Collection of Abstracts of the Lectures which will be given at the International Workshop “Mathematical Physics – today, Priority Technologies – for tomorrow” 12–17 May 1997, Kiev, Ukraine

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COLLECTION OF ABSTRACTS of the LECTURES
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“MATHEMATICAL PHYSICS – TODAY,
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About differential calculus on $q$-deformed twistors

We propose the short version of $q$-deformed differential calculus on the light-cone using twistor representation. The commutation relations between coordinates and momenta are obtained. The quasiclassical limit introduced gives an exact shape of the offshell shifting.

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Generalized action principle and Superfield equations of Dirichlet super-$p$-branes and 5-brane of M-theory

It is proposed the generalized action for $D = 10$ Dirichlet super-$p$-branes and $D = 11$ dimensional super-5-brane. The superfield equations for these objects are derived from the generalized action. They are the base for the further investigation of the extrinsic geometry of the named theories.

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THE LEVY STABLE RANDOM DISTRIBUTIONS AND THE PHASE TRANSITION THEORY

A random variable which describes a macroscopic body according to general principles of statistical mechanics is supposed to be the Levy stable random variable in the state of phase transition. It gives possibility to deduce all well known properties of the phase transitions. In particular it explains a description of phase transitions by means of the renormalisation semigroup, the existence of singularities and their classification
for the thermodynamic functions, the universality property and the universality classes of phase transitions etc. On this basis we have built the 2-parametric scaling theory of phase transitions and derived a singular part of thermodynamic function of the Ising model.

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DIFFERENTIAL AND INTEGRAL CALCULI
ON BRAIDED HOPF ALGEBRAS

Braided non-commutative differential geometry is studied. We investigate the theory of (bicovariant) differential calculi in braided abelian categories. Previous results on crossed modules and Hopf bimodules in braided categories are used to construct higher order bicovariant differential calculi ("Braided De Rham complex") over braided Hopf algebras out of first order ones. These graded objects are shown to be braided differential Hopf algebras with universal bialgebra properties. This extends Woronowicz’s results on (bicovariant) differential calculi to the braided non-commutative case.

Let $H$ be a Hopf algebra in a rigid braided monoidal category with split idempotents. Results about Hopf modules are applied to prove the existence of an invertible object $\int H$ and $(\int H)$-valued(-based) integrals on (in) $H$ characterized by the universal property. Fully braided version of Radford’s formula for the fourth power of the antipode is obtained. Connections of integration with cross-product and transmutation are studied.

Keywords: Braided category, Hopf algebra, Hopf bimodule, Non-commutative Differential Geometry, Invariant integrals, Transmutation, Bosonization.
Entropic characteristics of dynamical systems

With any non-commutative dynamical system (i.e., automorphism group of $C^*$-algebra) one can associate a “classical” dynamical system on a compact Hausdorff space. Entropic and topological properties of such systems are investigated. In particular, the properties of uniform positive entropy and completely positive entropy are defined and studied.

Second order approximation for an optical polaron in the strong coupling case

We propose a method of constructing of the second order approximation for the ground state energy for a class of model Hamiltonians with a linear type of interaction with respect to Bose operators in the strong coupling case. For an application of the above-mentioned method we have considered the polaron model and proposed a set of nonlinear differential equations for the ground state energy calculation in the strong coupling case. We have considered also the radially symmetric case.

New Method of Study for Free Boundary Problems

We study solvability and smoothness of the free boundary in the problems of jet and cavitation flows. These problems are substantively nonlinear due to the fact that the boundary is partly unknown. We apply a new method that can be also used in some other free boundary problems of Mathematical Physics.
Two examples of computer algebra research

We summarize two examples of current computer algebra research areas:

- Gröbner bases and
- theorem proving based on computer algebra.

**Gröbner Bases:** The method of Gröbner bases is a uniform approach to the solution of quite some fundamental problems in algebraic geometry and commutative algebra, e.g., systems of non-linear algebraic equations effective computation in residue rings module polynomial ideals, linear diophantine systems with polynomial coefficients, and computation of fundamental invariants. In the talk we present the main theorem of the theory of Gröbner bases, the algorithm for constructing Gröbner bases, and the most important applications of this algorithm.

**Theorem Proving:** Currently two very different approaches for computer-supported theorem proving based on computer algebra are pursued. The first approach reduces the problem of theorem proving for a given class of formula to an algebraic problem, e.g., the problem of constructing Gröbner bases. The provers in this class are efficient but “black box”. The second approach uses current computer algebra systems, e.g., Mathematica, as a language vehicle only and aims at proof systems that imitate human proving as closely as possible, i.e., the proofs generated are “white box”. In the talk we will give examples of both approaches with an emphasis on the “white box” approach currently investigated in the author’s Theorema Project.
Aharonov–Bohm effect and scattering in the pair of Hilbert spaces

The problem of the scattering of a charged test particle in the gravitational background of axially symmetrical wormhole in the presence of the Aharonov-Bohm type magnetic field is considered. It is shown that the natural mathematical framework appropriate for the problem is the scattering theory in the pair.

Multiparameter quantum deformation of BRST algebra

We investigate a multiparameter deformation of BRST algebra. Using the results of the bicovariant differential calculus we give the conditions which deformed BRST algebra must satisfy for consistency.

