ABSTRACT of Principle Scientific Results
of Research Project DFNI T02/6 from 12.12.2014

1.Astrophysics of compact objects in gravitational theories
We studied the structure and the universal properties of the relativistic stars and other compact objects in general relativity and the modified theories of gravity. Our results include the first models of rapidly rotating stars in the modified gravity and their gravitational wave emission. Classification theorems for compact objects with a photon sphere and for wormholes were also formulated and proven. We have systematically developed the theory of lightlike "thin-shell" wormholes, extensively generalizing the celebrated Einstein-Rosen "bridge" and correcting an essential omission in the classic Einstein-Rosen paper. We uncovered a new type of "tubelike" universes containing several electrically charged wormholes, which display a charge-confining phenomenon completely analogous to the quark confinement in quantum chromodynamics.

2. Cosmology – evolution of the Universe
We developed a new theory of unified description of "dark" energy and "dark" matter in the evolution of the Universe. We proposed a new mechanism of dynamical spontaneous symmetry breaking of supersymmetry, as well as a new mechanism of dynamical generation of Higgs spontaneous breaking of electroweak gauge symmetry in particle physics during the "late" post-inflationary epoch of the Universe. Explicit solution for an electrovacuum gravitational shock wave has been constructed. We have laid the foundations for the study of composite models of cosmological inflation via the methods of the gauge/gravity duality. We have built the first calculabe model of this type, albeit only in a specific regime. We have enlarged the class of inflationary regimes, that are compatible with current observations.

3. Gauge-gravity (holographic) duality – theoretical aspects
The role of entanglement entropy in holographic theories has been extensively studied and elucidated. We have uncovered a surprising new deep connection between the local and global characteristics in gauge-gravity duality, on one hand, and hierarchies of integrable (exactly solvable) systems of nonlinear evolution equations, on the other hand. We have derived explicit results for the correlation functions in the semiclassical approximations – an important step towards the exact proof of gauge-gravity duality conjecture.

4. Gauge-gravity (holographic) duality – mathematical aspects
We have derived and studied the impact and the applications to gauge-gravity duality of several important results abou the characteristics of two-dimensional conformal field theory of higher rank. We have found the anomalous dimensions and the mixing matrix (to second order in perturbation theory) for the most general 2-dimensional su(2) coset conformal fieldtheoretic models and have shown its universality. We have obtained numerous new results about the construction of „boundary-to-bulk" invariant operators

within the gauge-gravity holographic context. These approaches have been applied, in particular, to the classification of unitary representations with positive energy of superalgebras relevant for gauge-gravity duality.

5. Fundamental mathematical aspects of symmetries in quantum systems

The connection between quantum statistics and Lie superalgebras is explored. Representation theory of basic classical Lie superalgebras is applied and the properties of certain generalized quantum statistics and non-standard quantum systems are investigated. In particular, mixed systems of parafermions and parabosons are considered and the corresponding parastatistics Fock spaces are explicitly constructed. An approach to two dimensional quantum field theoretical models is developed in which an algebraic structure of dynamical quantum group type plays the role of generalized gauge symmetry. One of the reasons why this area, essentially related to braid group statistics, attracts attention is its potential application to topological quantum computers. We have thoroughly discussed the historical and the theoretical aspects of the modern experiments with entangled quantum states confirming the violation of the Bell inequalities. We have proved the conjecture of Krob and Thibon for the quantum pseudo-plactic algebra which is a non-commutative analogue of the algebra of the symmetric functions.

6. Fundamental aspects of quantum field theory

A new local approach for renormalization of massive quantum field theories in position space has been found, which is based on extensions of associate homogeneous distributions. A new mathematical formulation of the notion of a vertex algebra has been found that is beyond the standard framework of conformal field theory. We have uncovered new deep connections of quantum field-theoretic structures and number theory in fundamental mathematics.