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ABSTRACT of Principle Scientific Results

1. Gravity theories dual to supersymmetric gauge theories

We uncovered and thoroughly examined: vast classes of string solutions with large quantum numbers, the dispersion relations for these classes of solutions, the corresponding operators from the dual gauge theory and their anomalous dimensions, three- and four-point correlation functions, and other significant properties, phenomena and effects in theories with maximal and reduced supersymmetry. We also initiated a project for the generalization of the holographic correspondence for spaces whose geometry is not anti-de Sitter. By considering semi-classical limits of specific string configurations, new results are obtained for these dualities beyond the super-gravity approximation.The validity of the holographic duality for some high-energy scattering processes is proven, by comparing our newly derived results from string and gauge theory viewpoints. Our investigations on this problem lead to the conclusion that the string/gauge theory duality can still exists when the super-symmetry is not the maximal one, and even for some non-super symmetric cases.

2. Axiomatic quantum field theory, higher-dimensional conformal theories and vertex algebras

It is found that invariance under finite conformal transformations in Minkowski space-time imply the so called strong locality among quantum fields as well as rational functional form of the correlation functions. This result is in fact a remarkable generalization to the case of higher space-time dimensions of the vertex algebras (describing the algebras of observables) – a fundamental structure within the context of 2-dimensional quantum field theory models and string theory.

3. Lightlike branes in black hole and elementary particle physics, and cosmology.

We uncovered and studied in detail a number of interesting new physical effects triggered by lightlike branes – processes of spontaneous compactification/decompactification transitions of space-time, singularity-free black holes, new types of "thin-shell" wormholes and new lightlike braneworlds. Furthermore, we constructed new models of charge confinement behind/inside "tubelike" wormholes qualitatevily equivalent to quark confinement in QCD.

4. Black holes in higher-dimensional general relativity

We studied in further details the properties and the diversity of the black hole solutions in 5D Einstein-Maxwell-(dilaton) gravity. Our results include the formulation and proof of several uniqueness theorems, the construction of a number of new exact solutions describing various black hole configurations, and the investigation of their thermodynamics, including the derivation of the Smarr relations and the first law. Another line of other studies is devoted to the stability analysis of certain self-gravitating configurations and numerical calculation of their quasinormal modes.

5. Two-dimensional non-critical string theory models

Two types of 3-point tachyon correlators in the open non-critical string are constructed, based respectively on the FZZ and ZZ type Liouville boundary theories. The crossing relations in the presence of defects are investigated both in the general rational theories and in the Liuoville theory and applied to the study of the 2d realization of some correlators with Wilson and 't Hooft loop operators and the proof of their duality.

6. Two-dimensional integrable models – applications of quantum-group and conformal invariance, quantum groups and their representations

The Lecture Notes "*Quantum Groups and Braid Group Statistics in Conformal Current Algebra Models*" (EdUFES, Vitoria, E.S., Brazil 2010) by I.Todorov and L.Hadjiivanov are intended to serve as an introductory course to Hopf algebras, permutation and braid group statistics and other symmetry issues in conformal and axiomatic QFT. Various problems of quantization, renormalization and non-commutativity related to quantum WZNW monodromy matrices are studied. Semiclassical 3-point function in the AdS_3 WZW модел is constructed. We give the classification of BPS and possibly protected states for the conformal superalgebras su(2, 2/N). We propose the class of 'conformal Lie algebras'. We introduce the **new notion** of *parabolic relation* between non-compact Lie algebras giving explicitly the algebras parabolically related to conformal Lie algebras. This is applied to the construction of invariant differential operators for E_{7(-25)}, su(n,n), sp(n,R), E_{6(-14)}. We give explicitly an integral operator realising a non-relativistic version of the AdS/CFT correspondence. We explore a number of algebras having in common underlying combinatorial structures of Young tableaux. Nonhomogeneous scaling transformations embedded in the Schrödinger group are studied with applications to non-equilibrium critical dynamics.

7. Topological protection of storage and processing of quantum information

We find an Ising anion configuration, which can be used as a realization of a topological quantum computer where the storage and processing of information are protected against errors and incoherence thanks to the topological properties of the system. We study effects of Coulomb blockade of conductivity of quantum dots realized in a two-point Fabri-Perrot interferometer working in a quantum Hall regime.

8. Integrability and studies of quaternion and quanternion-contact manifolds

It is shown that points of the phase space of Calogero-Moser trigonometric systems are in one-one correspondence with the points of the representation space of the solutions of the Kadomtsev-Petviashvili equation. It is proved that solution of the heterotic Killing-spinor equations satisfying the anomaly cancellation with non-trivial fluxes are solutions of the heterotic equations of motion in dimensions 5,6,7,8. The extremals and the best constant of the Sobolev-Folland-Stein inequality are explicitly determined on the quaternionic Heisenberg groups and the corresponding quaternionic contact Yamabe problem on the quaternionic 7-sphere is solved.