WORKSHOP ON NONPERTURBATIVE GAUGE DYNAMICS

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ABSTRACTS

Fiorenzo Bastianelli

$N = 2$ spinning particle description of tensor fields

We study the quantization on the torus of the $N = 2$ spinning particle coupled to spacetime gravity to obtain a worldline representation of the effective action of an arbitrary tensor field. This approach yields a drastic simplification over standard heat-kernel methods. It contains on top of the usual proper time a new modular parameter implementing the reduction to a single tensor field.

Gaetano Bertoldi

Argyres-Douglas singularities via Matrix Models and double scaling limits

We engineer a family of four-dimensional $\mathcal{N} = 1$ theories with adjoint superpotential whose matrix model spectral curve develops an on-shell A_{n-1} Argyres-Douglas singularity. We show this via both the strong coupling approach and the usual matrix model analysis. The glueball superfields and coupling constants of the low-energy theory are non-analytic and the singularity. We consider the large N limit of these models and argue that suitable double scaling limits have a dual description in terms of a four-dimensional non-critical string theory.

Stefano Bolognesi

(Almost BPS) Vortices in $\mathcal{N} = 1$ Theories

We study vortices in $\mathcal{N} = 2$ SQCD broken to $\mathcal{N} = 1$ by a superpotential for the adjoint field. The tension can be written as a BPS part plus a non-BPS contribution: $T = T_{BPS} + T_{non\,BPS}$. The BPS tension is equal to $4\pi|\mathcal{T}|$ where we call $\mathcal{T}$ the *holomorphic tension*. This is directly related to the central charge of the supersymmetry algebra. We compute the holomorphic tension as a holomorphic function of the couplings, the mass and the dynamical scale: $\mathcal{T} = \sqrt{W'^2 + f}$. We study the limit in which the non-BPS contribution can be neglected because small with respect to the BPS one.

Considering the case of degenerate masses, a nonabelian vortex arises in r-vacua upon the breaking by a superpotential for the adjoint field. We find the BPS tension computing the dual-quark condensate. Then we find that it is equal to a simple quantity in the chiral ring of the theory. Our result sheds light on the duality $r \leftrightarrow N_f - r$, seeing it as the exchange

first $\leftrightarrow$ second sheet of $\mathcal{N} = 1$ Riemann surface. Results are derived in field theory and also in MQCD.

Frank Ferrari

Three aspects of strongly coupled gauge theories

I shall briefly review: i) the properties of instantons at large N_c and at strong coupling; ii) the quantum space of parameters of $N = 1$ theories; iii) the relation between matrix models and algebraic geometry.

Gaston Giribet

Liouville Theory Description of Instantons in AdS^3

Based on the correspondence existing between the Belavin-Polyakiv-Zamolodchikov equations in quantum Liouville field theory and the Knizhnik-Zamolodchikov equation in $SL(2,\mathbb{R})_k$ Wess-Zumino-Novikov-Witten model, I present a description of certain non-perturbative effects in AdS^3 in terms of the Liouville theory description. The existence of this effects, identified by Maldacena and Ooguri as world-sheet stringy instantons, corresponds to simple symmetries of five-point Liouville correlation functions.

Lothar Göttsche

Instanton counting and Donaldson invariants

This is joint work with Nakajima and Yoshioka. Nekrasov's partition function can be viewed as the generating function for the Donaldson invariants of the affine plane $\mathbb{A}^2$.. We determine the Donaldson invariants of a compact smooth toric surface in terms of the Nekrasov partition function in the case of rank 2. Using Nekrasov's conjecture, proven by Nekrasov-Okounkov and Nakajima-Yoshioka, this determines the Donaldson invariants of toric surfaces completely. I will also try to also mention some generalizations.

Luca Griguolo

Two-dimensional Yang-Mills theory, large N limits and moduli spaces of holomorphic differentials

We describe and solve a double scaling limit of large N Yang-Mills theory on a two-dimensional torus, inspired by noncommutative geometry. We find the exact strong-coupling expansion of the free-energy in this limit and describe its relation to the conventional Gross-Taylor string theory. Our approach is based on the solutions of certain saddle-point equations in the zero-instanton sector, that compute the volumes of the principal moduli spaces of holomorphic differentials.

Camillo Imbimbo (2 lectures)

The Kontsevich connection on the moduli space of Liouville branes

Kontsevich matrix models have been introduced in the early 90's to describe all genus correlators of non-critical bosonic strings in their *closed* sectors. The same closed string amplitudes had been previously computed by means of completely different kind of matrix models, the so-called double-scaled matrix models. Recently it was understood that Kontsevich matrix models are to be identified with *open* string field theories on particular kind of branes of non-critical bosonic strings. The equivalence of Kontsevich and double-scaled matrix models represents therefore another instance of open-closed string duality. After reviewing this background material we explore the interpretation of Kontsevich theory as open string field theory. We uncover the existence of a connection on the moduli space of open non-critical strings and show that it captures contact terms of boundary conformal Liouville theory. We discuss the geometrical interpretation of the equations which characterize the Kontsevich connection and point out that they imply that the Kontsevich partition function describes a holomorphic half-density on the open moduli space.

Pieralberto Marchetti

Confinement and topological defects

We discuss mechanisms of confinement via condensation of topological defects in pure Yang-Mills theories. The defect-gas approach to gauge theories and the related classification problem are breafly introduced. The construction of quantum field operators via line defects is outlined. It is argued that, in the lattice regularization, the presence of the roughening transition suggests that the confinement mechanism in the strong and weak (relevant to continuum theory) coupling regimes are somewhat different. The approaches to confinement based on vortices and monopoles ("center dominance" and "Abelian dominance") are presented, together with a recent proposal reconciling the two in $SU(2)$ Yang-Mills theory, based on the construction of a regular-monopole quantum field operator.

