Ninth Biennial Workshop "Continuous Advances in QCD 2011"
May 12-15

Currently quantum chromodynamics (QCD), and strongly coupled gauge theories at large, experience rapid development mainly in connection with the advent of supersymmetry based methods and ideas from string/brane theory. Although this tendency dates back to the mid-1990s, the last 2-3 years have been especially fruitful, with significant breakthroughs in a number of directions. The Workshop, organized by the William I. Fine Theoretical Physics Institute, was devoted to thorough discussions of these directions. A large body of experts from major world laboratories, including a constellation of young people who were the driving force behind the recent developments, descended on Minneapolis to share and develop new ideas ignited by exchange of opinions and experiences of the active participants.

Over 60 excellent talks were delivered covering virtually all areas of growth in QCD and other strongly coupled gauge theories. A few talks were not directly related to QCD. These talks were meant to represent promising discoveries in related areas, such as construction of the fully consistent theory of massive gravity (at the classical level).

The Workshop started with **E. Shuryak's** *(Stony Brook University, New York)* talk on the so-called W bags, coherent states of a large number of W bosons. While they cannot be produced in collider experiments, they are likely to play a role in cosmology. In a hybrid cosmological scenario "hotspots" – the W bags – naturally appear. Baryon number violations occur with significant rate inside these hotspots. The predicted value of the baryon asymmetry is close to the observed one.

The next two talks, **E. Poppitz** *(University of Toronto)* and **M. Unsal** *(Stanford University)* were devoted to magnetic bins, topological defect molecules discovered recently. It was argued that the controllable regime of color confinement on $R_3 \times S_1$ due to the magnetic bins can (Polyakov-like confinement) can be extrapolated, without phase transitions, on R_4 (the Seiberg-Witten confinement).

Z. Komargodski *(IAS Princeton)* gave an inspiring presentation on the emergence of the vector meson dominance (VMD) in supersymmetric QCD. VMD is a mysterious feature of real QCD where it was established phenomenologically 40 years ago, with no sensible theoretic explanations. The difficulty of finding such an explanation is due to the fact that there is no appropriate adjustable parameter in QCD. Komargodski noted that in the supersymmetric version such a parameter exists, and moreover, and provides a rigorous justification for VMD. The basic tool used in Komargodski's analysis was Seiberg's duality. VMD was established in the dual model.

The same duality looms large in the subsequent talk of **A. Yung** *(PNPI, St. Petersburg and University of Minnesota, FTPI)* on the monopole confinement in super-QCD. His talk summarized the results of 6 years of explorations of this problem by Shifman and Yung. The most recent discovery is the non-Abelian duality in the quark vacua of N=1 super-Yang-Mills theory with the U(N) gauge group and N_f flavors (N_f>N). Both theories from the dual pair support non-Abelian strings which confine monopoles (or dyons with the root-like quantum numbers). Screened quarks and gauge bosons of the original theory decay into confined monopole-antimonopole pairs and form stringy mesons.

A. Hanany *(Imperial College, London)* reported on an extremely elegant mathematical construction which gives a huge class of previously unknown N=2 supersymmetric (quiver) theories based on the product of SU(2) gauge groups, SU(2) flavor summitries and matter in trifundamental representation. All these theories possess superconformal invariance.

A. Armoni's *(University of Wales, Swansea)* talk was about 4D-3D correspondence and a four-dimensional interpretation of the Acharya-Vafa theory. Several years ago Acharya and Vafa suggested a rather mysterious model on the world volume of the Dvali-Shifman domain walls in super-Yang-Mills theory. Acharya and Vafa derived their model from string theory and D brane considerations. Armoni noted that basic features of the Acharya-Vafa model can be readily understood if one interprets them as properties of the domain walls in the four-dimensional super-Yang-Mills theory.

G. Gabadadze *(New York University)* broke sensational news: with coauthors, he managed to construct four-dimensional covariant non-linear theories of massive gravity which are ghost-free in the decoupling limit to all orders. These theories re-sum all nonlinear terms of an effective field theory of massive gravity. Away from the decoupling limit the Hamiltonian constraint is maintained, hence, excluding the possibility of the Boulware-Deser ghost. Such a theory has been sought for years; this is the first time that formidable obstacles were overcome and a solution found.

Z. Bern *(University of California, Los Angeles)* outlined a great picture of N=8 supergravity amplitudes reducible, to every given order in the coupling constant, to squares of appropriate gauge theory amplitudes. If this observation is proven to be valid up to all orders, N=8 supergravity will turn out to be renormalizable! This would be the most remarkable surprise in this range of questions for decades.

During and after the Workshop many participants expressed their enthusiasm about the high level of scientific presentations and the amount of breakthrough results reported. Many said they could hardly remember any conference with such a high rate of truly exciting talks. A group of participants proudly formed a "club" of those who have not missed a single FTPI conference on high energy physics. People are already extremely excited for the next conference in two years.