MI12: Gauge and String Theories

S. Bellucci (Resp.), S. Ferrara (Ass.), S. Krivonos (Osp.), A. Marrani (Bors. PD), A. Shcherbakov (Bors. PD), A. Sutulin (Osp.), B.N. Tiwari (Bors. PD), V. Yeghikyan (Bors. PD), A. Yeranyan (Bors. Fermi Institute)

Research Activity

The string corrections to the Riemann curvature tensor were found to first-order in the string slope parameter. This was done for D = 10, N = 1 supergravity, the presumed low energy limit of string theory. We then used a related constraint and proceed to find a third-order solution [1].

From the perspective of the statistical fluctuation theory, we explored the role of the thermodynamic geometries and vacuum (in)stability properties for the topological Einstein–Yang–Mills black holes. In this paper, from the perspective of the state-space surface and chemical Weinhold surface of higher dimensional gravity, we provide the criteria for the local and global statistical stability of an ensemble of topological Einstein–Yang–Mills black holes in arbitrary spacetime dimensions $D \geq 5$. Finally, as per the formulations of the thermodynamic geometry, we offer a parametric account of the statistical consequences in both the local and global fluctuation regimes of the topological extremal Einstein–Yang–Mills black holes. [2].

We examined the statistical nature of the charged anticharged nonextremal black holes in string theory. From the perspective of the intrinsic Riemannian geometry, the first principle of the statistical mechanics shows that the stability properties of general nonextremal nonlarge charged black brane solutions are divulged from the positivity of the corresponding principle minors of the space-state metric tensor. Under the addition of the Kaluza–Klein monopoles, a novel aspect of the Gaussian fluctuations demonstrates that the canonical fluctuations can be ascertained without any approximation. We offer the state-space geometric implication for the most general nonextremal black brane configurations in string theory. [3]

We presented the scalar moduli stabilization from the perspective of the real intrinsic geometry. In this paper, we describe the physical nature of the vacuum moduli fluctuations of an arbitrary Fayet configuration. For finitely many Abelian scalar fields, we show that the framework of the real intrinsic geometry investigates the mixing between the marginal and threshold vacua. Interestingly, we find that the phenomena of wall crossing and the search of the stable vacuum configurations, pertaining to D-term and F-term scalar moduli, can be accomplished for the Abelian charges. For given vacuum expectation values of the moduli scalars, we provide phenomenological aspects of the vacuum fluctuations and phase transitions in the supersymmetry breaking configurations. [4]

We studied the thermodynamic geometry arising from the free energy for the two- and three-flavor finite temperature hot QCD near the critical temperature. We develop a geometric notion for QCD thermodynamics, relating it with the existing microscopic quantities, e.g. quark-number susceptibility, which appears naturally within an approximately self-consistent resummation of perturbative QCD. We further incorporate thermal fluctuations in the free energy, thus yielding the geometric properties of local and global chemical correlations. These investigations are perturbative in nature. Nevertheless,

one could apply the same line of thought for the geometric realization of underlying quark susceptibilities, either in the fabric of lattice QCD or in that of nonperturbative QCD. [5]

We performed an su(2) Hamiltonian reduction in the bosonic sector of the su(2)-invariant action for two free (4, 4, 0) supermultiplets. As a result, we get the five-dimensional N= 4 supersymmetric mechanics describing the motion of an isospin carrying a particle interacting with a Yang monopole. We provide the Lagrangian and Hamiltonian descriptions of this system. Some possible generalizations of the action to the cases of systems with a more general bosonic action, a four-dimensional system which still includes eight fermionic components and a variant of five-dimensional N= 4 mechanics constructed with the help of the ordinary and twisted N= 4 hypermultiplets were also considered. [6]

We demonstrated the effectiveness of the action-angle variables in the study of superintegrable systems. As an example, we construct the spherical and pseudospherical generalizations of the two-dimensional superintegrable models introduced by Tremblay, Turbiner and Winternitz and by Post and Winternitz. [7]

We study "minimal degree" complete bases of duality- and "horizontal"- invariant homogeneous polynomials in the flux representation of two-centered black hole solutions in two classes of $D = 4$ Einstein supergravity models with symmetric vector multiplets' scalar manifolds. Both classes exhibit an $SL(2, R)$ "horizontal" symmetry which mixes the two centers. [8]

