6 dimensional superconformal field theories

Seok Kim

(Seoul National University)

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Plan

- 6d superconformal field theories, discovered via string/M-theory.

- Hard to expect from the viewpoint of Lagrangian QFT. So very hard to study.
- Understanding these CFTs are the key to understand M5-branes.
- They are very novel as QFT. (tensor "gauge" theory, N^3, higher dimensional QFT, …)
- Recently, we are finding many useful "applications" of this QFT via compactifications.

- I will discuss…

➢ String theory approach, early attempts (mostly in late 90's) for microscopic studies [Lecture 1]

➢ Recent studies on SUSY observables from 5d maximal SYM

- Instanton partition function: technically, starts from Nekrasov (2002) [Lecture 2]
- 5d SYM & 6d (2,0) partition functions on curved manifolds [Lecture 3]

Some references:

1995 – 1997 (some in early 2000):

- “discovery” of new 6d SCFT: Witten; Strominger ; Witten; Seiberg, Witten ; Seiberg;
- DLCQ, matrix models: Aharony, Kachru, Berkooz, Seiberg, Silverstein; Aharony, Berkooz, Seiberg;
- deconstruction: Arkani-Hamed, Cohen, Kaplan, Karch, Motl; Lambert, Papageorgakis, Schmidt-Sommerfeld

(2007- : advanced techniques to study SUSY QFT [Pestun] , ……)

(2008 - : formulation of M2-brane QFT’s [Bagger,Lambert] [Gustavsson] [ABJM] , ……)

Re-investigate 5d maximal super-Yang-Mills theory to study 6d (2,0):

- Douglas(2010); Lambert, Papageorgakis, Schmidt-Sommerfeld (2010);
- Bern, Carrasco, Dixon, Douglas, Hippel, Johansson (2012);

- instantons:

Nekrasov (2002); Nekrasov, Okounkov (2003);
H.-C. Kim, S.K., E. Koh, K. Lee, S. Lee (2011); Haghighat, Iqbal, Kozcaz, Lockhart, Vafa (2013);

- SUSY partition functions of 5d SYM (2012 -): Kallen, (Qiu,) Zabzine; Hosomichi, Seong, Terashima; Imamura; (Fukuda,) Kawano, Matsumiya; Yagi; Jafferis, Cordova; Lee, Yamazaki; …

H.-C.Kim, S.K. (2012); H.-C.Kim, K. Lee (2012); Lockhart, Vafa (2012);
H.-C.Kim, J. Kim, S.K. (2012); H.-C.Kim, S.K. S.-S. Kim, K. Lee (2013);

6d SCFT: symmetries

- Superconformal field theories in higher dimensions (d=3,4,5,6) [Nahm]

d	symmetry		bosonic subgroup	$\mathcal{N}$ (extended SUSY)
3	$OSp(\mathcal{N}\|4)$	$\supset$	$SO(3,2)\times SO(\mathcal{N})$	$1,2,3,4,5,6,8$
4	$SU(2,2\|\mathcal{N})$	$\supset$	$SO(4,2)\times SU(\mathcal{N})\times U(1)$	$1,2$
4	$PSU(2,2\|4)$	$\supset$	$SO(4,2)\times SU(4)$	4
5	$F(4)$	$\supset$	$SO(5,2)\times SU(2)$	1
6	$OSp(8^*\|2\mathcal{N})$	$\supset$	$SO(6,2)\times Sp(2\mathcal{N})$	$1,2$

- Possible superconformal symmetries in 6d:

$$Q^i_\alpha,\ S^\alpha_i \text{ with } (i=1,\cdots,2\mathcal{N};\ \alpha=1,\cdots,4,\text{ chiral})$$

$$\overline{Q}^\beta_j = Q^i_\alpha C^{\alpha\beta}\Omega_{ij}\ ,\ \overline{S}^J_\beta = S^\alpha_i C_{\alpha\beta}\Omega^{ij}$$

$$\{Q^i_\alpha, S^\beta_j\} = \delta^i_j\delta^\beta_\alpha(-iD) - \delta^i_j J_\alpha{}^\beta - 4\delta^\beta_\alpha R_i{}^j$$

- (2,0) theory: maximal SUSY, admits a good classification. my lectures will be on this CFT.
- (1,0) theory: we know some examples. Some systematic studies are recently being made.