Algebra of Superconductivity

Cooper pairs are described as bosons belonging to the representation $D_{1/4}^+$ of $su(1, 1)$. The full second quantization scheme (including creation and annihilation operators for electrons of both helicity and Cooper pairs) is built by means of the superalgebra $osp(2|2)$. Phenomenological results of BCS theory are reproduced and the transition to the non superconductive status described as a contraction of the algebra.
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Scaling and Structure Functions in Helical Turbulence

The influence of the mean helicity on the scaling properties of turbulent fluid is discussed. The transformation properties of a Hopf-like equation for a characteristic functional is analyzed. The scaling relations in stratified fluid were obtained. It is shown that helicity define a new characteristic scale $L_\ast \sim l_h (l_h / L_{BO})^4$ (here $l_h = \overline{\eta}/\overline{\varepsilon}$, $\overline{\eta}, \overline{\varepsilon}$ - helicity and energy dissipation, $L_{BO}$ - Bolgiano–Obukhov scale).

Separately helical scaling in isentropic gas is analysed. Helicity leads to $E(k) \sim k^{-3}$ spectrum in shock wave limit. Scale invariance properties of characteristic functional allows to obtain scaling relations for high order structure functions also.

The mean helicity evolution in freely decayed turbulence is studied. Additional Kármán-Howarth type equations are obtained. The solution of these equations gives an exact relation between triple two-pointed longitudinal-transversal velocity correlations and the average helicity dissipation. This relation is a kind of Kolmogorov’s well-known $4/5$ law.

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Entropy for canonical *-endomorphisms

It is reported recent results about Connes–Narnhofer–Thirring entropy for *-endomorphisms on simple $C^*$-algebras, which arise from the structure of these algebras canonically.
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Symmetry analysis as an action guide in the design of nanotechnological machinery

Development of quantum engineering put forward new theoretical problems. Experimentators combine thousands of similar mesoscopic cells such that arises some artificial medium that with new electromagnetic properties. To describe such media new electromagnetic equations are introduced. A general analysis of accessible symmetries of pointlike cells and its interactions is done. The procedure of multipole parametrizations of dipole media: electric, magnetic, polar and axial toroidal, is worked out. Among basic vectors of these parametrizations poloidal dipole moments are introduced. The forms of interactions of all basic dipoles with ununiform and/or alternative external fields are found. The form of proper fields or potentials for each basic dipole is given.

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Category-theoretical generalization and development of Lie-Cartan-Laptev method of investigation of differential-algebraic models in theoretical physics

Any principal bundle along with its category generates a finite-dimensional category of isomorphisms of own layers - associated groupoid describing all category stratifications. In this case morphisms in category are characterized by property to induce identity mapping in groupoid. Associated groupoid allows to determine universal connection set as a
set of all functors from all curves base groupoid to associated groupoid. This fact provides a basis for our generalization of well-known connection notion in category of associated bundles (for example, nonlinear stable connection in high order frames stratifications as the most natural geometrical structure for description of invariants of high order ordinary differential equations systems).

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Representations of Affine Lie Algebras
We will discuss the recent developments in the theory of Affine Lie Algebras representations, in particular Verma type modules induced from non-standard Borel subalgebras and corresponding categories with Bernstein-Gelfand-Gelfand duality. We will also discuss the classification of irreducible modules of a non-zero level with finite-dimensional weight spaces which is reduced to the classification of torsion free modules for simple Lie algebras of type $A_n$ and $C_n$.

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Representations of the non-standard $so_q(n)$ and $so_q(n - 1, 1)$ in Gel’fand–Zetlin basis
It is proved by explicit construction that the $q$-analogue of Gel’fand-Zetlin basis is suitable for obtaining generic irreducible representations of the non-standard $q$-deformed algebras $so_q(n)$ as well as irreducible representations of their 'noncompact' counterparts $so_q(n - 1, 1)$, at least in the case of $q$ not equal to roots of unity.
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RIGOROUS DERIVATION OF THE GENERALIZED KINETIC EQUATION

We rigorously consider the problem of the derivation of the Boltzmann equation from the dynamics of many particles. For low densities we prove that the Cauchy problem for the BBGKY hierarchy with initial data satisfying the chaos property, in the space of summable functions, is equivalent to the Cauchy problem for a generalized Boltzmann equation. The classical Boltzmann equation is the result of the passage to the appropriate kinetic limit in the obtained generalized kinetic equation.

In order to formulate mathematically this problem, we examine the Cauchy problem for the BBGKY hierarchy, starting from initial data which are products of one-particle distribution functions. Such a general assumption for the initial data is natural for the kinetic description of a gas, since its states, in this case, are characterized only by the one-particle distribution function.

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The matched differential calculus on the $GL_q(2,C)$ group and on its subgroups and $\sigma$-models on the $SL_q(2,R)$, $SL_q(2,R)/U_q(1)$ and $C_q(2|0)$ in low dimensions

The matched differential calculi on the $GL_q(2,C)$ and on its subgroups $SL_q(2,C)$, $U_q(2)$, $SU_q(2)$, $Sp_q(2,C)$, $Sp_q(2)$, $T_q(2)$, $U_q(1)$, on the Borel subgroups $B_L(C)$, $B_U(C)$ and on their real forms are constructed. The $\sigma$-models on the quantum group manifolds $SL_q(2,R)$, $SL_q(2,R)/U_q(1)$, $C_q(2|0)$ in low dimensions are constructed. The classical solutions of the 1-dimensional $SL_q(2,R)$ and $C_q(2|0)$ $\sigma$-models are obtained.
Dynamical entropy and quantum K-systems

Connes, Narnhofer, Stormer and Thirring introduced the concept of entropy for automorphisms of $C^*$-algebras. It is important to study dynamics of quantum systems. Recently some remarkable results were obtained in computations of CNT-entropy for models of statistical physics. This allows one to study quantum K-systems introduced by Narnhofer and Thirring. We consider various examples of K-systems and describe their properties. We also present a wide enough class of systems with a completely positive entropy. In particular, the space translations of CCR-algebra and even part of CAR-algebra with quasi-free states of Park and Shin belong to this class. Some of these results were obtained in cooperation with S.V. Neshveyev.

