part of mainstream symbolic dynamics, any such classification sheds light on the multidimansional shifts of finite type generated by the shift and suitable shift-commuting automorphisms. Here the main result presented during this part of the conference was the *Counterexample to the Williams conjecture* due to Kim and Roush, which was investigated in detail and subsequently described in a series of lectures by M. Boyle. S. Tuncel presented new results on the *Classification of Markov endomorphisms*, which were joint work with B. Marcus.

Amongst many further results connected with symbolic $\mathbb{Z}^d$-actions one should list D. Lind's lecture on *Milnor's entropy geometry and algebraic $\mathbb{Z}^d$-actions*, J. Steif's investigation of *Higher-dimensional T, T^{-1}-systems*, in which he proved Bernoullicity of varying degrees (depending on the dimension) in dimension ≥ 3, B. Kamiński's study of *Invariant sigma-algebras of multi-dimensional processes* and E.A. Robinson's lecture on *The Krieger representation theorem for a class of multidimensional shifts of finite type.*

A number of visitors to the program worked on and presented results in areas of Dynamics not specifically related to multiparameter ergodic theory. M. Keane gave a beautiful elementary proof of *Birkhoff's classical ergodic theorem*, V.F.R. Jones spoke on *Planar algebras*, which have some very intriguing connections with Wang tiles (hence with two-dimensional shifts of finite type) and Bratteli diagrams (hence with interval exchange transformations), there were two lectures on the general concept of *Randomness* (by V. Sós and K. Petersen), J. Feldman and M. Smorodinsky presented new results on *Standard and nonstandard processes* (a problem connected with the classification of dcreasing families of sigma-algebras), and Y. Kifer explained work on *Computations in chaotic dynamics via random perturbations.* Two participants investigated noncommutative dynamical systems (S. Bezuglyi and T. Hamachi), and S. Williams and D. Silver worked on *Applications of Symbolic Dynamics to Knot Theory.* A number of visitors studied dynamical properties of arithmetical expansions (Aaronson, Johnson, Nakada, Shelton, Yuri), or formal languages (D. Fiebig, U. Fiebig and W. Krieger).

This list of research topics and lectures is far from exhaustive, but should give an indication of the direction and breadth of the program. A further feature of the program was the exceptionally high financial contribution to the program from outside sources, including USD 3000.– from the Dynamical Systems Research Center at Penn State University for additional support of postdocs.

A. Katok, K. Schmidt

Further talks in the Conference in ergodic theory, geometry and arithmetic.

M.Ya.Antonovskii: 1965 School in Ergodic Theory at Humsan, Uzbekistan. Reflections and recollections of the organizer.
A.Katok: Ergodic theory from Humsan to Vienna.
H. Furstenberg: Stiffness of group actions
G. Knieper: Volume growth and the distribution of closed geodesics in manifolds of nonpositive curvature.
B.Leeb: Groups quasi-isometric to symmetric spaces.
B.Farb: Quasi–isometry and rigidity: latices and beyond.
E.Ghys (ENS-Lyon): Smooth linearizations of SL(n) actions around a fixed point
I.Benoist (Paris VII): Linear groups with positive eigenvalues
G.Tomanov (U.Lyon): On the quadratic and unitary inequalities in the S-adic case.
P.Foulon (Strasbourg): Dynamical rigidity in Finsler geometry.
V.Kaimanovich (Rennes): Singularity of the harmonic measure on symmetric spaces.
H. Abels (Bielefeld): A quantitative version of finite generatedness for lattices.
W.Ballmann (Bonn): Property T for groups acting on complexes.
U.Hamenstaedt (Bonn): Cocycles, cross-ratios and eigenfunctions in negative curvature.
F. Grunewald (Dusseldorf): On ternary quadratic forms.
P de la Harpe (Geneva): Growth on root lattices and Ehrhart polynomials.
I.Goldsheid (London): Zariski dense semi-groups of Lie groups: propertoes of eigenvalues and invariant sets.
A.Starkov (Istra): Closures of horospherical leaves on hyperbolic manifolds
G.Soifer (Bar-Ilan): Discontinuous groups of affine transformations with orthogonal linear part
S.Katok (Penn State): Automorphic forms of the complex hyperbolic space
S.Hurder (Illinois-Chicago): Boundary Chaos for open manifolds
S.Adams (Minnesota): Dynamics on Lorentz manifolds.
C-B.Yue (Penn State): On the representation variety of complex hyperbolic Kleinian groups.
Y. Gao (Yale): Superrigidity for isometric group actions on CAT(-1) spaces
A.Torok (Princeton): Regularity and rigidity of cocycles
V.Nitica (Indiana): Cocycles over Anosov actions.
N.Qian (Yale): Tangential flatness and local rigidity of higher rank lattice actions.
A.Wilkinson (Norstwestern): Prevalence of non-Lipschitz Anosov foliations and conjugacies.
E.Gutkin (USC): Polygonal billiards and cofinite lattices.

Program on Mathematical Relativity

Organized by B. Beig, ESI, 1.1.–30.6.1997.
6 Preprints contributed: [467], [460], [475], [507], [515], [524]
Money spent: AS 391.000.- (ESI), AS 4.000.– (foreign).

The work in this program was devoted to the study of analytical and geometrical problems related to - mostly classical - aspects of the Einstein Equations (EE's).

V.Moncrief worked out higher order energies of the so-called Bel- Robinson type which play a crucial role in global existence proofs for the Vacuum Einstein Equations (VEE's). These calculations are part of a long-term project, with L.Andersson, on solutions of the VEE's on manifolds of the form M x R, with M a compact hyperbolic space. The aim is to prove stability of the flat solutions of this form, obtained as a certain quotient of (the interior light cone of a point of) Minkowski space. Such a result would be a cosmological analogue of the celebrated theorem, due to Christodoulou and Klainerman, on the nonlinear stability of Minkowski space.

A.Fischer and V.Moncrief continued their collaboration on ADM reduction. They proved that the only critical points of the reduced Hamiltonian (on compact manifolds of negative Yamabe type) are Cauchy data for the expanding, flat hyperbolic models from above.

V.Moncrief and J.Nelson continued work involving the quantized 2+1- EE's (with a cosmological constant) on T x R, with T a 2-torus.

R.Beig and N.0'Murchadha studied the maximal slicing of the extended Schwarzschild spacetime. They gave rigorous estimates of the decay of the lapse function as the last maximal slice is approached.

E.Malec and N.O'Murchadha worked on the spherically symmetric Einstein-Massless Scalar Field system. In particular they found rigorous estimates for the influence of the phenomenon of backscattering on the intensity of the outgoing radiation.

R.Beig and L.Szabados found a conformal invariant of initial data sets on compact 3-manifolds. This invariant, in the special case of totally geodesic initial data sets, reduces to the one of Chern and Simons. The behaviour of this invariant under evolution of initial data sets by the EVE's will be studied in the future.

R.Beig and B.Schmidt looked at some open issues in the asymptotic structure of stationary vacuum spacetimes. Their results will form a part of a review article on stationary spacetimes they are in the process of writing.

There was a lively interaction among participants of the workshop and, moreover, with the participants of the parallel program on CR structures, organized by L.Mason, P.Nurowski and H.Urbantke.

Spaces of geodesics and complex structures in general relativity and differential geometry

Organized by Lionel Mason,, Pawel Nurowski, Helmuth Urbantke. March, April and June, July 1997.

17 Preprints contributed: [432], [434], [451], [461], [464], [470], [471], [477], [486], [487], [493], [505], [516], [518], [520]; [521], [522].

Money spent: AS 518.500.-(ESI).

Characterisation of the progress. The program consisted of two interrelated parts. The first focussed on application of spaces of null geodesics to general relativity and second to problems in differential geometry.