  [Heckman, Morrison, Vafa] (F-theory) [Tomasiello et.al.] (massive IIA)

Discovery of (2,0) SCFT

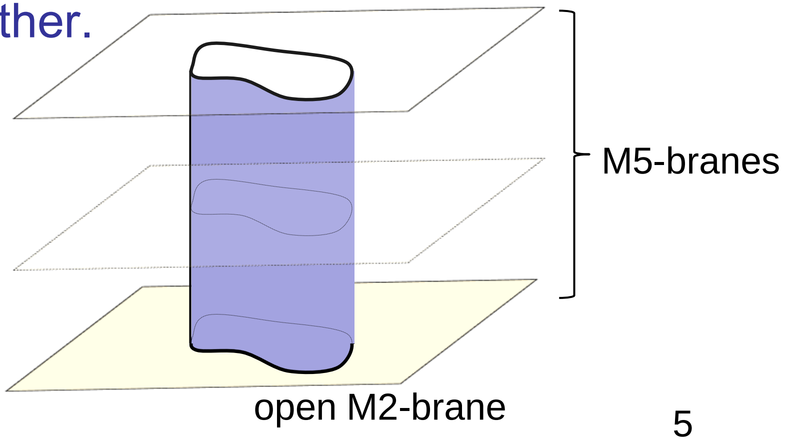
- Witten (1995): take type IIB strings on $\mathbb{R}^{5,1} \times \mathbb{C}^2/\Gamma$ $\qquad \Gamma = A_n, D_n, E_6, E_7, E_8 \subset SU(2)$

A_n	$(z_1, z_2) \to \left(e^{\frac{2\pi i}{n+1}} z_1, e^{-\frac{2\pi i}{n+1}} z_2\right)$
D_n	$(z_1, z_2) \to \left(e^{\frac{\pi i}{n-2}} z_1, e^{-\frac{\pi i}{n-2}} z_2\right)$, $(z_1, z_2) \to (z_2, -z_1)$
$E_6,\ E_7,\ E_8$	more involved...

- 6d tensionless strings live on the tip of orbifold (D3's wrapping singular 2-cycles)
- decoupled from 10 dimensional degrees at low E

- Worldvolume theory on N M5-branes (N=n+1) [Strominger] [Witten]:
- 6d strings in "Coulomb phase": end-locus of M2s, charged under N 2-forms
- **Tensionless** when M5's are on top of each other.

$$\int_{\Sigma_2} B_{\mu\nu} dx^\mu dx^\nu$$



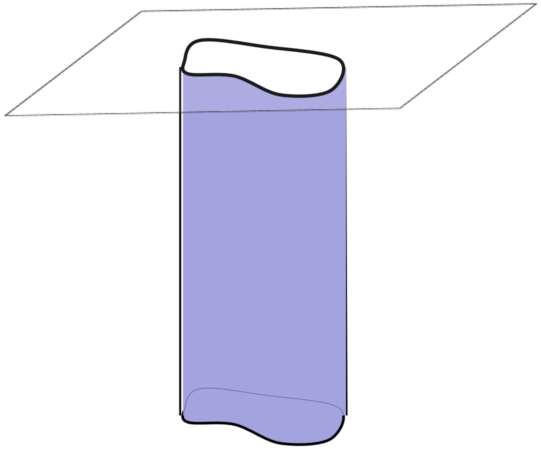
Abelian M5-brane theory

- Single M5-brane: massless tensor supermultiplet of (2,0) SUSY

$B_{\mu\nu}$: field strength $H = dB$ satisfies $H = \star_6 H$

Ψ^i_α: $\Gamma^7\Psi^i = +\Psi^i$, $i = 1,2,3,4$ for $Sp(4)_R = SO(5)_R$ spinor $(\overline{\Psi}_j = (\Psi^i)^T C\Omega_{ij}$: symplectic-Majorana)