FRT quantization theory for the nonsemisimple Cayley-Klein groups

We suggest to regard the nonsemisimple Cayley-Klein (CK) groups as the groups over associative algebras with nilpotent commutative generators. The modification of Faddeev-Reshetikhin-Takhtadjan (FRT) theory of the quantum groups and algebras is developed to be applicable for these groups and the quantum orthogonal CK groups are described with the help of this theory. The quantum orthogonal CK algebras are obtained as the dual objects to the corresponding quantum groups.
Mathematical models of protein evolution

An alignment between two proteins determines in a straightforward way a Markov matrix. Given a family of proteins, it is of interest to try to organize the corresponding matrices into a one-parameter “evolution”. We show how to do this, and discuss the implications.

On the differential calculi on the Quantum Group $GL_q(1|2)$

The noncommutative differential geometry on the Quantum group $GL_q(1|2)$ is proposed.

Phase transition in the ANNNI model with an external magnetic field

The class of anisotropic Ising models of magnetism in the presence of external magnetic field in the system is investigated. The phase transition theorems from paramagnetic state to (in)commensurate phase in this system is proven. The expression for the critical magnetic field is found. On the basis of spectrum analysis of linearized operator branching equations are derived and the small branching theorems are proven for commensurate and incommensurate configurations.
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Generalisation of Periodic Schrödinger Operators  

Spectrum of an operator matrix  

\[ H := \begin{pmatrix} -\frac{d^2}{dx^2} + p(x) & q(x) \\ q(x) & u(x) \end{pmatrix}, \]  

acting in the space \( L_2(\mathbb{R}) \times L_2(\mathbb{R}) \), is studied. Here the functions \( p(x) \), \( q(x) \), and \( u(x) \) are real, continuous, and 1-periodic. Operators of such a kind occur, e.g., in linear magnetohydrodynamics and describe oscillations of a hot compressible gravitating plasma layer in periodic magnetic field.  

We prove that spectrum \( \sigma(H) \) is absolutely continuous, has bands and gaps structure, and consists of the range \( I_0 \) of the function \( u(x) \) and closed intervals \( I_k \) which accumulate at infinity and maybe at the left endpoint \( u_- \) of \( I_0 \). The last situation, known in literature as Suadam’s phenomenon, is of great physical interest. We establish some sufficient conditions for such an accumulation and find band asymptotics at \( u_- \) and \(+\infty\).  

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Quantum Dynamical Entropy Revisited  

We define a new quantum dynamical entropy, which is a hybrid of the closely related, physically oriented entropy introduced by Alicki and Fannes in 1994, and of the mathematically well-developed, single-argument entropy introduced by Connes, Narnhofer and Thirring in 1987.
We show that this new quantum dynamical entropy has many properties similar to the ones of the Alicki–Fannes entropy, and also inherits some additional properties from the CNT entropy. Also, the new quantum dynamical entropy generalizes the classical dynamical entropy of Kolmogorov and Sinai in the same way as does the AF entropy. We compute, respectively estimate the new hybrid entropy for the shift automorphism on the quantum spin chain, for the Powers–Price shift systems, and also for the noncommutative Arnold map on the irrational rotation C*-algebra, leaving some interesting open problems.

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UNREASONABLE EFFECTIVENESS OF QUANTUM FIELD THEORY

QFT enjoys a tremendously wide range of application in physics; it is both a language with which a vast variety of physical processes can be discussed, and it provides a model for elementary particles, which thus far has passed every test. No other framework exists in which one can calculate so many phenomena with such ease and accuracy. I survey those successes of QFT, which derive specifically from the presence of infinities in the formalism; i.e., processes related to symmetry breaking, both spontaneous and anomalous.

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On the Infrared Problem in Thermo Field Theory

In Thermo Field Dynamics, one complements the basic fields by a set of auxiliary fields in order to deal with an irreducible set of operators. The advantage is that the pure state expectation values in the thermal state
created by the stical mechanics for mixed states are equivalent. This mechanism can be squeezed into a rigorous mathematical formulation, as long as one defines QFT in a box and introduces a momentum cut-off. Nevertheless, if one removes the cut-offs, new (unphysical) infrared divergencies appear in perturbation theory. Our results shed some light on the origin of these infrared problems. Starting figate the correlations between the standard degrees of freedom of QFT and the new degrees of freedom created by the TFD mechanism. Only in the high energy limit a tensor product structure turns out to be an appropriate approximation. Our analysis also shows a thignt relation between spectral properties of the generator of time translations and the decay of spatial correlations in thermal equilibrium states, in complete analogy to the well understood case of the vacuum state.