1) Particular attention was paid to analytic subtleties associated with the Robinson theorem. The theorem in its original version says, in particular, that if a space-time $\mathcal{M}$ admits a congruence of shear-free and null geodesics k then there exists a null Maxwell field associated with k in $\mathcal{M}$. Discussing this T. Bailey, D. Hill, L. Mason, P. Nurowski, I. Robinson, G. Sparling, J. Tafel, A. Trautman, H. Urbantke found examples of nonanalytic but smooth congruences of shear-free and null geodesics which do not admit any solution to the Maxwell equations for the associated null 2-form. This means that the Robinson theorem as quoted above needs some additional assumptions (e.g. analyticty or realizability) as conjectured by Tafel in 1985. Our examples are based on the relation between congruences of null geoedesics and 3-dimensional CR-manifolds associated with them. The main arguments in the construction of the examples are as follows.

a) Suppose we have a shear-free congruence of null geodesics in space-time, such that its associated CR-structure admits a nonconstant solution to the tangential CR-equation. Then there exists a null Maxwell field associated with the congruence if and only if there exists a second independent solution to the tangential CR-equation.

b) Given a three-dimensional CR-manifold $\mathcal{Q}$ with a smooth CR-strucrture it is straightforward to associate with it a 4-dimensional Lorentzian manifold (space-time) in which there exists a smooth congruence of shear-free and null geodesics which has $\mathcal{Q}$ as its CR-manifold.

c) Rosay constructed smooth CR-structures on 3-manifolds that admit only one nonconstant solution to the tangential CR-equation.

Combining a), b) and c) we conclude that any of Rosay's CR-structures give rise to a congruence of shear-free and null geodesics in a space-time which does not admit an associated null Maxwell field.

The following related problem was not solved: Suppose that we have a congruence whose corresponding CR-structure does not admit any nonconstant solution to the tangential CR-equation. Is it possible to associate a null Maxwell field to such a congruence? Since the situation is even worse than in the case a) it is very likely that the answer is no - but the participants were unable to prove it. This is the only other alternative to the case discussed above and the realizable case for which Robinson's theorem can be seen to work in a straightforwardly.

A. Trautman summarizes the above in the following **conjecture**: A congruence of shear-free and null geodesics in space-time defines a null Maxwell field if and only if its associated CR-manifold is locally embeddable in $\mathbb{C}^2$.

There were also discussions concerning the problem of an existence of nonanalytic congruences in Minkowski space-time. Although there were lively discussions between D. Hill, G. Sparling, J. Tafel and H. Urbantke, the issue was not resolved.

This part of the activity was concluded by a series of lectures by G. Sparling on CR-structures in physics.

2) Algebraically special space-times naturally fitted to the project since, due to the Goldberg-Sachs theorem, these are the only Einstein space-times that admit congruences of shear-free and null

geodeiscs. L. Mason and J. Tafel presented two views on global properties of such space-times. Mason proved that the only algebraically special space-time which is assymptotically simple is Minkowski space. A paper by J. Tafel and S. Pukas is in preparation and one by L. Mason has already been submitted as an ESI preprint and will appear in Classical and Quantum Gravity.

Global properties of space-times were also discussed by J. Beem, who pointed out that horizons may not be differentiable, and that such pathologies can exist even on dense subsets of the horizon.

A different problem was discussed by R. Low who studied singularities of wave fronts. It relates to the work of E.T. Newman and S. Frittelli who encountered such problems in their Null Surface Formulation of General Relativity.

L. Szabados gave a review of definitions of gravitational energy and J. Frauendiener derived an integral formula on hypersurfaces in space-time that unifies integral form of Raychauduri equation for null congruences and Bondi mass loss formula. They were collaborating with the participants of the parallel workshop organized by R. Beig. Also P. Tod used this opprtunity in preparation of his review of Mathematical Relativity.

3) Reformulations of the 4-dimensional Einstein equations in the spirit of twistor theory were discussed. The persons involved in the discussions were: S. Fritelli, J. Lewandowski, L. Mason, T. Newman, P. Nurowski, R. Penrose, D. Robinson, G. Sparling, J. Tafel, P. Tod, A. Trautman, H. Urbantke.

The activity included a series of lectures by R. Penrose on twistors in curved space-times, folllowed by G. Sparling's lectures on his abstract twistor spaces for the Einstein (not anti-self-dual) space-times. In particular, Sparling (and Z. Perjes) constructed abstract twistor spaces for Einstein space-times with six symmetries (and for the Schwarzschild solution).

P. Nurowski developed formulation of the Einstein equations on the bundle of null rays over the space-time and its double branch cover. This formulation is based on an attachment of a (possibly degenerate) elliptic curve to each point of the space-time. In particular, the formulation gives a new view on the Petrov classification, since the degenererecies of the principal null directions at the space-time point correspond to the degeneracies of the elliptic curve attached to this point.

This formulation was compared with the Null Surface Formulation of General Relativity of T. Newman and his collaborators. A joint paper of Fritelli, Lewandowski, Newman and Nurowski about these relations is being prepared.

D. Robinson developed his chiral action formulation of the vacuum Einstein equations.

L. Mason and J-P. Nicolas completed their paper 'Global solutions of the Rarita-Schwinger equations and the Einstein equations' in which analytic results about the Rarita-Schwinger equations are proved and their connections with the Einstein equations are discussed. This was also lectured on by L. Mason and will be presented as an ESI preprint.

4) There were discussions on integrable systems. This relatively new field of apllications of twistor theory had a strong representation during the workshop. The people involved were: J. Armstrong, M. Dunajski, L. Mason, P. Nurowski, M. Przanowski, G. Sparling, J. Tafel, P. Tod, N. Woodhouse.

M. Dunajski and L. Mason worked on their twistor construction of anti-self-dual hierarchies. M. Przanowski presented his joint work with J. Plebański which gave a differential equations aspect of the same problem.

In a series of lectures, M. Przanowski presented his results on algebraically special Einstein 4-manifolds with positive definite metric. The results were used by Nurowski and Przanowski to construct a 4-dimensional example of Ricci flat metric admitting almost-Kähler non-Kähler structure. The nonconstructive proof that such examples exist was presented by J. Armstrong. This is surprising in view of the result of K. Sekigawa who proves that under the assumption of compactness of the Einstein manifold every almost-Kähler structure is Kähler.

P. Tod presented his work on 4-dimensional Einsteinian D'Atri spaces, proving that they are locally symmetric. This was conjectured by Sekigawa and Vanhecke some time ago.

J. Tafel completed his joint work with D. Wójcik on null Killing vector reductions of the Yang-Mills equations in flat 4-manifold with metric of neutral signature.

5) P. Kobak and P. Nurowski worked on the Lorentzian counterpart of the twistorial construction of harmonic maps. The paper on this is being prepared in collaboration with M. Bobieński, and was discussed with P. Gauduchon, A. Trautman and S. Salamon.

Suggestions for future activity. Not all the aims of the project were achieved. Some topics listed in the project description were not touched on at all, mainly because some of the invited guests could

not come to ESI.

On the other hand there are also topics which require further elaboration. These include (we list the topics with the associated persons in the proposal): non-analytic congruences in Minkowski space (Sparling, Tafel, Urbantke), global properties of algebraically special solutions (Mason, Tafel), relations between null surface formulation of GR and elliptic fibrations (Fritelli, Newman, Nurowski), twistor formulation of anti-self-dual hierarchies (Dunajski, Mason), Lorentzian counterpart of the twistorial harmonic maps construction (Nurowski, Kobak), Twistor approaches to the Einstein equations (Mason, Nicolas).

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Preprints contributed: 432, 434, 451, 461, 464, 470, 471, 477, 486, 487, 516, 518, 520, 521, 522.