ϕ^I: $I = 1,2,3,4,5$ for $SO(5)_R$ vector



- Couples to (infinite) open M2-brane sources.
- Equal electric/magnetic charges (should source H^+ only).

$$S_{\rm el} = \int_{\Sigma_2} B = \int_{D_3} H \ , \ S_{\rm mag} = \int_{D_3} \star_6 H \qquad S_{\rm WZ} = \int_{D_3} 2H^+$$

- Dirac quantization forces the couplings as above: **no coupling parameter**

- "Coulomb branch" of multiple M5's: N tensors couple to finite-tension self-dual strings in the same way (tensions proportional to VEVs): **self-dual strings**

Basic propreties: gauge theory…?

- Moduli space is $(\mathbb{R}^5)^{r_G}/W_G$ (r_G: rank, W_G: Weyl group of $G = U(N), SO(2N), E_{6,7,8}$)
- In the Coulomb branch, massive strings' charges are classified by ADE roots:

$$S_{\rm WZ} = q_i \int_{D_3} 2H^{i+}$$

anomaly cancelation for $\delta B_{\mu\nu} = 2\partial_{[\mu}\epsilon_{\nu]}$ with self-dual strings: $q \cdot q = 2$

Dirac quantization: $q \cdot q' \in \mathbb{Z}$

all possibilities realized by type IIB models

[Henningson et.al.] (2004)

- Compactifying on S^1, we get 5d SYM w/ ADE gauge groups. (or M5 to D4 for A_n)

reduce to "5d tensor" and then dualize to vector
(precise sense is known only for Abelian case)

$$\frac{4\pi^2}{g_{YM}^2} = \frac{1}{r_1}$$

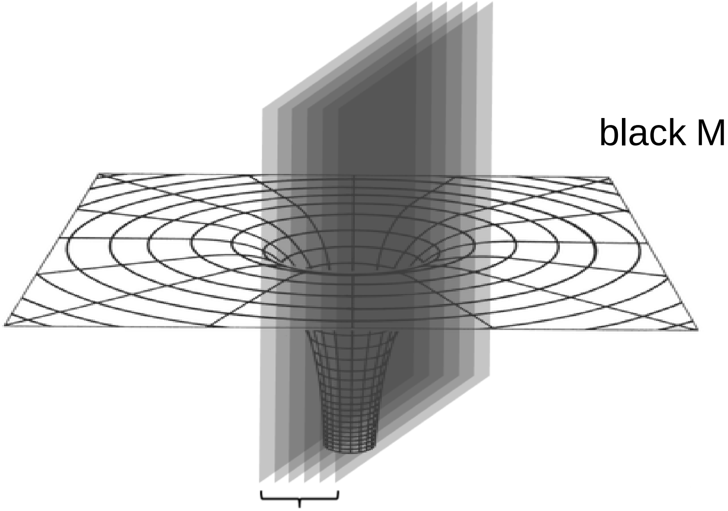
$$\frac{1}{2}\epsilon_{\mu\nu\rho\alpha\beta}F^{\alpha\beta} = H_{\mu\nu\rho}$$

- So, there are indirect notions in which ADE can be regarded as "gauge groups"
- However, a precise form of non-Abelian tensor gauge theory is unknown.

Strongly interacting theory

- No continuous parameters: M-theory only has 11d Planck scale. So at low E, M5-brane system has neither dimensionful nor dimensionless parameters.
- No perturbative approximation. We don't (yet) have a Lagrangian description.
- Some aspects of this theory (known from string/M-theory) are mysterious.

  E.g. on N coincident M5-branes, there are indications that N^3 light degrees live on it.