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**Position and momentum operators in the q-oscillator algebras**

The natural form of the position operator in $q$-oscillator algebra is $X_p = q^{pN}(a^+ + a)q^{-pN}$, where $p$ is a real number. Using the theory of Jacobi matrices, the theory of classical moment problem and the theory of basic hypergeometric functions, it is shown that, depending on values of $q$ and $p$, $X_p$ can be unbounded symmetric operator (which has the deficiency indices (1,1) and is not self-adjoint, but has self-adjoint extensions), bounded self-adjoint operator with continuous spectrum or self-adjoint operator of trace class. Explicit form of spectrum and eigenvectors are found for particular values of $p$. 

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p-Adic Commutation Relations

We construct representations of the canonical and deformed commutation relations by bounded operators on p-adic Banach spaces. Functions from the Mahler basis of the space of p-adic valued continuous functions over p-adic integers and their multiplicative analogues are shown to be the p-adic counterparts of the Hermite and q-Hermite functions. The analogue of the Stone-von Neumann uniqueness theorem fails in the p-adic case.

Inverse Problem and analyticity

We consider the Hill operator $-d^2/dx^2 + q(x)$ in $L^2(\mathbb{R})$, where $q$ is a periodic real potential. Using nonlinear functional analysis we prove that the mapping $h : q \rightarrow h(q) = \{h_n\}_1^\infty$ is the real analytic isomorphism, where $|h_n|$ is the height of “quasimomentum” vertical slits. Then we study

1) the Löwner equation for the energy $E(k, h)$, $k$ is the quasimomentum and the parameter $h_n$ is changed,

2) inverse problems for the Hill operator and the Dirac operator,

3) the KdV equation and non-linear Schrödinger equation; Hamiltonian, Momentum, ... as the analytic function of $h$, we get their derivatives.
4) electrostatic problems in a multiply-connected domain on the plane, including the inverse problem.

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The Construction of Tensor Invariants of Mapping of Manifolds with Connectivities

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Anyons and the Calogero–Sutherland model

I describe a simple construction of the solutions of the quantum Calogero–Sutherland (CS) system which uses anyons i.e. quantum fields with exotic statistics on the circle. I first explain how to construct anyons by generalizing the boson–fermion correspondence. I then show that the existence of a special operator $\mathcal{D}$ with particular commutator relations with products of the anyon field operators allows to obtain the solutions of the CS model from anyon correlation functions which can be easily computed. This operator $\mathcal{D}$ can be regarded as the second quantization of the CS Hamiltonian. I also mention relations to the fractional quantum Hall effect, $W_{1+\infty}$-algebras, and conformal field theory.

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Possible approach to geometrization of interaction and theory of the elektron

A new approach to geometric description of partikle and interection is suggested. Translation rules from wave function have a stracture of the
Dirac aquatin on arbitrary manifold. A solution of the equation derived in geometrical interpretation is give. The diffraction of electrons is considered, wave function of which are the complete numbers from Clifford algebra. The coherent states in the system of few fermions are structured. Interference of the wave packets, when their initial conditions are mutually approaching, may lead to formation of specific states of multi-fermion systems (clasters), in which few fermions are localized in one point, but in different states, that is an analogue of the coherence for fermions.

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**Kleinian functions: addition laws on hyperelliptic Jacobians**

The theory of Kleinian hyperelliptic functions a generalisation of Weierstrass’ approach in the elliptic functions theory. We present here the addition theorems for the hyperelliptic Kleinian functions. Our construction is based on the explicit expression of the ratio \( \frac{\sigma(u-v)\sigma(u+v)}{\sigma(u)^2\sigma(v)^2} \) on the hyperelliptic Jacobian of arbitrary genus \( g \), which is a generalization of the well-known formula form the theory of elliptic functions

\[
\frac{\sigma(u-v)\sigma(u+v)}{\sigma(u)^2\sigma(v)^2} = \varphi(v) - \varphi(u).
\]

The ratio \( \frac{\sigma(u-v)\sigma(u+v)}{\sigma(u)^2\sigma(v)^2} \) appears to be a polynomial on the Kleinian functions \( \varphi_{i,j}(u) \) and \( \varphi_{i,j}(v) \) with \( i, j = 1, \ldots, g \). Using the recursive families of differential polynomials generated by the Sylvester’s determinant identities we find these polynomials explicitly.
Infinite dimensional Lie algebras and black hole entropy

We give a local analogue of a formula obtained by Kac and Wakimoto concerning representations of infinite dimensional Lie algebras. In general Quantum Field Theory our formula applies to black hole thermodynamics. The relative free energy between two thermal equilibrium of the background system turns out to be proportional to the variation of the conditional entropy in different superselection sectors. The constant of proportionality is half of the Hawking temperature. As a consequence the value of the relative free energy is quantized proportionally to the logarithm of an integer.

Modular functors constructed from non-semisimple data

We develop a categorical picture of topological field theory using presentation of 4-manifolds via bridged links calculus, which amounts to computations with tangles. TFT is considered as a 2-functor from the double category of extended three dimensional cobordisms determined via a ribbon braided tensor abelian category (e.g. the category of representations of a quantum group at a root of unity), which is not necessarily semisimple. In particular we get representations of mapping class groups of surfaces and invariants of 3-manifolds. In this picture a torus with one hole can be viewed naturally as a braided Hopf algebra.
Quantum Space-Time and Classical Gravity

A review will be given of recent efforts to find relations between the commutation relations which define a noncommutative geometry and the gravitational field which remains as a shadow in the commutative limit.

