CERN Theory Retreat

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Les Houches

Profile

- Born in Athens
- Doctorat from Ecole Normale Supérieure (University of Paris)

string thermodynamics & cosmology

- Previous position : MPI for Physics, Munich
- In my 2nd year as Fellow at the TH

Interested in both mathematical aspects of string theory & applications

- string perturbation theory at loop level (BPS saturated amplitudes)
- spontaneous breaking of supersymmetry & perturbative corrections
- topological amplitudes & connection to SUSY gauge theories

Overview of Recent Research

String theory - Supergravity - SUSY gauge theory (& techniques in Number theory)

- Radiative corrections to gauge couplings in non-supersymmetric string vacua

  arXiv: 1407.8023, 1509.00027

  with: C. Angelantonj and M. Tsulaia

- New methods for one-loop amplitudes based on Poincaré series

  arXiv: 1110.5318, 1203.0566, 1304.4271, 1502.00007

  with: C. Angelantonj and B. Pioline

- Proposal for refinement of topological string & connection to Nekrasov partition function

  arXiv: 1302.6993, 1309.6688, 1508.01477

  with: I. Antoniadis, S. Hohenegger, K.S. Narain and A. Zein Assi

- Gauged supergravity (non geometric fluxes) & string uplift

  arXiv: 1307.0999, 1202.6366

  with: C. Condeescu and D. Lüst

A Gauge theory - String theory connection

Localisation techniques may be used to compute the partition function of supersymmetric gauge theory on the Ω background

- 5d (rigid) supersymmetric gauge theory with N=2 on $R^4 \times S^1$
- SU(N) gauge group

Nekrasov 2002

$$Z_{\rm Nek}(\epsilon_+,\epsilon_-) = {\rm Tr}\,(-1)^F\, e^{-2\epsilon_- J^3_-}\, e^{-2\epsilon_+(J^3_+ + J^3_R)}\, e^{-\beta H}$$

Hilbert space on R^4

Cartan generators of

$$\mathrm{SO}(4) \sim \mathrm{SU}(2)_+ \times \mathrm{SU}(2)_-$$

translations on S^1

A Gauge theory - String theory connection

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~ vacuum amplitude on a Melvin like background

fibration of R^4 over S^1 " Ω background "

A Gauge theory - String theory connection

Non-trivial relation with N=2 String theory

$$\int d^4x\, F_g(\phi)\, R^2_{(-)}\, F^{2g-2}_{(-),\mathrm{grav}}$$

- class of higher derivative gravitational couplings
- 2 self-dual Riemann tensors and (2g-2) self-dual graviphoton field strengths
- F_g computed by the free energy of the topological string (twisted version)

field theory limit for $\varepsilon_+=0$ reproduces the perturbative gauge theory partition function

$$\sum_{g\geq 0} g_{\mathrm{s}}^{2g-2}\, F_g\big|_{\mathrm{F.T.}} = \log Z^{\mathrm{pert}}_{\mathrm{Nek}}(\epsilon_+ = 0, \epsilon_- = g_{\mathrm{s}})$$

Antoniadis, Gava, Narain, Taylor 1993

A Gauge theory - String theory connection

Is it possible to find a generalisation of F_g that produces the gauge theory partition function in the full Ω background ?

$$\frac{1}{\epsilon_-^2 - \epsilon_+^2} \sum_{g,n} \epsilon_-^{2g}\, \epsilon_+^{2n}\, F_{g,n}\big|_{\text{F.T.}} = \log Z^{\text{pert}}_{\text{Nek}}(\epsilon_+, \epsilon_-)$$

- this is indeed the case for generalised couplings of the form

Antoniadis, I.F., Hohenegger, Narain, Zein Assi 2013

$$\int d^4x\, F_{g,n}(\phi)\, R^2_{(-)}\, F^{2g-2}_{(-),\text{grav}}\, F^{2n}_{(+),T}$$

vector multiplet of Kähler modulus T on heterotic K3 x T^2

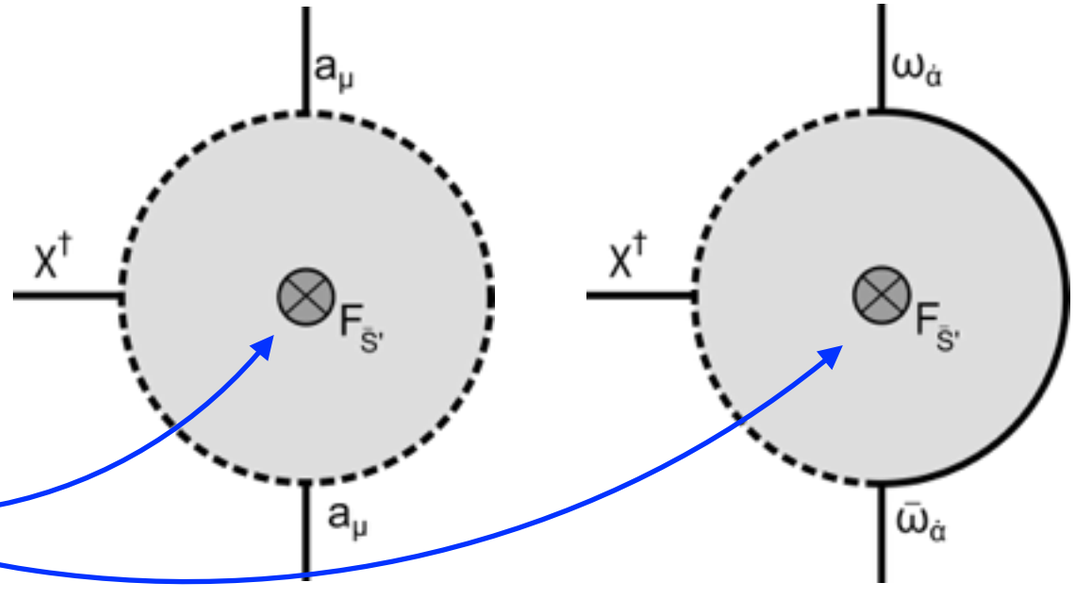
A Gauge theory - String theory connection