Local Quantum Physics

Organized by D. Buchholz, H. Narnhofer, J. Yngvason, September 1 – December 31, 1998
11 Preprints contributed: [446], [448], [449], [469], [496], [498], [499], [501]; [525], [528], [529].
Money spent: AS 883.000.- (ESI), AS 435.000.– (foreign)
Part of the program was the

Workshop on local quantum physics. September 29 - October 4, 1997
Lectures given:
R. Haag (Neuhaus/Schliersee): Objects, events and localization in quantum theory
R. Stora (Annecy): Memories about renormalized perturbation theory
K. Fredenhagen (Hamburg): Local (perturbative) construction of interacting fields on curved spacetime
I. Ojima (Kyoto): Spontaneous collapse of supersymmetry
H. W. Wiesbrock (Berlin): On modular theory and its application to physics
J. Roberts (Rome): New directions in superselection theory
O. Steinmann (Bielefeld): Particles as localized objects in quantum field theory
S. Doplicher (Rome): On the C*-algebra of a Hilbert bimodule
M. Müger (Rome): Superselection structure of massive quantum field theories in 1+1 dimensions
K. H. Rehren (Hamburg): Statistics and modular theory of solitons
H. J. Borchers (Göttingen): On the embedding of von Neumann algebras
B. Schroer (Berlin): Modular localization, H-temperature and bootstrap formfactor program
D. Guido (Rome): Superselection structure of conformal nets and applications to quantum field theories in curved spacetimes.
S. Summers (Gainesville): Geometric modular action and spacetime symmetry groups
M. Wollenberg (Leipzig): An inverse problem in modular theory
E. Seiler (Munich): Continuum limits of spin models and local cohomology
F. Strocchi (Pisa): Fermion boundary conditions and vacuum parameters
N. Landsman (Cambridge): Theta-angles and anomalies in QFT
G. Morchio (Pisa): Generalized Weyl systems
U. Moschella (Como): De Sitter quantum field theory: Introduction and applications
F. Bros (Saclay): Quantum field theory in de Sitter universe.
B. S. Kay (York): Quantum fields in non globally hyperbolic spacetime
H. Grosse (Vienna): Simple field theoretical models on non-commutative manifolds
W. Junker (Potsdam): On a Euclidean approach to QFT on curved spacetimes
R. Verch (Göttingen): On wavefront sets and algebraic quantum field theory
R. Conti (Rome): On sectors with infinite statistics
C. D'Antoni (Rome): Extension of antiautomorphisms and the PCT symmetry
T. Matsui (Fukuoka): Classification of positive energy representations for massive lattice models
K. Baumann (Göttingen): On bounded Bose fields in 1+1 dimensions commuting for space- and time-like distances

More than 30 experts for the structural analysis in relativistic quantum field theory participated in this 3 month project at ESI and worked together on about 5 different but interrelated topics. The program was centered about an intense one-week workshop to which further researchers were invited. Beside it between 2 and 4 more informal talks were delivered each week by participants on an ad hoc basis. The topics covered in this project range from the structural analysis of nets of local algebras through problems in the theory of superselection sectors and thermal quantum field theory to quantum field theory on curved spacetime. In spite of this diversity of problems there appears to be an almost universal mathematical tool for their treatment: modular theory. This intriguing fact was the leading

theme in this project and its deeper understanding was one of the central goals. The results obtained provide further evidence to the effect that modular theory is a primary key to the understanding of local quantum physics. In the following an outline is given of the specific problems treated and results obtained by the participants of the project.

a) Modular theory, local algebras and spacetime symmetries. The relation between the modular operators appearing in quantum field theory, the lattice structure of local algebras of wedge-like regions and the and spacetime symmetries was discussed by by H.J. Borchers, D. Buchholz, D. Guido, B. Kuckert, H. Rehren, B. Schroer, S.J. Summers, S. Trebels, E.H. Wichmann and J. Yngvason.

H. Borchers worked on the question under which circumstances the modular groups associated with algebras of wedge–like regions coincide with the Poincaré transformations. Discussions with D. Buchholz, S. Summers and I. Todorov helped to isolate obstructions to this coincidence and led H.J. Borchers to a new characterization of theories with a unique representation of the Poincaré group. In another project H.J. Borchers and J. Yngvason investigated the structure of the modular groups which are associated with cone-like regions in representations induced by temperature states. For a class of chiral theories they were able to show that these groups still have an interpretation as (local) spacetime symmetries.

D. Buchholz and S.J. Summers continued during this project their investigation of the role of the modular conjugations in quantum field theory. Discussions with E.H. Wichmann led them to a more stringent formulation of their condition of geometric modular action which is designed to characterize preferred (vacuum like) states on a large class of spactime manifolds. The latter aspect of this work has triggered stimulating (partly controversial) discussions with J. Bros, K. Fredenhagen, B. Kay, U. Moschella and R. Verch. The results obtained so far seem to indicate that at least for spacetimes with a sufficiently big isometry group the aforementioned condition serves its purposes. These results will soon appear as ESI preprint.

B. Kuckert was able to improve his recent uniqueness theorem for modular symmetries by making use of a (yet unpublished) result of S. Trebels which he learned from the author during the workshop. H.J. Borchers, D. Guido and E.H. Wichmann were also involved in the discussions of this problem.

H. Rehren worked on modular theory in low-dimensional field- theoretic models, primarily for soliton sectors, and established an interpretation of the CPT and Spin-Statistics-Theorem in terms of the associated modular structures.

Finally, B. Schroer presented some intriguing ideas on the reconstruction of local algebras in interacting theories from free fields by introducing the notion of modular Møller operators. This novel approach to the so-called formfactor program seems to deserve a more detailed mathematical analysis.

b) Superselection structure and statistics. The second major topic of this project was the analysis of the superselection structure in case of quantum field theories which do not fit into the so-called DHR-setting, either because of the presence of long range effects or because of the structure of the underlying spacetime manifold. Various aspects of this circle of problems were treated by C.D'Antoni, D. Buchholz, S. Doplicher, D. Guido, G. Morchio, H. Rehren, J.E. Roberts, V. Schomerus, F. Strocchi, S.J. Summers, I. Todorov and R. Verch.

C.D'Antoni, S.J. Summers and R. Verch began a general study of the sector structure at short distances by using the method of the scaling algebra. There is some hope to establish criteria by which one can decide whether in a given theory charged sectors appear or disappear in the scaling limit (compare the confinement problem).

In a joint project D. Buchholz, S. Doplicher, G. Morchio, J.E. Roberts and F. Strocchi aimed at clarifying the localization properties of charged states in quantum electrodynamics. To this end an analysis of the classical Dirac-Maxwell theory, perturbative computations and a formal discussion in the indefinite metric formalism were carried out. The conclusion was that there is no obvious algebraic obstacle to localizing charged states on the algebra generated by the charge density and the magnetic field in a given Lorentz system. Since a mathematically satisfactory treatment of full quantum electrodynamics has not been accomplished yet, more rigorous results seem presently out of reach. But the above findings support an old conjecture of J. Fröhlich according to which the electric charge has better localization properties than normally assumed. The present findings seem to be the key to a general structural analysis of the charged superselection sectors in abelian gauge theories.

In a closely related project D. Buchholz, S. Doplicher and J.E. Roberts analyzed the question in which sense a particular type of charge is localized. They concluded that any charge has a canonical

localizing net, i.e. a net on which it is localized. The size of this localizing net is then a measure of how well the charge in question can be localized. They also established conditions on the localizing net which allow one to generalize standard results from the theory of superselection sectors.

J.E. Roberts also worked with D. Guido, B.S. Kay and R. Verch on superselection sectors and the connection between spin and statistics in quantum field theories on curved spacetime.

Problems related to the superselection structure of theories in low dimension were treated by H. Rehren (cf. above) and in a collaboration of V. Schomerus and I. Todorov. The latter project concerns braid group properties and fusion rules for chiral WZNW models and relates the current work of V. Schomerus and A. Alekseev with earlier work of Y. Stanev and I. Todorov.

c) Thermal states. The rigorous structural analysis of thermal states in relativistic quantum field theory is receiving increasing attention in recent years and was also discussed by several participants of this project (H.J. Borchers, J.Bros, D. Buchholz, Ch. Jäkel, I. Ojima, J. Yngvason).

The work of H.J. Borchers and J. Yngvason on the geometrical significance of the modular structure in case of thermal states was already mentioned. One may expect that these results will stimulate further investigations of this unexpected feature of thermal states.

The concept of "Goldstone particle" in thermal quantum field theory was studied by J. Bros and D. Buchholz. It was recognized that the decrease properties (in spatial variables) of the so-called damping factor in a Källèn-Lehmann type representation of thermal current-field correlation functions is strongly correlated with the possible occurrence of a Goldstone particle in the thermal bath. This observation may be the key to a more satisfactory understanding of the spectral implications of the spontaneous breakdown of symmetries in thermal states.