GROUP APPROACH TO THE MEASURE OF INDIVIDUAL OBJECT COMPLEXITY

One of the key topics in recent physics is the complexity of dynamical processes in systems. The examples of complication are the dissipative structures, autowaves, chaos and so on. The first questions connected with selforganization usually is the conditions for such phenomena arising and second is to find the measure of complexity. The second problem is less investigated. The existent approaches since the works of R. Shannon was based mainly on the notion of probability information (G.Nikolis, Yu.Klimontoich, G.Ebeling and many others). But in many problems it is necessary to take in hand the complexity measure of individual objects such as geometrical figures, the distribution of temperature and concentration, the velocity flow of liquids in hydrodynamics and so on. Remarks that for nonprobabilistic objects there are only few strict works (A.Kolmogorov, V.Rashevsky, G.Jumaire). By intuition it recognized, that the dissymmetry of object is the measure of complexity in many physical, psychological and others phenomena. Results presented in report give strict sence for the measure of symmetry in object.

The basic idea is to explore the generalization the measure of information of word in some alphabet described. As the measure of complexity it is proposed to take the power of object orbit under the selected group of
automorphisms. The description of geometrical object is received by the
discretization and quantification procedures. There are some theorems
on the complexity measure for Morse function and geometrical figures in
report. It is discussed the applications to infinitesimal symetries, gauge
theories, operator algebras and so on. Also the results of computer ex-
periments obtained with the help of A.Polyarush are described.

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“DRY TURBULENCE” AS A TEST FOR CHAOS
COMPUTATION IN DISTRIBUTED SYSTEMS.

Chaotic behavior of various parameters in scientific and technical prob-
lems attracts more and more attention and finds wider usage. In the
past such problems were mostly solved whether for systems of ordinary
differential equations of small dimension (e. g. Lorenz system), or for
discrete manifolds of small dimension (logistic equation).

Lately shift of interest could be seen in researches of chaotic behavior
in distributed systems (discrete and continuous). There are researches
on turbulence in liquids [1], chaos in oscillator chains, chaotic behavior
of amplitude equations of Curamano- Sivashinsky type, etc.

Because of great complexity of corresponding problems, one of impor-
tant (and frequently sole) method of studying them is numerical com-
putation. But it is well known that given for a case of smooth solution
numerical methods demand special grounding and testing. Because of
this it is very important to investigate problems with chaotic behavior
which have exact solution as test problems for testing numerical methods
(finite-differential schemes) on them.

The topic of this report is studying such questions on an example
of “dry turbulence”. This phenomena was found in distributed systems
described by second-order hyperbolic equation with non-linear boundary
conditions, for the case in which the exact solution can be found. Note
that the exact solution is defined by a one-dimensional discrete (in time) mapping.

Namely the “dry turbulence” is proposed as an example problem for testing standard and improved differential schemes. It is known [2] that when solving hyperbolic equations by numerical methods two kinds of error appear: dissipation and dispersion of finite-differential schemes. In this report the influence of these kinds of error is studied for problems with chaotic solutions. Methods used for finite-difference schemes were McCormac’s, Bim & Young’s and special schemes with substantially reduced dispersion. These special schemes are build on principles of studying and averaging dispersion errors, described in [2]. Among such methods it is needed to note the anti-dispersion method.


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Weakly bound 3 and 4 body Coulomb systems

We present general results on the stability of 3 and 4 body systems of charged particles, as a function of the masses and the charges of these particles. These properties allow a considerable saving of effective calculations. Illustrations are for instance the instability of the proton-electron-positron system, or of the alpha-proton-electron system, or, conversely, the strict stability of the hydrogen molecule.
Multivalued Infinite-dimensional Semidynamic Systems and Their Attractors

During last years, deep results on the global attractors for evolution differential equations, describing a flow of dense incompressible liquid, equations of chemical kinetics, wave equations, on the system phase-field equations and many others were obtain using abstract apparatus of one-parametrical semigroups nonlinear operations in Banach spaces. These research, in turn, stimulated development of nonlinear semigroups theory, set new problems and tasks. Work on the continuous and semicontinuous dependence of the attractors of semigroups from parameters, estimates of their Hausdorf and fractal dimension, approximations and others, have appeared.

However these results could not be used for the investigations systems which initial state does not uniquely define their further behavior are developed. Evolution equations without uniqueness of solutions, differential-operator inclusions and variational inequalities etc. belongs to such.

It turns out that under natural condition the above object creates multivalued flows and semiflows which are multivalued analogs of one-parametrical groups and semigroups of operators.

In this announcement using the theory of set-valued analysis we develop the qualitative theory of multivalued systems. Multivalued flows and semiflows are defined, the existence of attractors and - limit sets for these flows and their topological properties are studied. These results are applied to evolution inclusions in Banach spaces, variational inequalities with multivalued operators and also to some examples of the Mathematical Physics.


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The solutions of the reduced field equations and the polarization effects in anisotropic space-time

Possible effects of the linear and circular polarization of an electromagnetic field propagating in a space-time with metric of the Bianchi-1 type are considered. It is shown that, for a free field, the degrees of linear and circular polarization are conserved as the photon travels along a geodesic. The angle of rotation of the polarization plane is calculated in the axially symmetric case.

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q-3nj Symbols and Their First Few Differential Coefficients at q=1

The 3nj symbols of the first and the second kinds have been extended to their q-forms, called q-3nj symbols. In this paper, we present

1. descriptions of q-3nj symbols in terms of braid groups,
2. expressions of the first few differential coefficients of q-3j, q-6j, q-9j symbols at q=1,
3. Various novel identities of q-3nj symbols.

Results on differential coefficients of q-3nj symbols at q=1 provide new classes of relations among 3nj symbols of SU(2).