N >>1 M5-branes

black M5-brane at temperature T

$$\frac{S_{BH}}{(\text{volume})_5} \sim N^3 T^5$$

- Despite the absence of concrete Lagrangian description, this system is expected to obey basic properties ("axioms") for relativistic QFT's [Seiberg] (1996)

Microscopic descriptions

- Microscopic descriptions: on subsectors, or breaking some symmetry, or EFT.
- Discrete light-cone quantization (DLCQ):

  [Aharony, Berkooz, Kachru, Seiberg, Silverstein] [Aharony, Berkooz, Seiberg] (1997)

- Take $R^{1,1}$ part of $R^{5,1}$: $x^\pm \equiv x^0 \pm x^1$: compactify $x^- \sim x^- + 2\pi R^-$, regard x^+ as time
- This is compactifying on a spatial circle with $R \to 0$ [Sen] [Seiberg] (1997)
- Sector with k units of KK momenta at finie E (v ~ rest mass): non-relativistic QM

- Matrix quantum mechanics of D0-D4, decoupled from the “bulk D0’s”.

$$L_{QM} = \frac{1}{g_{QM}^2}\mathrm{tr}_{k,N}\left[\frac{1}{2}(D_t\varphi^I)^2 + \frac{1}{2}(D_t a_m)^2 + D_t q_{\dot\alpha} D_t \bar{q}^{\dot\alpha} + \frac{1}{4}[\varphi^I,\varphi^J]^2 + \frac{1}{2}[a_m,\varphi^I]^2 - (\varphi^I\bar{q}^{\dot\alpha})(q_{\dot\alpha}\varphi^I) - D^{\dot\alpha}{}_{\dot\beta}D^{\dot\beta}{}_{\dot\alpha} + \cdots\right]$$

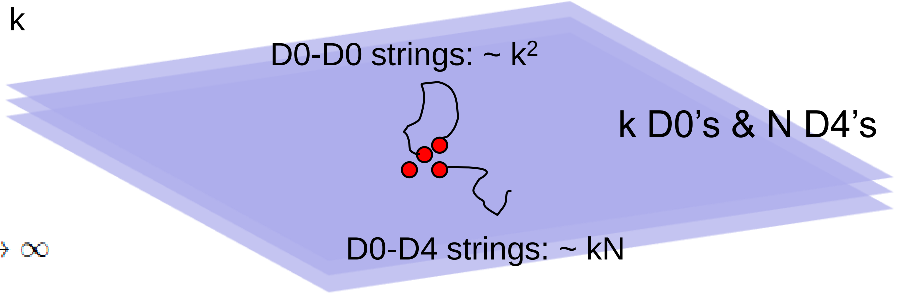
transverse k^2

longitudinal k^2

N x k

$$D^{\dot\alpha}{}_{\dot\beta} = \bar{q}^{\dot\alpha}q_{\dot\beta} + \frac{1}{4}(\bar{\sigma}^{mn})^{\dot\alpha}{}_{\dot\beta}[a_m,a_n] - \frac{1}{2}\delta^{\dot\alpha}_{\dot\beta}(\text{trace})$$

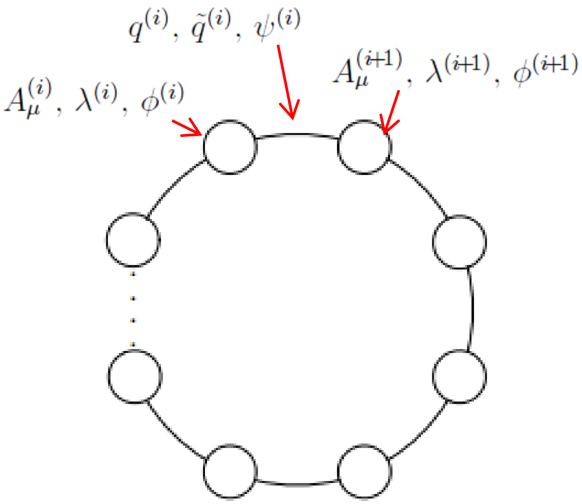
The bulk modes decouple in the limit $\ell_p \to 0$, or $g_{QM}^2 = \frac{R^3}{\ell_p^6} \to \infty$



(More discussions on it later)

Microscopic descriptions

- Deconstruction: 4d N=2 SUSY U(N)^K gauge theory, coupled to K bi-fundamental hypers.