The general mathematical structure of thermal states in relativistic quantum field theory was studied by Ch. Jäkel. Discussions with J. Bros, D. Buchholz, I. Ojima and J. Yngvason helped to clarify various technical points which appeared in this analysis. It seems that prominent features of the vacuum sector, such as the Reeh-Schlieder and the split property can also be established in thermal states.

The physical role of the center variables in thermal and vacuum states has been the research topic of I. Ojima who worked on the relation between the nature of the fluctuations of order fields, low energy theorems and the large deviation principle. Discussions with D. Buchholz, S. Doplicher, N. Landsman and J.E. Roberts lead to the clarification of certain group theoretic aspects of the problem which are related to the partial spontaneous breakdown of symmetries.

d) Quantum field theory on curved spacetime. Recently there has been much progress in the characterization of elementary physical states on curved spacetime manifold and a substantial part of this project was devoted to this topic. The following participants were actively involved in these discussions: H.J. Borchers, J. Bros, D. Buchholz, S. Doplicher, H. Fredenhagen, B. Kay, U. Moschella, S.J. Summers, R. Verch.

J. Bros and U. Moschella continued their collaboration on problems related to quantum field theory on (anti) de Sitter spacetime. They made significant progress on the Fourier-Laplace analysis on these spaces from the viewpoint of classes of holomorphic functions in appropriate tuboid domains. This is an important ingredient in their program of constructing field propagators on holomorphic spaces. Discussions with H.J. Borchers, D. Buchholz and S.J. Summers dealt with the relation between the principle of maximal analyticity of J. Bros and U. Moschella and the condition of geometric modular action (cf. above) and modular covariance. They stimulated an investigation of global properties of vacuum-like states on de Sitter space by H.J. Borchers and D. Buchholz. Another interesting issue which was discussed is the relation between the holomorphic approach of J. Bros and U. Moschella and the wave-front set condition of R. Brunetti, K. Fredenhagen and M. Radzikowski.

S. Doplicher and K. Fredenhagen analyzed in which sense the local algebras of free massive fields in their basic model of quantum spactime deform to the usual local algebras on Minkowski space if the Planck length is treated as a parameter tending to zero, while the mass of the field is fixed. Interesting partial results emerged, although the problem turned out to be unexpectedly subtle.

The question of the existence of a local vacuum for quantum fields in curved spacetime was addressed by B. Kay. The point of view which he adopts in his approach to characterize preferred states is very different from the principle of geometric modular action proposed by D. Buchholz and S.J. Summers. There has been a very stimulating and encouraging exchange of ideas on this issue. B. Kay also discussed with R. Verch the question as to how one might possibly weaken the Hadamard condition

for linear quantum fields in curved spacetime while maintaining local quasi-equivalence.

e) Concepts and constructive methods. Besides the work addressed to the above specific issues there has been a fruitful exchange on general conceptual and constructive problems amongst the participants of this project, especially K. Baumann, J. Bros, M. Dubois-Violette, R. Haag, H. Narnhofer, D. Schlingemann, E. Seiler, O. Steinmann, R. Stora and E.H. Wichmann.

The intriguing ideas of R. Haag on a reformulation of quantum theory based on the concept of "event" were discussed both in seminars and in many private conversations. It would be desirable to develop an appropriate mathematical setting which allows one to formalize these physically attractive ideas.

K. Baumann worked on the existence of so-called bounded Wightman fields, a question raised originally by J. Yngvason. His results, which partly emerged in conversations with H. Rehren, provide strong evidence to the effect that bounded Wightman fields in two spacetime dimensions which commute at space- and timelike distances are sums of p-products of chiral Fermi fields.

The problem of the relation between the Wightman framework of quantum field theory and the algebraic setting was discussed by H. Narnhofer and E.H. Wichmann. Special attention was given to the question whether every subnet of a local net of von Neumann algebras which is generated by Wightman fields can also be regarded as generated by (possibly multi-variable) fields. An affirmative answer to this question seems within reach.

An interesting approach towards the direct construction of local C*- algebras by Euclidean methods was completed by D. Schlingemann during this project. Discussions with J. Bros, E. Seiler and J. Yngvason helped to settle various technical points which had appeared in this work.

O. Steinmann worked on a justification of the perturbative construction of quantum electrodynamics by methods of axiomatic field theory. His treatment of the infraparticle problem stimulated a general discussion of the particle concept in theories with long range forces.

R. Stora commented on an approach *a la* Epstein-Glaser towards the perturbative construction of non-abelian gauge theories which has been put forward by the group of G. Scharf in Zürich. He pointed out that some apparent cohomological obstructions ought to be checked and M. Dubois-Violette was able to show that there are no such problems. This conceptually surprisingly simple approach seems therefore quite promising.

The use of geometrical methods of analytic completion versus the Dyson wave equation method for determining the null regions of commutator functions was discussed by H.J. Borchers, J. Bros, D. Buchholz, R. Stora and E.H. Wichmann. It turned out, much to the surprise of the experts, that for certain non-standard regions the Dyson method gives stronger results than the analytic techniques.

Finally, problems appearing in renormalization theory triggered a discussion between J. Herman, B. Kuckert, M. Oberguggenberger and I. Todorov on the application of new types of generalized functions (Colombeau-framework) to problems in constructive quantum field theory.

The preceding outline of activities reveals the broad spectrum of problems treated and the many interrelations between the various subjects. The fact that more new intriguing questions were raised during this project than answered provides evidence of the stimulating and fruitful atmosphere at ESI. It is to be expected that a substantial part of the ongoing projects mentioned above will be finished within a few months and will result in further ESI-publications.

The efficient handling of all practical matters by the staff of the Institute and the excellent working conditions (apart from some minor shortcomings of the electronic equipment) were essential for the success of this project. There was unanimous agreement that this intensive exchange between experts working in quite different areas will have substantial impact on the future development of local quantum physics.

Nonlinear theory of generalized functions

Organized by M. Oberguggenberger (Innsbruck), September – December 1997

5 Preprints contributed: [502], [508], [511], [512], [513].

Money spent: AS 518.500.- (ESI), AS 124.000.– (foreign)

The aim of the project was to develop applications of the nonlinear theory of generalized functions to various fields in mathematical analysis and mathematical physics, and in particular, to investigate

the interplay of nonlinearity and creation and propagation of singularities in models involving differential equations and generalized functions. The project proceeded in the three phases (i) Lie groups, symmetries and relativity; (ii) evolution equations and propagation of singularities; (iii) nonlinear models with stochastic processes from October 15 - December 20, 1997 (with an early contribution of P. Olver in September). The general and intended character of the project was to bring together experts from these fields with a core of researchers in algebras of generalized functions for talks, discussions and joint research.

There were 30 invited visitors, 4 guests from abroad visiting on their own, and 10 - 15 mathematicians and physicists from Vienna participating regularly in research and discussions.

Results. In the sequel, the activities and results will be grouped roughly according to the themes of the three phases, with an additional item: structure theory and interaction with quantum field theory. Following the description of activities, main results (which were obtained at the workshop and have led or will lead to publications) are emphasized separately.

Lie groups, symmetry and relativity. In this area, four topics were pursued:

(i) Lie group actions on generalized solutions to nonlinear parial differential equations. This involved nonlinear transformations of delta waves, invariance of solutions in the sense of association to hyperbolic systems of conservation laws under group transformations, nonprojectable group actions in algebras of generalized functions, and Lie semigroups (Dapic, Hermann, Kunzinger, Rosinger, M.O.). **Results:** it Sufficient conditions for invariance in the association sense, new examples of transformation of delta waves.

(ii) Ordinary differential equations and generalized functions. Study of ordinary differential equations in Colombeau algebras, control theory, and delta function terms (Hermann, Nedeljkov, Gramchev, M.O.). **Results:** it A class of ODEs with delta function terms was found which admits distributional solutions.

(iii) General relativity: Foundations were laid for modelling distributional curvature by means of generalized function algebras, and geodesics as well as symmetries in impulsive gravitational waves were studied (Vickers, Steinbauer, in collaboration with Aichelburg, Balasin). **Results:** it Computation of broken geodesics and geodesic deviation in the geometry of pp-waves.