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Generalized action principle and extrinsic geometry for N=1 and N=2 superparticles

The generalized action functional for D=3,4,6,10 N=1, 2 superparticle is proposed. Description of superparticle motion in terms of extrinsic geometry is constructed.

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Quantized groups

Let $G$ be unimodular Lie group, $N(G)$ the von Neumann algebra generated by the left-shift operators on $L_2(G, dg)$ where $dg$ is Haar measure.

A group $G_0$ is said to be quantized by a group $G_1$ if $N(G_0)$ is the algebra of the space of a ring-group $K$ [1] while is the algebra of the space of the ring-group $K'$ dual $K$.

The word “quantized” is relevant here because one can rigorously treat the formal substitution of the number coordinates in the group law of one group involved in the given definition by the infinitesimal operators of another one.

There are given sufficient conditions of quantization expressed in Lie group (or Lie algebra) terms for a certain class of Lie groups. These conditions permit to construct specific pairs of Lie groups which quantize each other.

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**Stochastic Dynamics and Boltzmann Hierarchy**

Stochastic Dynamics equivalent to the Boltzmann hierarchy is constructed. For these dynamics, the Liouville (Ito) equation is deduced and the Boltzmann hierarchy regarded as an evolution equation in certain functional spaces is established. On the basis of these dynamics, by analogy with BBGKI hierarchy, a semigroup of evolution BBGKI operators is constructed and, by using this semigroup, the existence of global solutions is proved both in the spaces of integrable and bounded functions. The solvability of the Boltzmann hierarchy guarantees the solvability of the Boltzmann equation. The existence of global strong, mild and weak solutions of the Boltzmann equation is proved.

On the basis of known global solution of the BBGKI and Boltzmann hierarchies for systems of hard spheres, we prove the existence of the Boltzmann-Gard limit for an arbitrarily large time interval and, thus, the Boltzmann equation is derived from BBGKI hierarchy for an arbitrarily large time interval.

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**A Category of Geometric Spaces: Geometries Induced by Group Actions**

The area of noncommutative geometry (NCG) has been opened by J. Andre’ about 25 years ago. It is a natural generalization of classical (affine) geometry investigating spaces having directed lines (i.e. noncommutative join operations on points) and is an interdisciplinary field. We present an algebraically oriented representation of such geometric spaces (configurations, axioms are expressible by systems of equations). NCG forms a very large category where highly nonlinear line shapes occur. We focus on so-called group spaces obtained by a covapaces induced by semi-direct
products of groups. Further topics to be addressed: the simplicial structure of a space; fibered geometric spaces (inspired by the concept of fiber bundles); problems of automated deduction (verification) in NCG (computer algebra applications). Of interest would be to investigate which role NCG (and the directed line structures) might play in physics.

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On representations of Wick algebras, multidimensional q-CCR and q-CAR

We study the structure of homogeneous Wick ideals in Wick *-algebras. The results are applied to the Kleineke-Shirokov type theorems for multidimensional q-CCR and q-CAR.

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Symmetry Breaking and Critical Behaviour of Anharmonic Quantum Systems

Quantum lattice systems with unbounded spins are considered from the point of view of spontaneous symmetry breaking. Some new results about long-range order behaviour are obtained for the systems in arbitrary dimension with a wide class of spin-spin long-range interactions without assuming the reflection positivity property.

The role of strong quantum fluctuations in the critical behaviour of anharmonic crystals are investigated. Particularly, we prove that there exist sufficiently small critical mass of particles, such that the correspondent quantum state is unique and any critical phenomena are absent at any temperature.
Bäcklund transformations for isotropic Landau-Lifshits equations as well as their applications and generalisations

In the present paper we argue that it is possible to construct Bäcklund transformations for Landau-Lifshits equations with biaxial anisotropy. For the isotropic Landau-Lifshits equations a new nonlinear pseudopotential representation is found using the Walquist-Estabrook method. This representation is applied for construction of Bäcklund transformation. A method is demonstrated which allows one to generate solutions of the initial partial differential equation on the basis of some closed solutions. It is achieved by solving the pseudopotential ordinary differential equations.

Refined algebraic quantization and quantum field theory in curved space-time

An appropriate generalization of the so-called refined algebraic quantization scheme developed for constrained Hamiltonian systems is applied to free particle dynamics in curved space-time and shown to have interesting consequences for quantum field theory in curved space-time. In particular, there exists a natural generalization of the notion of Schwartz space and hence tempered distributions to curved space-times. Various covariantly defined states distinguished by this approach on generic space-times are examined for their physical content. They include Fock vacua as well as a general quasifree state.
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A continuous renormalization group analysis of fermionic quantum field theory

I discuss a continuous renormalization group equation for fermionic quantum field theories, and show bounds that take into account the fermionic sign cancellations. The method applies in particular to the many-fermion systems that model the behaviour of electrons in metals.

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Duality of 2D Nonhomogeneous Ising Models on Finite Lattice

Duality relations for the 2D nonhomogeneous Ising model on the finite square lattice wrapped on the torus are obtained. The partition function of the model on the dual lattice with arbitrary combinations of the periodical and antiperiodical boundary conditions along the cycles of the torus is expressed through some specific combination of the partition functions of the model on the original lattice with corresponding boundary conditions. It is shown that the structure of the duality relations is connected with the topological peculiarities of the dual transformation of the model on the torus.