This relation is true for the full non-perturbative gauge theory partition function

$$\frac{1}{\epsilon_-^2 - \epsilon_+^2} \sum_{g,n} \epsilon_-^{2g}\, \epsilon_+^{2n}\, F_{g,n}\Big|_{\text{F.T.}} = \log Z_{\text{Nek}}(\epsilon_+, \epsilon_-)$$

Antoniadis, I.F., Hohenegger, Narain, Zein Assi 2014

- verified by instanton calculations in dual type I theory on K3 x T^2
- D9 branes with D5-instantons wrapping the internal space
- string disk diagrams



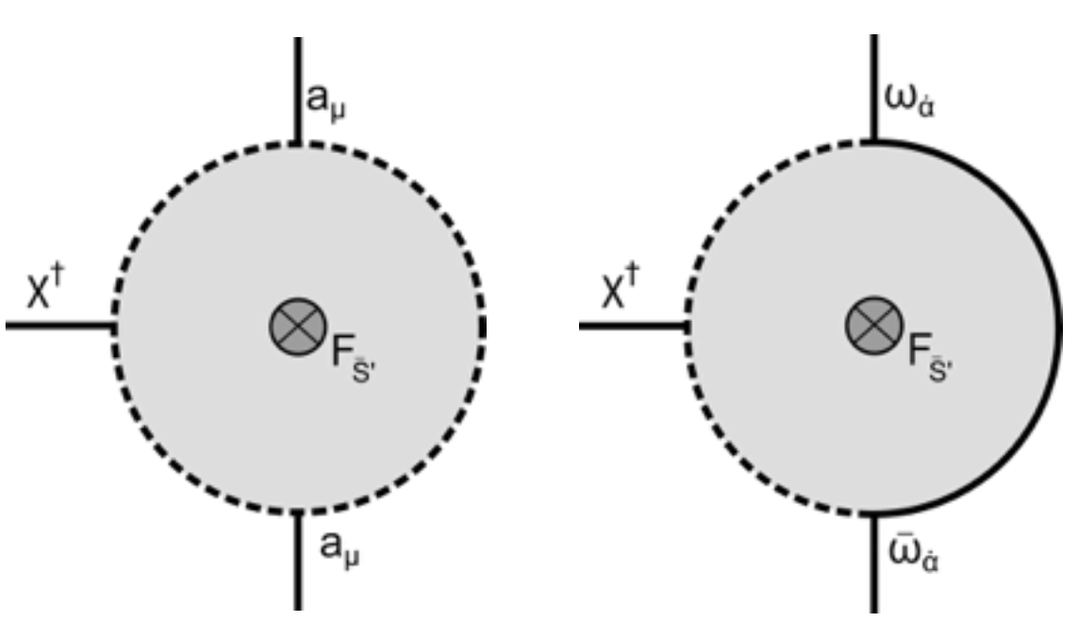
bulk insertions of self-dual field strengths

ADHM moduli at the boundary

A Gauge theory - String theory connection

$$\frac{1}{\epsilon_-^2 - \epsilon_+^2} \sum_{g,n} \epsilon_-^{2g}\, \epsilon_+^{2n}\, F_{g,n}\Big|_{\text{F.T.}} = \log Z_{\text{Nek}}(\epsilon_+, \epsilon_-)$$

Antoniadis, I.F., Hohenegger, Narain, Zein Assi 2014



reproduces the full Ω-deformed ADHM action

The field theory limit of these couplings indeed reproduces the full non-perturbative gauge theory partition function

A Gauge theory - String theory connection

Questions :

- what is so special about the T-vector of K3 x T^2 ?
- contamination by hypermultiplet moduli - loss of BPS property
- can these couplings be turned topological in some appropriate (local) limit ?

$$\int d^4x\, F_{g,n}(\phi)\, R^2_{(-)}\, F^{2g-2}_{(-),\mathrm{grav}}\, F^{2n}_{(+),T}$$

Answers :

Antoniadis, I.F., Hohenegger, Narain, Zein Assi 2015

- exactly calculable in string length, but one could also use any (matter) vector multiplet
- holomorphicity property is replaced by set of differential equations for genus-g correlators
- specific conditions for the couplings to acquire holomorphy (local limit)
- recover generalised holomorphic anomaly equation proposed in the literature (refinement)

Huang, Kashani-Poor, Klemm 2010, 2011

Further Questions / Directions

- ☑ Better understand the conditions in terms of CY geometry
- ☑ Mass deformations, N=2*

Thank you