- 4d superconformal theory (gauge coupling g_4)
- Go to Higgs branch by giving VEV $v\mathbf{1}_{N\times N}$ to K scalars.
- Claim [Arkani-Hamed, Cohen, Kaplan, Karch, Motl] (2001) :

Take $K, v, g_4 \to \infty$, with $g_5^2 \equiv \frac{g_4}{v}$ =fixed, $2\pi R \equiv \frac{K}{g_4 v}$ =fixed.

$a \equiv \frac{1}{g_4 v} = \frac{2\pi R}{K} \to 0$ in the limit

At $E \ll \frac{1}{a}$, the system is the 6d $(2,0)$ theory on T^2 with radii R, $\frac{g_5^2}{4\pi^2}$

- "discretized" 5d maximal SYM on S^1: low E theory on D4's, S^1 compactified M5's

Divide S^1 with radius R into K steps with length $a = \frac{2\pi R}{K}$.

Discretize all 5d fields: $\partial_5 \Phi(x^5 = an) \to \frac{\Phi^{(n+1)} - \Phi^{(n)}}{a}$

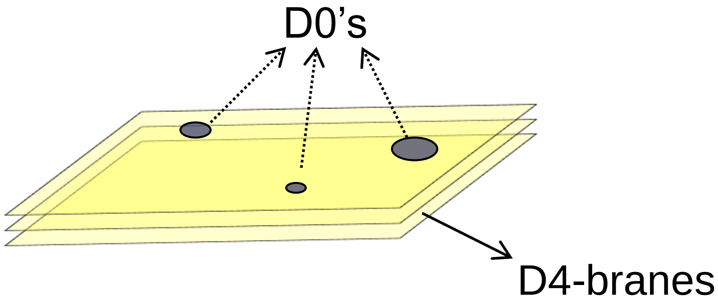
g_5 is the 5d gauge coupling $\sim$ 6th circle's radius

- Claims that "latticizing" (thus attempting to give sense to) the low E effective theory of (2,0) also provides a UV description of the latter.

5 dimensional maximal super-Yang-Mills

- All these have to do with 5d SYM, obtained by circle compactification. (M5 to D4)
- The Kaluza-Klein degrees: reduces to D0-branes, marginally bound to D4's.
- These are visible as 5d SYM solitons: “instanton” solitons

$F_{\mu\nu} = \pm \star_4 F_{\mu\nu}$ on R^4



$$k = \frac{1}{8\pi^2}\int \mathrm{tr}(F\wedge F) \in \mathbb{Z}$$

$$E = \frac{1}{4g_{YM}^2}\int d^4x\mathrm{tr}(F_{\mu\nu}^2) = \frac{1}{8g_{YM}^2}\int d^4x\mathrm{tr}\left(F_\mu \mp \star_4 F_{\mu\nu}\right)^2 \pm \frac{1}{2g_{YM}^2}\int \mathrm{tr}(F\wedge F) \geq \frac{4\pi^2|k|}{g_{YM}^2}$$

The radius of 6th circle: $\frac{4\pi^2}{g_{YM}^2} = \frac{1}{r_1}$

- This makes 5d SYM interesting: UV degrees seen in the 5d effective theory.
- But the theory appears non-renormalizable. $[g_{YM}^2] = L^1$

5d SYM…?

- Other approaches I explained try to give precise sense to the usage of 5d SYM.
- DLCQ: This is just the quantum mechanics for instanton solitons of 5d SYM (more on it later)
- Deconstruction: 4d theory has monopoles & dyons, taking place of to 5d instantons

- In any of these approaches, one needs to do nonperturbative/strong coupling studies to understand 6d (2,0):
- Technically difficult in all approaches.
- Maybe even ill-defined from the "naïve 5d SYM" in general.

- Are there 6d observables directly computable even from the naïve 5d SYM?