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Structural Turbulence in Boundary-Value Problems
Consideration is being given to some boundary-value problems for PDE descriptive of the turbulent processes in ideal media, specifically, in idealized electric circuits with distributive parameters. We describe properties of attractors of individual trajectories and of a global attractor for the corresponding infinite dimensional dynamical system (with the phase space being the space of $C^1$-functions), in particular, we evaluate their topological characteristics (entropy, fractal dimension, etc.). We suggest scenarios for self-birthing structures and describe their spatial-temporal evolution (the cascade process of emergence of coherent structures, intermittence, forming self-similar and fractal structures, etc.). We investigate the self-stochasticity phenomenon laid in the fact that the attractor of deterministic system contains random functions.

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On the Universality of the Local Eigenvalue Statistics in Unitary Invariant Matrix Models

The local behaviour of eigenvalues of unitary invariant matrix models in scaling and double scaling limits of infinite dimensionality has been considered. The universality conjecture proposed by Dyson is proved rigorously for these models. The connection between the unitary invariant matrix models and asymptotical behaviour of orthogonal polynomials with varying weights has been discussed also.

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On the Periodic, Quasiperiodic and Stochastic Invariant Solutions of a Hydrodynamic Model of Continual Media with Relaxation
The aim of this work is to investigate certain class of solutions of modelling PDE system simulating non-linear waves propagation in relaxing media. For this purpose we employ an ansatz suggested by the symmetry properties of the system under consideration and enabling to pass to an ODE system describing a set of travelling wave solutions. Finite-dimensional system obtained this way is studied by the analytical tools and also with the help of numerical simulation both stating the existence of certain domains in parametric space corresponding to periodic, quasi-periodic and stochastic solutions. The last regimes arising as a result of period doubling cascade were studied with the help of bifurcation diagrams technique. It was shown that chaotic patterns are inhomogeneous including domains with periodic movements that are different from $2^n T$.

Employment of the Poincaré sections technique enabled us to conclude that there exist the well-known period $5T$ and $6T$ domains predicted by the Sharkovskii theorem. Besides it was stated another features of chaotic attractor inherent to the system under consideration. The most characteristic property of this attractor is as follows. The period $3T$ domain of the system manifests histeretic features. There coexist two attractors: chaotic attractor and period $3T$ attractor. Scenario of the patterns developments on this interval depends on the direction of movement along the parameter $D$ values (the velocity of the wave pack).

From numerical study it is also seen that complex oscillating regimes exist over a wide range of parameter $D$ values so the patterns’ formation could take place practically at arbitrarily large value of the Mach number.

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Bosonic symmetries of the massless Dirac equations

The results on the spin 1 symmetries of massless Dirac equation of paper (Krivsky I.Yu, Simulik V.M. // Theor. Math. Phys., 1992, v.90, N3, P.388–406) are proved completely in the space of 4-component Dirac spinors on the basis of unitary operator in this space, connecting this equation with the Maxwell equations containing gradient-like currents.
Nonlocal representations of conformal group are found, which generate the transformations leaving the massless Dirac equation being invariant.

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Unbounded gaps for cocycles and invariant measures for their Mackey actions

The property of bounded gaps for real-valued cocycles of an ergodic automorphism is introduced, which turns out to be an invariant of weak equivalence. It is established that any probability preserving flow is a Mackey range of a recurrent cocycle with bounded gaps, and, on the contrary, the Mackey action of a cocycle with unbounded gaps of type $II_1$ ergodic automorphism must be of a different type.

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Equilibrium states in quantum systems of particles with singular magnetic interaction

Equilibrium systems of quantum nonrelativistic spinless particles, interacting via an effective (depending on position vectors of all particles) electromagnetic singular potential with a zero electrostatic component are considered. Vector magnetic potential is expressed as a gradient of a scalar singular magnetic potential almost everywhere. The systems include the celebrated Chern-Simon particle system.
For simplest choices of selfadjoint extensions of n-particle Hamiltonians and a pair short-range magnetic potential Gibbs reduced density matrices (RDNs) are computed in the thermodynamic limit, using the fact that the systems are integrable (the n-particle Hamiltonian is unitary equivalent to the n-particle free-particle Hamiltonian).
It is shown, that for anyonic type selfadjoint extensions for which the wave functions have jumps on the hyperplanes, where coordinates of particles coincide, the behavior of the 1-d systems do not differ much from the behavior of the systems, characterized by selfadjoint extensions without the jumps for MB (Maxwell-Boltzmann) statistics.

It is established that for 1-d system with the magnetic long-range potential, coinciding with the Coulomb potential, the RDMs are nontrivial in the thermodynamic limit if special differences of coordinates sit on a 1-d lattice for MB statistics. The same statement is true for the system with the Bose and Fermi statistics for small values of activities of particles of different sorts and selfadjoint extensions, excluding the jumps of wave functions.

The 1-d system with the jumps of wave functions is an analog of the celebrated 2-d Chern-Simons particle system, whose magnetic potential is the Coulomb potential, and conclusion drawn for the former may be valid for the latter, which is believed to describe a phenomena of high-temperature superconductivity.

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On geometric aspects of representation theory of compact Lie groups

Description of the space of holomorphic sections of the linear fiber bundle over the coset space of complexified compact Lie group $G$ by borelian subgroup $B$ is given. Compact group $G$ in our case is a group of unimodular unitary matrices. This gives explicit realization of irreducible representations of unitary groups in the framework of Borel-Weil theory. Besides explicit formulas or given for kernels of invariant (with respect to compact group) scalar product.
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On possible scheme of the classification for Integrable Hamiltonian Systems

It was shown that the functional arbiterness obtained by the author under investigation of the reformulation of the Hamiltonian dynamics in the phase superspace with help of the odd Poisson bracket can be used, in principle, for the classification of integrable Hamiltonian systems.