(iv) First investigations into geometric theory of generalized functions on manifolds, and generalized manifolds (Hermann, Hazewinkel, Kunzinger, Kriegl).

Evolution equations and propagation of singularities. Activities in this area can be summarized in three groups:

(i) Schrödinger equations. The nonlinear Kronig-Penney model was investigated both in algebras of generalized functions and concerning distributional limits; and similarly the semilinear Schrödinger equation with additive white noise (Lange, Russo, M.O.). Further, operator theory methods were developed that apply to generalized function potentials in the linear, stationary Schrödinger equation (Antonevich, Radyno). **Results:** it Solution of the nonlinear Kronig-Penney model and limiting behavior for positive measures as potential; generalized solutions to the linear Schrödinger equation with additive white noise.

(ii) Hyperbolic conservation laws and related topics. The nature of singular shocks and delta shocks in conservation laws was clarified (Keyfitz, M.O.). All possible Rankine-Hugoniot conditions obtainable in solutions in the sense of association, using generalized Heaviside functions to solve the Riemann problem, were characterized (Egorov, M.O.). The relation of Colombeau solutions to Maslov asymptotic solutions was investigated (Omel'yanov). In models with dispersion or diffusion, blow-up mechanisms were studied (Bona, Scialom, Egorov). **Results:** it Discovery of the occurence of singular shocks in systems obtainable from gas dynamics; characterization of all possible Rankine-Hugoniot conditions.

(iii) Regularity theory. The notion of $\mathcal{G}^\infty$-regularity was further developed, in particular, $\mathcal{G}^\infty$-hypoellipticity of linear operators with non-constant, degenerate coefficients (Reissig) as well as linear operators with constant, generalized coefficients (Pilipović, Nedeljkov). Modelling of boundary layers in generalized functions was discussed (Gues). In diffusion equations, general results on the propagation region of analyticity and Gevrey regularity of initial data were obtained (Biagioni, Gramchev). **Results:** it $\mathcal{G}^\infty$-hypoellipticity of a class of degenerate operators was proved, determination of propagation domains of analyticity in Kuramoto-Sivashinsky-type equations.

In addition, the construction of Colombeau solutions in semilinear elliptic equations (Marti, Scarpalezos, Delcroix) and nonlinear Klein-Gordon equations (Pilipović, Nedeljkov, Wang, M.O.) was continued.

Nonlinear models with stochastic processes. The main investigations focused around semilinear heat equations with additive and multiplicative white noise, study of pathwise limits and asymptotic series in Wick renormalized solutions (Russo). This was extended to semilinear wave- and Schrödinger equations. Mechanisms leading to "trivial" limits were further investigated. A comparison of the Colombeau approach and the Hida white noise approach to stochastic PDEs led to a unification on a higher level of generalization. The possibility of using the concept of viscosity solutions in the Hida white noise approach was discussed (Holden, Øksendal). Various notions of "measurement solutions" (regularized derivatives) as related to stochastic differential equations and Colombeau generalized functions were discussed (Ubøe, Zhang). **Results:** it A general theorem on pathwise limits explaining the mechanism in semilinear stochastic PDEs with additive white noise was proven. The case of multiplicative white noise in the semilinear heat equation was settled.

Structure theory, quantum field theory. Various approaches to the construction of Colombeau generalized functions (scales, seminorms, sheaf methods, nonstandard valuations) were unified (Marti, Radyno, Scarpalezos, T. Todorov). A first construction of a Colombeau-type algebra containing periodic hyperfunctions was obtained (Valmorin). A characterization of $\mathcal{G}^\infty$-regularity in terms of generalized point-values was achieved (Pilipović, M.O.). The applicability of infinite dimensional differential calculus to characterize Colombeau generalized functions was investigated (with Kriegl). **Results:** it Construction of Colombeau algebras containing periodic hyperfunctions, point-value characterization of $\mathcal{G}^\infty$-regularity.

As a result of interaction with the ESI-program "Local Quantum Physics"

(organizers: D. Buchholz, J. Yngvason, H. Narnhofer), the question of applicability of generalized function algebras in renormalization problems of quantum field theory was repeatedly discussed with I. Todorov, H. Grosse, B. Kuckert and others. Certain regularization processes in the Thirring model were seen to be representable by Colombeau generalized functions.

Publications. Apart from the ESI-preprints listed separately, a proceedings volume "Nonlinear Theory of Generalized Functions" of the workshop will be published in the Pitman Research Notes in Mathematics Series. The proceedings volume will contain short review articles on the fields represented by the participants, in their interaction with the questions of nonlinearity and singularities as worked out during the program. It is intended as a survey of the state of the art in the field.

Further, a book project "Geometric Theory of Generalized Functions", as a collaboration of M. Grosser, M. Kunzinger, M.O., R. Steinbauer was initiated as a result of discussions at the workshop. It has been accepted for future publication by Kluwer.

In addition, the work "Parametric Lie Group Actions on Global Generalised Solutions of Nonlinear PDEs" presented by E.E. Rosinger at the workshop has also been accepted for publication by Kluwer.

Collaborations initiated. Apart from various collaborations among participants already existing, a

number of new joint projects were started as a consequence of the workshop. This includes work on general relativity involving J. Vickers, R. Steinbauer, H. Balasin (Southampton - Vienna); a joint project on Lie transformation groups with S. Pilipović and his school and M. Kunzinger, M. Grosser (Novi Sad - Vienna); nonlinear Schrödinger equations with H. Lange and M. Oberguggenberger (Köln - Innsbruck) and fundamental solutions to linear PDEs in the Colombeau setting, N. Radyno and M. Oberguggenberger (Minsk - Innsbruck).

Conclusion. From my point of view, the project successfully achieved its aims. The nonlinear theory of generalized functions has found a firm place in mathematical analysis. New applications and extensions of old applications demonstrated its applicability in a wide range of problems. Apart from the mathematical benefits of the project, the interaction with local and invited physicists proved particularly fruitful. The project also served to crystallize new directions of research in nonlinear models with generalized functions. Notably, the main focus in the near future will be on differential geometric aspects, applications to general relativity, regularity theory in partial differential equations and structure theory of algebras of generalized functions.

I would like to add that all participants were highly satisfied with the working conditions and stimulating atmosphere at the Erwin-Schrödinger-Institute. I also pass on the enthusiastic words of praise for institution and administration of the Erwin-Schrödinger-Institute that were expressed by practically all participants.

February 5, 1998 Michael Oberguggenberger, Universität Innsbruck.

Programs of 1996

Condensed Matter Physics – Dynamics, Geometry, and Spectral Theory.

Topological, Conformal and Integrable Field Theory.

Representation Theory with Applications to Mathematical Physics.
preprints contributed: [488], [492]

Mathematical Problems of Quantum Gravity. Continuation of the 1996 program, organized by A. Ashtekhar and P. Aichelburg.
Money spent: AS 69.000.–(ESI).
19 Preprints contributed: [417], [418], [420], [422], [430], [441], [456], [457], [458], [459], [462], [463], [472], [473], [474], [476], [509], [510], [517].

Hyperbolic Systems with Singularities.
16 Preprints contributed: [416], [423], [427], [429], [436], [437], [438], [442], [444], [445], [455], [468], [483], [489], [491], [504].

Guests via Director's shares

Guests of Walter Thirring.
Money spent: AS 44.000.– (ESI), 3.000.– (foreign).
5 Preprints contributed: [431], [440], [443], [478], [490]

Guests of Klaus Schmidt. Everything is included in the program report on Ergodic Theory.

Guests of Peter Michor.
Money spent: AS 146.000.–(ESI), AS 352.000.–(foreign)
16 preprints contributed: [415], [419], [426], [435], [452], [453], [454], [465], [466], [479], [482], [485], [496], [506], [514]; [523].

