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

Boltzmanngasse 9
A-1090 Wien, Austria

Scientific Report for the Year 1996

Vienna, ESI-Report 1996

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ESI–Report 1996

ERWIN SCHRÖDINGER INTERNATIONAL INSTITUTE OF MATHEMATICAL PHYSICS, SCIENTIFIC REPORT FOR 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.

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)

List of Preprints

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. Therefore we enclose the list of all preprints, not only those of 1996.

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Dept. of Physics P.O.Box 849,
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sashaz@physics.rutgers.edu,
sashaz@imp.uni-moutp2.fr,
Quantum Field Theory, Statistical Mechanics,
High – energy Physics,
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