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Group–Theoretical Properties of Duality Symmetric Fields in Field Theory and Superbrane Models

Discussed is a solution of the problem of manifest Lorentz covariance and general coordinate invariance of the Lagrangian formulation for describing duality symmetric and self-dual fields in Maxwell theory, supergravity and a five–brane model.

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Sonoluminescence, Squeezed Light, SO(2,1) Group and Black Hole Radiation

The phenomenon of coherent sonoluminescence i.e. light emission by hydromechanical system driven by macroscopic acoustical force is considered as a physical vacuum excitation. The Schwinger treatment of light emission by the collapse of a cavity in a dielectric medium is discussed. The statistical properties of emitted light are investigated. It is shown
that the light state is a squeezed vacuum state. The relation between squeezed vacuum states and solutions of infinite component Majorana-Dirac equation in (2,1) dimensions is established. The statistical properties of light emitted by black hole evaporation are investigated too. The question is discussed: the black hole radiation, is it black? This question arises because in spite of black holes emit the radiation with Plank spectrum, this radiation is squeezed radiation to be distinguished in quantum optics from thermal radiation.

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Gaussian Analysis as a Tool for Mathematical Physics

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Mathematical physics in the second half of this century

I will review the most important results of mathematical physics in my scientific lifetime. These are the KAM-theorem, the singularity theorem in General Relativity and the proof of stability of matter.

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Extended Supersymmetry and Minimality Principle

A supersymmetry generalization of minimality principle is proposed. Closed relationships between the possibility of this generalization and arbitrariness in definitions of covariant derivatives in (extended) superspace
are considered. The generalization gives the possibility of the uniform description of the interactions of the neutral particles with spin 1/2 and anomalous magnetic moment with fields of $N = 1, 2$ Maxwell supermultiplet.

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**On some double categories in mathematical physics**

The structure of double category connected with new additional structures on categories is considered. The double categories in topological quantum field theory are presented.

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**Quantum Spaces and Non-Commutative Structures**

Based on quantum groups a generalization of the Heisenberg algebra can be found that leads to a lattice structure of the Minkowski space.

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**Principles of Controlled Dynamics**  
of **Infinite-Dimensional Nonlinear Systems**
Methods of the theory of nonlinear semigroups in Banach space is a powerful tool in a qualitative investigations of control infinite-dimensional system. By studing of the semigroups one can establish (in terms of generators depending on control) the existence of some qualitative properties of an infinite-dimensional dynamical system. However for many interesting cases and spaceally for evolution equations with non monotone operators there is either no uniqueness, or the question of uniqueness is opened. (e.g. the case of the system of navier-stocks equations for m i 3). On similar case it's naturally to suppose that a resolution operator exists in the class of multivariate mappings and is not total. I.e. it's domain does not coincide with the whole space.

In this talk we discuss some problems of qualitative analysis and synthesis of controlled objects. The objects are described by nonlinear equations, differential operator equations, evolution inclusions and variational non equalities in partial derivatives and also by their systems without assumption of solution uniqueness. One should choose parameters or a regulator structure (or both of them) so that a closed dynamical system has given topological properties. In particular, let two sets $K_s$, $K_f$, be given in a phase space $H$. For a system that started from an arbitrary point of the set $K_s$ it's necessary to synthesise a control such that in time $t^* = t^*(K_s,F_f)$ the trajectory reached some neighbourhood of the final set $K_f$ and remain there for all $t \leq t^*$. To solve this problem we suggest the minimax principle for construction attracting sets in closed systems. We use essentially variational theory in Banach spaces and the theory of multivariate semidynamical system, that have been recently developed profoundly.

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**A Result on Ovaloids in Affine Space**

Let $A(n)$ be the $n$-dimensional affine space. A compact strictly convex hypersurface without boundary in $A(n)$ is called an ovaloid. W. Blaschke made the following conjecture (1923): An ovaloid in $A(3)$ with constant scalar curvature relative to affine metric is an ellipsoid. The conjecture was proved by R. Schneider in 1967. In 1985 M. Kozlowski and U. Simon got the following theorem: If $M$ is an ovaloid and is Einstein relative to affine metric in $A(n+1), n > 2$, then $M$ is an ellipsoid. At that time they made the following conjecture: An ovaloid with constant scalar curvature relative to affine metric in $A(n+1)$ is an ellipsoid. In this paper we prove: An ovaloid with parallel Ricci curvature tensor relative to affine metric in $A(n+1)$ is an ellipsoid. Our result is a generalization of the Theorem of Kozlowski and Simon. But their conjecture is still open.

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**Numerical Methods for Solving the Inverse Scattering Problem**

The problem of the numerical reconstruction of a potential by the scattering data is well known and important from the mathematical point of view and for physical applications. However the development of the corresponding numerical methods is sufficiently complicated by the reason of an ill-posedness of the problem. In this report the regularizing methods for the inverse scattering problem in the matrix case are suggested. They are based on the Marchenko’s and Krein’s methods and on the analysis of the asymptotic behaviour of the phase shift and the module of the Jost function for high energies. As usually the regularization assumes some a priory information about the smoothness and integrability of an unknown potential and of corresponding phase shift.

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