Guests of Hoffman-Ostenhof.
Hoffmann-Ostenhof is also the local coordinator of the EU TMR-network 96-0001 'Partial Differential Equations and Applications in Quantum Mechanics' (November 1996–October 2000, ca. AS 2.5 Mio to be spent at ESI), together with TU Berlin, University of Wales, Université de Paris-Sud, University of Kopenhagen, Universität Regensburg.
Money spent: AS 103.000.–(ESI), AS 365.000.—(foreign, EU)
8 preprints contributed: [421], [447], [480], [481], [495], [500], [514]; [527]

Guests of H. Grosse.
Money spent: AS 23.000.–(ESI), AS 2.000.—(foreign)
1 preprint contributed: [526]

Guests of A. Cap.
Money spent: AS 7.000.–(ESI).
preprints contributed: [450]

List of Publications

We try to keep track of the bibliographical data of the published versions of the preprints – this is incomplete and we are constantly updating it. Papers in mathematics have been bibliographically completed up to Nr. 240.

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Shcherbina Maria (Kharkov),
Shlosman Senya (Moscow),
Shubin Mikhail (Boston),
Siedentop Heinz (Oslo),
Sigal Israel Michael (Toronto),
Simoni Alberto (Napoli),
Simons Ben (London),
Sjöstrand Johannes (Palaiseau Cedex),
Solovej Jan Philip (Aarhus, Denmark),
Sparano Giovanni (Napoli),
Spohn Herbert (München),
Steif Jeffrey (Göteburg),
Stern Allen (Alabama),
Stone Michael (Urbana, Illinois),
Sütő András (Budapest),
Szász Domokos (Budapest),
Szőke Róbert (Budapest),
Tafel Jacek (Warsaw),
Tamagawa Wataru (Yokohama),
Tartakoff David S. (Illinois),
Teotonio – Sobrinho Paulo (Chicago),
Testard Daniel (Marseille Cedex),
Todorov Ivan (Sofia),
Tóth Bálint (Budapest),
Tulczyjew Wlodzimierz (Camerino Valle San Benedetto),
Ueltschi Daniel (Lausanne),
Umehara Masaaki (Bonn),
Upmeier Harald (Marburg),
Vajaitu Viorel (Bucarest),
Vilasi Gaetano (Salermo),
Vinogradov Alexandre (Salermo),
Vitale Patrizia (Napoli),
Vizman Cornelia (Timisora Romania),
Vogt Dietmar (Wuppertal),
Wegner Franz (Heidelberg),
Werner Reinhard F. (Osnabrück),
Wermer John (Providence, RI, USA),
Wiegmann Paul B. (Chicago),
Wilkinson Michael (Glasgow, Scotland),
Winkler Veronika (Graz),
Wipf Andreas (Jena),
Wölfle Peter (Karlsruhe),
Woynarovich Ferenc (Budapest)
Yano Masamichi (Yokohama),
Yngvason Jakob (Reykjavik, Iceland),
Yokura Shoji (Kagoshima),
Zabrodine Anton (Moscow),
Zahradnik Miloš (Praha),
Zamolodchikov Alexander B. (New Jersey).

In the year 1996:

Alekseev A. (Russia),
Alexeevski D. (Russia),
Appert C. (France),
Ashtekar A. (USA),
Asorey M. (Spain),
Astashkevich A. (Russia),
Aubry S. (France),
Babelon O. (France),
Bach V. (Germany),
Bäcker A. (Germany),
Baez J. (USA),
Baladi V. (Switzerland),
Barbero González J. (Spain),
Barchini L. (Argentina),
Barvinsky A. (Russia),
van Beijeren H. (Netherlands),
Benatti F. (Italy),
Benedicks M. (Sweden),
Benettin G. (Italy),
Benfatto G. (Italy),
Bernard D. (France),
Birman M. (Russia),
Biskup M. (Czech Republic),
Bizoń P. (Poland),
Bjorken J. (USA),
Blau M. (Germany),
Bobenko A. (Russia),
Bonetto F. (Italy),
Bonora L. (Italy),
Bressaud X. (France),
Breymann W. (Germany),
Brunner I. (Germany),
Buffenoir E. (France),
Bunimovich L. (USA),
Burago D. (Russia),
Cappelli A. (Italy),
Carta P. (Italy),
Cheng S. (Austria),

Chernov N. (Russia),
Choquard P. (Switzerland),
Christiansen P. (Denmark),
Cohen E. (USA),
Contucci P. (Italy),
Cortés V. (Spain),
Craig W. (USA),
D'Andrea A. (Italy),
Demitchev A. (Russia),
Deser S. (USA),
Dimitrov I. (Bulgaria),
Doliwa A. (Poland),
Donnay V. (USA),
Dorfman J. (USA),
Dubrovin B. (Russia),
Dvorsky A. (Ucraine),
Durhuus B. (Denmark),
Eastwood M. (Australia),
Enolskii V. (Ucraine),
Exner P. (Czech Republic),
Evans D. (Australia),
Faddeev L. (Russia),
Falceto F. (Spain),
Fecko M. (Slovakia),
Fefferman C. (USA),
Felder G. (Switzerland),
Fialowski A. (Hungary),
Fischer T. (Germany),
Flato M. (France),
Frenkel E. (Russia),
Frenkel I. (Russia),
Fuchs D. (USA),
Fuchs J. (Germany),
Futorny V. (Ucraine),
Gallavotti G. (Italy),
Gambini R. (Uruguay),
Ganchev A. (Bulgaria),
Gannon T. (Canada),
Gaspard P. (Belgium),
Gawedzki K. (France),
Gentile G. (Italy),
Germoni J. (France),
Gervais J. (France),
Gindikin S. (Russia),
Giulini D. (Germany),
Golenishcheva – Kutuzova M. (Russia),
Grecchi V. (Italy),
Haag R. (Germany),
Halliwell J. (Great Britain),
Herbst I. (USA),
Hirzebruch F. (Germany),
Hoffman C. (USA),
Hoffmann T. (Germany),
Hryniv O. (Ucraine),
Israel W. (Canada),
Ivanov A. (Russia),
Jacobson T. (USA),
Janssen T. (Netherlands),
Jonsson T. (Iceland),
Jurčo B. (Czech Republic),
Just K. (Germany),
Kac V. (USA),
Kantz H. (Germany),
Kashaev R. (Russia),
Katanaev M. (Russia),
Katok A. (USA),
Kazdan J. (USA),
Kellendonk J. (Germany),
Keller G. (Germany),
Kirillov A. (Russia),
Kirillov Jr. A. (Russia),
Klein M. (Germany),
Klimčik C. (Slovakia),
Knörrer H. (Germany),
Kohmoto M. (Japan),
Kostant B. (USA),
Kotecký R. (Czech Republic),
Krámli A. (Hungary),
Krasnov K. (Ucraine),
Krive I. (Russia),
Krüger T. (Germany),
Kucharz W. (Poland),
Kupershmidt B. (USA),
Kutz N. (Germany),
Langmann E. (Austria),
Laptev A. (Sweden),
Ledrappier F. (France),
Lepri S. (Italy),
Leslie C. (Canada),
Lewandowski J. (Poland),
Liakhovskaia A. (Russia),
Lieb E. (USA),
Litvinov G. (Russia),
Liverani C. (Italy),
Livi R. (Italy),
Löffelholz J. (Germany),
Loll R. (Germany),
Losik M. (Russia),
Lusztig G. (USA),
Maddaly K. (India),
Maeda Y. (Japan),
Majid S. (Great Britain),
Malikov F. (Russia),
Marchesoni F. (Italy),
Marchiafava S. (Italy),
Markarian R. (Uruguay),
Marolf D. (USA),
Mastropietro V. (Italy),
Mathieu O. (France),
Matschull H. (Germany),
Maume V. (France),
Meissner K. (Poland),
Mielke A. (Germany),
Milicic D. (USA),
Morozov A. (Russia),
Moskaliuk S. (Ucraine),
Mourão J. (Portugal),
Mussardo G. (Italy),
Myers R. (Canada),
Nadirashvilli N. (Russia),
Nazarov M. (Russia),
Nekrassov N. (Russia),
Neretin Y. (Russia),
Nguyen H. (USA),
Nicolai H. (Germany),
Nicolis G. (Greece),
Nijhoff F. (Netherlands),
Nishijima K. (Japan),
Novak J. (USA),
Olive D. (Great Britain),
Olchaneski M. (Russia),
Onichtchik A. (Russia),
Oseledets C. (Russia),
Owen M. (Great Britain),