Understanding the consequences of the E7(7) duality on the UV properties of N=8 supergravity requires unravelling when and how duality-covariant actions can be constructed so as to accommodate duality-invariant counterterms. For nonsupersymmetric Abelian gauge theories exhibiting U(1)-duality, with and without derivative couplings, it was shown that such a covariant construction is always possible. In this paper we describe a similar procedure for the construction of covariant nonlinear deformations of U(1)-duality invariant theories in the presence of rigid N=2 supersymmetry. This is a concrete step towards studying the interplay of duality and extended supersymmetry. [9]

We studied both the large and small U-duality charge orbits of extremal black holes appearing in D=5 and D=4 Maxwell-Einstein supergravity theories with symmetric scalar manifolds. We exploit a formalism based on cubic Jordan algebras and their associated Freudenthal triple systems, in order to derive the minimal charge representatives, their stabilizers and the associated "moduli spaces." After recalling N=8 maximal supergravity, we consider N=2 and N=4 theories coupled to an arbitrary number of vector multiplets, as well as N=2 magic, STU, ST2 and T3 models. While the STU model may be considered as part of the general N=2 sequence, albeit with an additional triality symmetry, the ST2 and T3 models demand a separate treatment, since their representative Jordan algebras are Euclidean or only admit nonzero elements of rank 3, respectively. Finally, we also consider minimally coupled N=2, matter-coupled N=3, and pure N=5 theories. [10]

We studied properties of $D = 4$ $N \geqslant 2$ extended supergravities (and related compactifications of superstring theory) and their consistent truncation to the phenomenologically interesting models of N=1 supergravity. This involves a detailed classification of the "degenerations" of the duality groups of type E 7, when the corresponding quartic invariant polynomial built from the symplectic irreducible representation of G4 "degenerates" into a perfect square. With regard to cosmological applications, minimal coupling of vectors in consistent truncation to N=1 from higher-dimensional or higher−N theory is non-generic. On the other hand, non-minimal coupling involving vectors coupled to scalars and axions is generic. These features of supergravity, following from the electric-magnetic duality, may

be useful in other applications, like stabilization of moduli, and in studies of non-perturbative black-hole solutions of supergravity/string theory. [11]

We described the systematical construction of the first order formalism for multi-centered black holes with flat three dimensional base-space, within the so-called T 3 model of N = 2, D = 4 ungauged Maxwell-Einstein supergravity. The three possible flow classes (BPS, composite non-BPS and almost BPS) are analyzed in detail, and various solutions, such as single-centered (static or under-rotating) and all known multi-centered black holes, are recovered in this unified framework. We also consider the possibility of obtaining new solutions. The almost BPS class is proved to split into two general sub-classes, corresponding to a positive or negative value of the duality-invariant polynomial for the total charge; the well known almost BPS system is shown to be a particular solution of the second sub-class. [12]

List of Conference Talks

S. Bellucci, On the road to N=2 supersymmetric Born-Infeld theory, Invited Presentation at the 5th Round Table France–Italy–Russia «Frontiers of Mathematical Physics», December 16-18, 2012

Publications by LNF Authors in the Year 2012

[1] STRING CORRECTIONS TO THE RIEMANN CURVATURE TENSOR AND THE THIRD-ORDER SOLUTION, S. BELLUCCI and D. O'REILLY, Mod. Phys. Lett. A 27, 1250122 (2012) [10 pages] DOI: 10.1142/S0217732312501222.

[2] Thermodynamic Geometry and Topological Einstein–Yang–Mills Black Holes, Stefano Bellucci and Bhupendra Nath Tiwari, Entropy 2012, 14(6), 1045-1078; doi:10.3390/e14061045

[3] STATE-SPACE GEOMETRY, NONEXTREMAL BLACK HOLES AND KALUZA–KLEIN MONOPOLES, Stefano Bellucci and Bhupendra Nath Tiwari, Mod. Phys. Lett. A 27, 1250095 (2012) [11 pages] DOI: 10.1142/S0217732312500952.

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[5] A GEOMETRIC APPROACH TO CORRELATIONS AND QUARK NUMBER SUSCEPTIBILITIES, Stefano Bellucci, Vinod Chandra and Bhupendra Nath Tiwari, Mod. Phys. Lett. A 27, 1250055 (2012) [6 pages] DOI: 10.1142/S0217732312500551.

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[10] Small orbits, L. Borsten, M. J. Duff, S. Ferrara, A. Marrani, and W. Rubens, Phys. Rev. D 85, 086002 (2012) [27 pages]

[11] Degeneration of groups of type E 7 and minimal coupling in supergravity, Sergio Ferrara, Renata Kallosh, Alessio Marrani, Journal of High Energy Physics, June 2012, 2012:74

[12] Multi-centered black hole flows, A. Yeranyan, Journal of High Energy Physics, August 2012, 2012:158