  BPS observables

Technical challenge

- Let me address the technical difficulty first: “computation at strong coupling”

- A cousin problem: strongly interacting M2-brane SCFT with OSp(8|4)

- QFT: ABJM (2008) $U(N) \times U(N)$ Chern-Simons gauge theory, A_μ, $\hat{A}_\mu$: CS level ± 1
  matters in bifundamental rep.: Φ^I, Ψ^I_α $(I = 1, 2, 3, 4)$

$$S = \frac{1}{4\pi}\int \mathrm{tr}\left(AdA - \frac{2i}{3}A^3\right) - \frac{1}{4\pi}\int \mathrm{tr}\left(\hat{A}d\hat{A} - \frac{2i}{3}\hat{A}^3\right) + (\text{interaction with matters})$$

- Learned a lot on M2 & M-theory from “BPS quantities” (2009 -):

  2009: S.K. (superconformal index); Kapustin-Willett-Yaakov (S^3 partition function & Wilson loops);

  2010: Drukker-Marino-Putrov ($N^{3/2}$ degrees); Jafferis (3d version of a-maximization); ………

- BPS observables in “old days”: many of them are computable from (almost-)free theory
- Recent: SUSY controls observables (so calculable), but very sensitive to interactions.
- E.g. many BPS observables are functions of the coupling constants.

BPS observables & 5d SYM

- BPS observables play 2 important roles in our studies from 5d SYM:

- With incomplete low E effective theory, it is not clear a priori how to write down consistent expressions for observables within the description.

- But SUSY path integrals for BPS observables are well-defined : due to a strong B/F cancelations, especially in the UV, they are free of UV divergence issues.

[Note. Whether the written-down 5d expression is the 6d observable we want to study is still highly unclear. In other words, we empirically find that "very nontrivial SUSY observables are correctly calculable from 5d SYM", but we should better understand "why it works." I will try to briefly comment on two possible resolutions to the last question, at the end of lecture 3.]

- Even with well-defined path integral, we need a strong-coupling calculus to see 6d physics.

- Question:

Can we learn about 6d (2,0) theory by exactly computing useful observables?

5d SYM & stable particles

- Fields & action of 5d maximal SYM:

$$\text{Fields: } A_\mu,\ \lambda^i_\alpha\ (i=1,2,3,4 \text{ for } SO(5)_R),\ \phi^I\ \ (I=1,2,3,4,5)$$

$$S=\frac{1}{g_{YM}^2}\int d^5x\,\mathrm{tr}\left[-\frac{1}{4}F_{\mu\nu}F^{\mu\nu}-\frac{1}{2}D_\mu\phi^I D^\mu\phi^I-\frac{i}{2}\bar\lambda_i\gamma^\mu D_\mu\lambda^i+\frac{1}{4}[\phi^I,\phi^J]^2-\frac{i}{2}\bar\lambda_i(\hat\gamma_I)^i{}_j[\phi^I,\lambda^j]\right]$$

- Massless W-bosons & superpartners; also, instanton solitons $F_{\mu\nu}=\pm\star_4 F_{\mu\nu}$
- Coulomb phase: massive BPS W-bosons & superpartners
- Marginal bounds of instantons & W-bosons: classical solitons [Lambert, Tong]

$$\begin{aligned}E &= \frac{1}{g_{YM}^2}\int d^4x\mathrm{tr}\left[\frac{1}{4}F_{\mu\nu}^2+\frac{1}{2}F_{\mu0}^2+\frac{1}{2}(D_\mu\phi)^2+\frac{1}{2}(D_0\phi)^2\right]\\ &= \frac{1}{g_{YM}^2}\int d^4x\mathrm{tr}\left[\frac{1}{8}(F_{\mu\nu}-\star_4F_{\mu\nu})^2+\frac{1}{2}(F_{\mu0}-D_\mu\phi)^2+(D_0\phi)^2\right]+\frac{4\pi^2k}{g_{YM}^2}+\mathrm{tr}(vq)\end{aligned}$$

$$\mathrm{tr}\,(vq)\equiv\frac{1}{g_{YM}^2}\int d^4x\,\partial^\mu\mathrm{tr}(\phi F_{\mu0})=\frac{1}{g_{YM}^2}\int_{S^3}dS^\mu\,\mathrm{tr}(vF_{\mu0})\sim g_{YM}\mathrm{tr}(v_{\rm can}q_{\rm quant})$$

- Each of them are ½-BPS. The bounds are ¼-BPS.
- These uplift to self-dual strings of M5, wrapping S^1 with momenta.