Pawelczyk J. (Poland),
Penkov I. (Bulgaria),
Petersen K. (USA),
Petkova V. (Bulgaria),
Petrina D. (Ucraine),
Pettini M. (Italy),
Petz D. (Hungary),
Pittner L. (Austria),
Popkov V. (Ucraine),
Popov V. (Russia),
Prešnajder P. (Slovakia),
Protsak V. (Ucraine),
Pullin J. (Argentina),
Radons G. (Germany),
Recknagel A. (Germany),
Rehacek J. (Czech Republic),
Reisenberger M. (Austria),
Rietsch K. (Austria),
Robbiano L. (France),
Rosso M. (France),
Rovelli C. (Italy),
Rudakov A. (Russia),
Rudolph D. (USA),
Ruffo S. (Italy),
Rugh H. (Denmark),
Ryan P. (Australia),
Sacchetti A. (Italy),
Salmhofer M. (Austria),
Santini P. (Italy),
Saussol B. (France),
Schimmrigk R. (Germany),
Schlingemann D. (Germany),
Schmitt B. (France),
Schomerus V. (Germany),
Schroer B. (Germany),
Schulz–Baldes H. (Germany),
Schweigert C. (Germany),
Schwimmer A. (Israel),
Seiler R. (Switzerland),
Serganova V. (Russia),
Shlosman S. (Russia),
Sierra G. (Spain),
Simon J. (France),
Slovák J. (Czech Republic),
Smithies L. (USA),
Sobolev A. (Russia),
Sommers E. (USA),
Stanev Y. (Bulgaria),
Stern E. (USA),
Sternheimer D. (France),
Stora R. (France),
Strobl T. (Austria),
Styrkas K. (Russia),
Suris Y. (Russia),
Szász D. (Hungary),
Takebe T. (Japan),
Tél T. (Hungary),
Theisen S. (Germany),
Thiemann T. (Germany),
Todorov I. (Bulgaria),
Troubetzkoy S. (USA),
Vaienti S. (Italy),
Varchenko A. (Russia),
Vershik A. (Russia),
Veselov A. (Russia),
Viana M. (Brazil),
Vinberg E. (Russia),
Vollmer J. (Germany),
Vybornov M. (Ucraine),
Wang W. (China),
Wegner F. (Germany),
Weiss B. (Israel),
Wojtkowski M. (USA),
Wolf J. (USA),
Woronowicz S. (Poland),
Wreszinski W. (Brazil),
Yngvason J. (Iceland),
Yokura S. (Japan),
Young L. (USA),
Zamolodchikov A. (Russia),
Zhao G. (China),
Zhelobenko D. (Russia),
Zierau R. (USA),
van Zon R. (Netherlands),
Zuckerman G. (USA),
Zweimüller R. (Austria).

In the year 1997:

Aaronson Jon (Tel-Aviv),
Abels Herbert (Bielefeld),
Adams Scot (University of Minnesota),
Aigner Martin (FU Berlin),
Albuquerque Paul (Universite Geneva),
Alexeevski Dmitri (Moscow),
Andersson Lars (Stockholm),
Antonevich Anatolij (Minsk),
Armstrong John (Oxford),
Ashtekar Abhay (Pennsylvania State),
Baez John C. (Riverside),
Bailey Toby (Edinburgh),
Ballmann Werner (Universitaet Bonn),
Barnes Julie (Western Carolina),
Baumann Klaus (Universität Göttingen),
Baumgärtel Helmut (Universität Potsdam),
Beem John K. (Missouri-Columbia),
Benoist Yves (Universite Paris VII),
Besson Gerard (Universite Grendoble),
Bezuglyi Sergey (Kharkov),
Biagioni Hebe de Azevedo (Campinas University),
Bičak Jiri (Charles University),
Bogolioubov Nicolai (Moscow),
Bona Jerry (Texas),
Borchers Hans-Jürgen (Universität Göttingen),
Borwein Jonathan (Simon Fraser University),
Bourgignon Jean-Pierre (IHES),
Boyle Mike (Maryland),
Bressan Alberto (Trieste),
Bridges Douglas (Waikato),
Bros Jacques (Saclay),
Brout Robert (Bruxelles),
Bruin Henk (Stockholm),
Brunetti Romeo (Napoli),
Buchholz Detlev (Universität Hamburg),
Burger Marc (Universite Lausanne),
Cavallaro Stefano (Sissa),
Chaleyat-Maurel Mireille (University Paris V),
Choe Geon Ho (Korea),
Chrusciel Piotr (Tours),
Conti Roberto (Roma),
Cortés Vicente (Bonn),
Cotsakis Spiros (University of the Aegean),
Courtois Gilles (Ecole Polyechnique),
D'Antoni Claudio (Universita di Roma "Tor Vergata"),
Dal'bo Francoise (Universite Rennes 1),
del Junco Andrés (Toronto),