Andrei Marshakov

Exactly solvable sigma-models and non-Abelian strings in $N = 1^*$ SUSY gauge theories

The string solutions in $N = 1^*$ gauge theories are discussed and the effective world-sheet theory for their non-Abelian modes is shown to be a non-linear $O(3)$ sigma model. We use the exact solution to the world-sheet sigma-model to analyze the confinement in $N = 1^*$ four-dimensional gauge theory and derive the spectrum of of monopole mesons.

Luca Mazzucato

Seiberg duality, ADE superpotentials and 2-matrix models

We study Seiberg duality in the chiral ring of a supersymmetric $U(N_c)$ gauge theory with two adjoints and fundamental matter, with ADE Landau–Ginzburg type superpotentials.

In the case of the A_n series, we find the magnetic solution corresponding to both the pseudoconfining and Higgs electric vacua; by means of the Dijkgraaf-Vafa method we match the effective glueball superpotentials and find the duality map in the quantum theory; we also give a picture of the analytic structure of the resolvents in the magnetic theory, as we smoothly interpolate between different Higgs vacua on the electric side. In the case of the D_{n+2} series we solve the chiral ring and study the curve of the related 2–matrix model and show that, despite being a cubic algebraic curve, it reduces to the usual double covering of the sphere.

Yu Nakayama

Effective gauge degrees of freedom and the (non)existence of the glueball superpotential

We propose an efficient way to obtain a correct Veneziano-Yankielowicz type integration constant of the effective glueball superpotential $W_{eff}(S, g, \Lambda)$, even for massless theories. Applying our method, we show some $N = 1$ theories do not have such an effective glueball superpotential, even though they have isolated vacua. In these cases, $S = 0$ typically.

Daniel Nogradi

Moduli and twistor spaces for calorons

The geometry of the moduli space of calorons (instantons on $R^3 x S^1$) with maximal symmetry breaking will be discussed. A correspondence will be given between stable holomorphic bundles on the projective plane and the moduli space. An explicit description of the twistor space of the moduli will be presented which encodes the hyperkahler metric. In the limit of large separations it will be shown that an $SU(n)$ caloron of charge k contains nk BPS monopoles. All of this will be illustrated by exact solutions for the gauge field and plots of the field strength. The most important application, finite temperature QCD will be commented on.

Vladimir Roubtsov

Commuting families in skew fields: Integrable systems associated with elliptic algebras

We propose a simple algebraic construction of commutative subsets in skew fields, which can be thought of as an analog of Separation of Variables for Integrable Systems (both in the quantum and classical case). Applications include some known examples of Integrable Systems associated with Poisson surfaces (Beauville-Mukai systems) as well as some new families of commuting elements in Sklyanin-Feigin-Odesskii elliptic algebras.

Ivo Sachs

$N = 2$ effective action as an integrated anomaly

Many of the exact results for effective actions in quantum field theory can be understood as integrated anomalous Ward-identities. Based on results by Intriligator-Vafa and Douglas-Cachazo-Seiberg-Witten and others we argue that the holomorphic effective action in $N = 2$ Yang-Mills theory can be understood as an integrated $U(1)$ anomaly.

Andrei Smilga

Superconformal gauge theory in 6 dimensions

We argue that the unified Theory of Everything should be a *field theory* living in *flat* bulk with extra dimensions and enjoying supersymmetry and conformal symmetry. The requirement of conformal supersymmetry restricts the bulk to have not more than 6 dimensions. Conformal theory in more than 4 dimensions necessary involves higher derivatives. Using the harmonic superspace technique we construct the lagrangian of the minimal superconformal gauge 6D theory. This theory is renormalizable. We calculate the beta function there and show that it does not vanish signalizing breaking of conformal symmetry at the quantum level. Conformal anomaly probably makes the ghosts (an intrinsic feature of all higher-derivative theories) untractable and hence this minimal theory cannot play the role of the TOE. We speculate that the real TOE should live in 6D and enjoy the *extended* $(2, 0)$ conformal supersymmetry which is kept intact after quantization. In this case, ghosts should not lead to uncurable inconsistencies. Unfortunately, we cannot write today a nontrivial interacting lagrangian involving such a symmetry.

Gabriele Travaglini

Perturbative Yang-Mills, gravity, and twistors, or: the return of the analytic S-matrix

Over the past year, amazing progress in understanding the structure of perturbative four-dimensional gauge theory has been achieved, prompted by Witten's conjecture that weakly-coupled Yang-Mills is dual to twistor string theory. A radical new approach to perturbative Yang-Mills is emerging, which has already led to many new results in weakly coupled gauge theory and gravity. In this talk I will focus on two main ideas: the new approach to loop amplitudes in Yang-Mills based on MHV diagrams, and the recently discovered recursion relations for scattering amplitudes at tree level in gauge theory and gravity (as well as the possible application to generic four-dimensional field theories).

Federica Vian

$\mathcal{N} = 1$ super Yang-Mills domain walls via the extended Veneziano-Yankielowicz theory

We show that a newly extended version of the low energy effective Lagrangian for $SU(N)$, $\mathcal{N} = 1$ super Yang-Mills supports the BPS domain wall solutions associated with any two

vacua aligned with the origin of the moduli space. For the two color theory the domain wall analysis is complete. We also discuss new non-BPS domain wall solutions connecting any two vacua of the underlying $SU(N)$ super Yang-Mills theory not necessarily aligned. When two vacua are aligned with the origin of the moduli space these solutions are the BPS ones.