[Their quantum bound are studied by Nekrasov's instanton partition function. (lecture 2)]

Properties of YM instantons

- The self-dual instantons have moduli: 4Nk real moduli for k instantons in U(N) SYM

$$D_\mu \delta A_\nu - D_\nu \delta A_\mu = \epsilon_{\mu\nu\rho\sigma} D_\rho \delta A_\sigma \ , \quad D_\mu \delta A_\mu = 0 \ \to \ (\bar{\sigma}^\mu D_\mu)^{\dot{\alpha}\alpha} \delta A_{\alpha\dot{\beta}} = 0$$

$$\delta A_{\alpha\dot{\beta}} = (\sigma^\mu)_{\alpha\dot{\beta}} \delta A_\mu$$

pair of chiral Dirac equation for $\dot{\beta} = 1, 2$:
index theorem counts 0-modes

- Zero modes from fermions as well.

- Moduli space approximation yields a quantum mechanical system:

- Supersymmetric sigma-model:

coordinates of 4Nk dimensional
moduli space

$$S_{QM} = \int dt \left[g_{MN}(X) \dot{X}^M \dot{X}^N + \cdots \right]$$

- reliable in strict sense only in special limits: low E scaling limit, DLCQ, …

- However, this QM is useful more widely for BPS observables.

- E.g. Nekrasov’s partition function on (Omega-deformed) R^4 x S^1:

$$Z\left[v, g_{YM}^2/r, \cdots\right]_{\mathbb{R}^4 \times S^1} = \boxed{\int [\mathcal{D}A_\mu(x^m, \tau) \cdots] e^{-S_{SYM}}} = \boxed{\int [\mathcal{D}X^M(\tau) \cdots]\, e^{-S_{QM}}}$$

5d supersymmetric path integral

All apart from instanton zero modes on R^4
cancel between B/F: reduces to 1d path integral

D-brane perspective

- D0-branes, marginally bound to D4-branes

- D0-D4-brane QM with 8 SUSY:

$$\left.\begin{array}{l}\text{QM vector multiplet: } \varphi^I,\ A_t,\ \bar\lambda^i_{\dot\alpha} \\ U(k) \text{ adjoint hyper: } a_m,\ \lambda^i_\alpha\end{array}\right\}$$ maximal SYM QM

$U(N)\times U(k)$ bi-fundamental hyper: $q_{\dot\alpha}$, ψ^i

D0-D0 strings: ~ k^2

~ N^2 D4-D4 strings unbound to instantons decouple

D0-D4 strings: ~ kN

k D0's & N D4's

$$L_{QM} \;=\; \frac{1}{g_{QM}^2}\mathrm{tr}_{k,N}\Big[\frac{1}{2}(D_t\varphi^I)^2+\frac{1}{2}(D_t a_m)^2+\frac{1}{4}[\varphi^I,\varphi^J]^2+\frac{1}{2}[a_m,\varphi^I]^2 \\ +D_t q_{\dot\alpha}D_t\bar q^{\dot\alpha}-\boxed{(\varphi^I\bar q^{\dot\alpha}-\bar q^{\dot\alpha}v^I)(q_{\dot\alpha}\varphi^I-v^I q_{\dot\alpha})}-D^{\dot\alpha}{}_{\dot\beta}D^{\dot\beta}{}_{\dot\alpha}+\cdots\Big]$$

instantons in Coulomb phase: UV theory same, changes vacuum

$$D^{\dot\alpha}{}_{\dot\beta}=\bar q^{\dot\alpha}q_{\dot\beta}\boxed{-\frac{1}{2}\zeta^A(\tau^A)^{\dot\alpha}{}_{\dot\beta}}+\frac{1}{4}(\bar\sigma^{mn})^{\dot\alpha}{}_{\dot\beta}[a_m,a_n]-\frac{1}{2}\delta^{\dot\alpha}_{\dot\beta}(\mathrm{trace})$$

FI parameter: turning on NS-NS B-field on D4, changes UV theory, IR physics unaffected

$SO(4,1)\to SO(4)=SU(2)_{1L}\times SU(2)_{1R}$ in massive particle background

$SO(5)_R\to SO(4)_R=SU(2)_{2L}\times SU(2)_{2R}$ with VEV $v^I=\delta^I_5 v$

Coulomb branch decouples with either g_{QM} or ζ large.