Delcroix Antoine (Antille-Guyane),
Dickinson H. (York),
Dickinson H. (York),
Djapic Nenad (Novi Sad),
Doplicher Sergio (Roma),
Dress Andreas (Universität Bielefeld),
Dubois-Violette Michel (Universite Paris XI),
Dunajski Maciej (Oxford),
Dupont Serge (Universitaet Bonn),
Egorov Yuri (Université Paul Sabatier),
Eloranta Kari (Helsinki University of Technology),
Eskin Alex (Chicago),
Farb Benson (Chicago),
Feldman Jacob (Berkeley),
Ferenczi Sebastien (Luminy),
Feres Renato (Washington),
Ferleger Serge (Pennsylvania State University),
Fidaleo Francesco (Universita "Tor Vergata"),
Fiebig Ulf-Rainer (Universität Heidelberg),
Fiebig Doris (Universität Heidelberg),
Field Timothy (Stevenage),
Fischer Arthur (California),
Foulon Patric (Strasbourg),
Frauendiener Jörg (Universität Tübingen),
Fredenhagen Klaus (Universität Hamburg II),
Friedrich Helmut (MPI Gravitationsphysik),
Frittelli Simonetta (Pittsburgh),
Furstenberg Hillel (Jerusalem),
Gambini Rodolfo (Montevideo),
Gao Yan (Yale),
Gauduchon Paul (CNRS-Ecole Polytechnique),
Gentili Fausto (Universita di Bologna),
Glasner Eli (Tel Aviv University),
Goldsheid Ilya (London),
Gramchev Todor (Universita di Cagliari),
Gratus Jonathan (Université Paris VI),
Grundling Hendrik (New South Wales),
Gues Oliver (Nice),
Guido Daniele (Universita di Roma "Tor Vergata"),
Guivarc'h Yves (Rennes),
Gutkin Eugene (University of Southern California),
Gutkin Eugene (University of Southern California),
Guttmann Anthony (Melbourne),
Ha Young-Hwa (Ajon University),
Haag Rudolf (Universität Hamburg),
Haiman Mark D. (U.C. San Diego),
Hamachi Toshihiro (Kyushu University),
Hamenstaedt Ursula (Bonn),
Harpe Pierre de la (Universite Geneva),
Hasselblatt Boris (Tufts University),
Hawkins Jane (North Carolina),
Haydn Nicolai T.A. (University of South California),
Hazewinkel Michiel (University Utrecht),
Hermann Robert (MIT),
Herzlich Marc (Ecole Polytechnique),
Hill C. Denson (Stony Brook),
Holden Helge (Norwegian Institute of Technology),
Huggett Steven (Plymouth),
Hurder Steve (Chicago),
Iozzi Alessandra (Maryland),
Iwanik Anzelm (Politechnika Wroclawska),
Izeki Hiroyasu (Germany),
Jakobson Michael (Maryland),
Johnson Aimee (Swarthmore College),
Johnson Kimberly (North Carolina),
Jones Vaughan (Univ. of Berkeley),
Junker Wolfgang (MPI Gravitationsphysik),
Jäkel Christian (Wien),
Kaimanovich Vadim (Rennes),
Kaminski Brunon (Copernicus University),
Kashiwara Masaki (RIMS Kyoto University),
Katok Anatole (Pennsylvania State University),
Katok Anatole (Pennsylvania State University),
Katok Svetlana (Pennsylvania State University),
Katok Svetlana (Pennsylvania State University),
Kay Bernard S. (York),
Keane Michael (Centrum voor Wiskunde),
Keyfitz Barbara Lee (Houston),
Kifer Yuri (Hebrew University),
Kim Young-One (Sejong University),
Kleinbock Dmitry (Princeton),
Klingler Bruno (Ecole Polytechnique),
Knieper Gerhard (Leipzig),
Kobak Piotr Z. (Uniwersytet Jagielloński),
Kopczyński Wojciech (Warsaw),
Kornfeld Isaac (North Dakota State University),
Koss Lorelei (North Carolina),
Krasnov Kirill (Pennsylvania State University),
Krieger Wolfgang (Universität Heidelberg),
Kuckert Bernd (Universität Hamburg),
Kunhardt Walter (Universität Göttingen),
Kwiatkowski Jan (Uniw. Kopernika),
Köster Sören (Aachen),
Lafontaine Jacques (Université Montpellier),
Landsman Nicolaas Pieter (Amsterdam),
Lange Horst (Universität Köln),
Langmann Edwin (KTH),
Ledrappier Francois (Ecole Polytechnique),
Lee Jungseob (Ajou University),
Leeb Bernhard (Universitaet Bonn),
Leitenberger Frank (Universität Leipzig),
Lemańczyk Mariusz (Copernicus University),
Lemmens Bas (Amsterdam),
Levesley Jason (York),
Lewandowski Jerzy (Warsaw University),
Liardet Pierre (Uni de Provence CMI),
Lieb Elliott (Princeton University),
Lind Douglas (Washington),
Losik Mark V. (Saratov State University),
Low Robert (Coventry University),
Lutz Matthias (Universität Göttingen),
Madore John (Paris Sud),
Major Péter (Hungarian Academy of Sciences),
Malec Edward Janusz (Jagiellonian University),
Margulis Gregory (Yale),
Marolf Donald (Syracuse University),
Marti Jean-André (Université Antilles Guyane),
Mason Lionel (Oxford),
Masur Howard (Chicago),
Matsui Tako (Kyushu University),
Mendes-France Michel (Math. Universite Bordeaux),
Merkulov Sergei (Russian Academy of Sciences),
Miglbauer Hans (TU-Graz),
Mintchev Mihail (Universitá di Pisa),
Moncrief Vincent (Yale University),
Morchio Giovanni (Universitá di Pisa),
Moschella Ugo (Milan),
Moskaliuk Stepan (NAS Ukraine),
Mozes Shahar (Hebrew University),
Müger Michael (Universita di Roma "Tor Vergata"),
Müller Franz (ETH Hoenggerberg),
Nadirashvilli Nikolai (MIT),
Nakada Hitoshi (Keio University),
Nedeljkov Marko (Novi Sad),

Nelson Jeanette (Turin),
Newman Ezra Ted (niversity of Pittsburgh),
Nicolas Jean-Philippe (Bordeaux 1 University),
Nitica Viorel (Indiana),
Nurowski Pawel (Warsaw University),
Oberguggenberger Michael (Universität Innsbruck),
Ogievetsky Oleg (MPI für Physik),
Oh Hee (Yale),
Ojima Izumi (Kyoto University),
Oksendal Bernt (Oslo),
Olver Peter (Minnesota),
Omelýanov Georgii (Moscow State Univ.),
Ó Murchadha Niall (University College Cork),
Owen Mark Philip (King's College London),
Park Kyewon Koh (Ajon University),
Penrose Roger (Oxford),
Perjés Zoltán (Budapest),
Pesin Yakov (Pennsylvania State University),
Petersen Karl (North Carolina),
Petrina Dmitri (Ucraian Academy of Sciences),
Petz Dénes (Technical Budapest),
Piacitelli Gherardo (Italy),
Picaud Jean-Claude (France),
Pilipović Stevan (Novi Sad),
Pollicott Mark (Manchester),
Popov Vladimir L. (Moscow State Technical University),
Priebe Natalie (North Carolina),
Przanowski Maciej (Łódź),
Pullin Jorge (Pennsylvania State University),
Qian Nantian (Yale),
Radin Charles (Texas),
Radyno Yakov (Belarussian State University),
Radyno Nikolai (Belarussian Academy of Science),
Rehren Karl-Henning (Universität Hamburg),
Reissig Michael (TU Bergakademie Freiberg),
Roberts John (Elias),
Robinson Arthur (George Washington University),
Robinson David (King's College London),
Robinson Ivor (Texas),
Rosinger Elemér (Pretoria),
Rozenblioum Grigori (Göteborg University),
Rudolph Daniel J. (Maryland),
Ruffing Andreas (MPI Physik),
Russo Francesco (Villetaneuse),
Scarpalezos Dimitris (Université Paris 7),
Schlesinger Karl-Georg (Wuppertal),
Schlingemann Dirk (04 17-04 25),
Schmeelk John (VCU Richmond),
Schmeling Joerg (Berlin),
Schmidt Bernd (MPI-Astrophysik),
Schomerus Volker (Universität Hamburg),
Schroer Bert (FU Berlin),
Scialom Marcia (Campinas State Univ.),
Seiler Erhard (MPI Physik),
Seke Josip (TU Wien),
Shah Nimish A. (Institute for Advanced Study),
Sharp Richard (Manchester),
Shelton Kennan (North Carolina),
Silver Daniel (South Alabama),
Simion Rodica (George Washington University),
Slovák Jan (Masaryk University Brno),
Smorodinsky Meir (Tel Aviv University),
Soifer Gregory (Bar-Ilan University),
Solomiak Michael (The Weizmann Institute of Science),
Souček Vladimir (Charles University),
Sparling George (Pittsburgh),
Starkov Alexander (All-Russian Electronical Institute),
Starkov Alexander (Moscow Region),
Steif Jeffrey (Chalmers University of Technology),
Steinmann Othmar (Universität Bielefeld),
Stepin Anatoli (Moscow State University),
Stiller Michael (Universität Hamburg),
Stora Raymond (LAPP Annecy),
Strack Paul (Chapel Hill),
Strocchi Franco (Scuola Normale Sup.),
Summers Stephen (Florida),
Szabados László (Benő),
Sós Veronika (Hungarian Academy of Sciences),
Tafel Jacek (Warsaw),
Taimanov Iskander (Novosibirsk),
Takahashi Satoshi (Osaka University),
Thouvenot Jean-Paul (Université Paris 6),
Tod Kenneth Paul (Oxford),
Todorov Ivan (Bulgarian Academy of Sciences),
Todorov Todor (Calif. Polytechnic),
Tomanov George (Universite Lyon),
Torok Andrew (Princeton),
Trautman Andrzej (Warsaw),
Trebels Stephan (Universität Göttingen),
Tuncel Selim (Washington),
Uboe Jan (Stord/Haugesund, Oslo),
Valmorin Vincent (Université Antilles Guyane),
Velani S.L. (Imperial College),
Verch Rainer (Universität Göttingen),
Vershik Anatoly (Russian Academy of Sciences),
Vervoort Marco (Amsterdam),
Vickers James (Southampton),
Volny Dalibor (Charles University),
Wang Ya-Guang (Shanghei Jiao Tong University),
Ward Thomas (East Anglia),
Wichmann Eyvind H. (University Berkeley),
Wiesbrock Hans-Werner (FU Berlin),
Wilkinson Amie (Northwestern University),
Williams Susan (South Alabama),
Wollenberg Manfred (Universtät Leipzig),
Woodhouse Nicholas M.J. (Oxford),
Yokura Shoji (Kagoshima),
Yue Chengbo (Pennsylvania State University),
Yuri Michiko (Sapporo University),
Zhang Tusheng (Henan),
Zhao Guosong (Sichuan University, China),
Zoller Peter (Universität Innsbruck).