- Higgs branch $4Nk + 4k^2 - 3k^2 - k^2 = 4Nk$: dimension of instanton moduli space

$$D^{\dot\alpha}{}_{\dot\beta}=\bar q^{\dot\alpha}q_{\dot\beta}-\frac{1}{2}\zeta^A(\tau^A)^{\dot\alpha}{}_{\dot\beta}+\frac{1}{4}(\bar\sigma^{mn})^{\dot\alpha}{}_{\dot\beta}[a_m,a_n]-\frac{1}{2}\delta^{\dot\alpha}_{\dot\beta}(\mathrm{trace})=0$$

& U(k) gauge-fix

- Coulomb branch decouples w/ g_{QM} or ζ large: Higgs branch yields SUSY σ-model

Moduli space dynamics

- Example: single U(N) instanton. The metric on 4N dimensional moduli space is

$$ds^2 = g_{MN}(X)dX^M dX^N = \underbrace{\boxed{ds^2(\mathbb{R}^4)}}_{\text{center-of-mass}} + \underbrace{d\lambda^2}_{\textbf{instanton “size”}} + \lambda^2 \left[\underbrace{\boxed{ds^2(S^3/\mathbb{Z}_2)}}_{SU(2)\text{ orientation}} + \underbrace{\boxed{ds^2(\mathcal{M}_{4N-8})}}_{\frac{SU(N)}{SU(2)\times U(N-2)}}\right]$$

$$\lambda^2 \sim \bar{q}^{\dot{\alpha}} q_{\dot{\alpha}}$$

- The size moduli: non-compact moduli from internal degrees

➢ Large: continuous spectrum. Presumably reflects IR physics of 6d CFT, but not clarified yet.

We study observables which are insensitive to this IR issue:

- observables in Coulomb phase (instanton size frozen): e.g. Nekrasov’s instanton partition function
- “gapped” CFT observables: local operator spectrum, compact space partition functions, …

➢ Small: Metric is singular. Moduli space dynamics is incomplete. Needs more UV input on 5d SYM.

The singularity can be resolved, e.g. by putting it in B-field background: beyond 5d SYM or SUSY QM

$$U(2)\ :\ d\lambda^2 + \frac{\lambda^2}{4}\left[d\theta^2 + \sin^2\theta d\phi^2 + (d\psi + \cos\theta d\phi)^2\right] \to \frac{1}{\sqrt{1+\frac{4\zeta^2}{\lambda^4}}}\left[d\lambda^2 + \frac{\lambda^2}{4}(d\psi+\cos\theta d\phi)^2\right] + \frac{\lambda^2}{4}\sqrt{1+\frac{4\zeta^2}{\lambda^4}}\left[d\theta^2 + \sin^2\theta d\phi^2\right]$$

$\boxed{\mathbb{R}^4/\mathbb{Z}_2}$

$\boxed{\text{Eguchi-Hanson metric: } \mathbb{R}^2 \times S^2 \text{ near } \lambda = 0}$

Plan for the next 2 lectures

- The supersymmetric partition function for the instantons: “Nekrasov”
- Partition function for the ADHM quantum mechanics in Coulomb phase
- Study them as the index of 6d KK states, bound to other BPS particles: can study the physics of self-dual strings wrapping S^1 factor: both in Coulomb & symmetric phases
- Study other observables of 6d (2,0) theory, from the 5d SYM partition functions: 6d superconformal index (S^5 x S^1), brief comments on other observables