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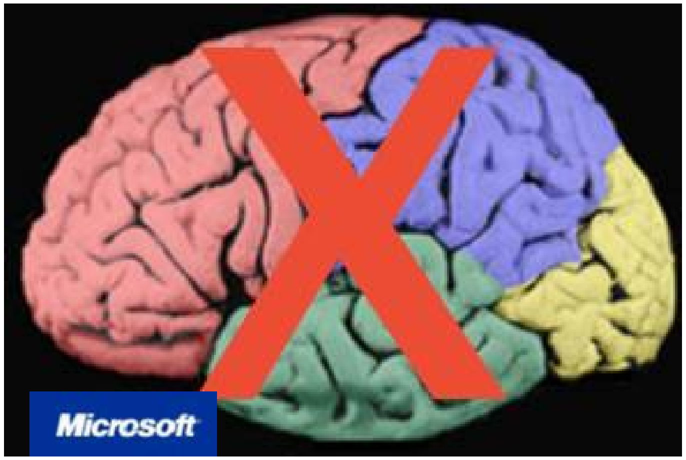
No actual brains of Micros*ft engineers were harmed in the making of this presentation.



Strings from Quivers

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IAS, Princeton and Tata Institute, Mumbai

Strings 2002, Cambridge

Based on:

S.M., Mukund Rangamani and Erik Verlinde,
"Strings from Quivers, Membranes from Moose"
hep-th/0204147

and work in progress.

Related work:

Mohsen Alishahiha and Mohammad M. Sheikh-Jabbari,
"Strings in PP-waves and Worldsheet Deconstruction"
hep-th/0204174

Stephen Naculich, Howard J. Schnitzer and Niclas Wyllard,
"PP-wave Limits and Orientifolds"
hep-th/0206094

Gautam Mandal, Nemani V. Suryanarayana and Spenta R. Wadia,
"Aspects of Semiclassical Strings in AdS_5"
hep-th/0206103

Plan of the talk:

1. **Outline:** Quivers and DLCQ
2. **Setting:** Large Quiver Theories and PP Wave Limit
3. **Proposal:** Gauge Theory Description of DLCQ String
4. **Dual:** Non-Relativistic Strings and Membranes
5. **Comments:** Parameters and Couplings
6. Conclusions

1. Outline: Quivers and DLCQ

- In light-cone quantization of strings, it is often useful to compactify a null direction.

  This leads to Discrete Light Cone Quantization (DLCQ) of the string theory.

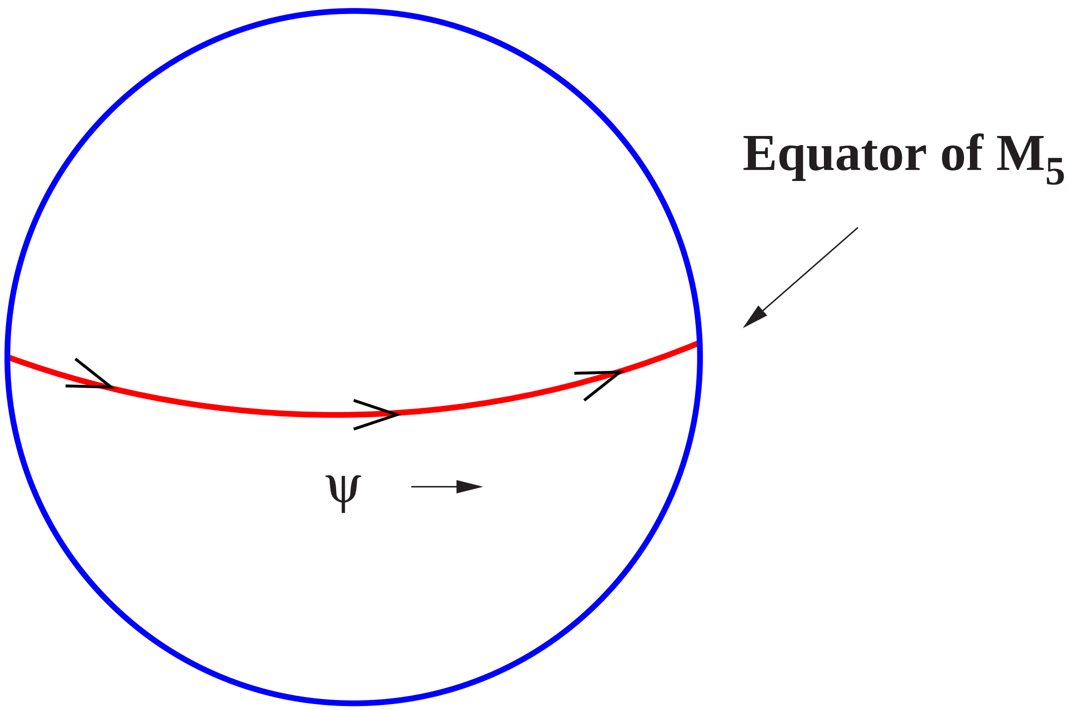
  In this description, the theory splits into sectors labelled by a discrete value of the quantized light-cone momentum.

  Interacting strings carry these quantized light-cone momenta, with the minimal momentum being carried by a "string bit".

  Such a program, for the gauge theory/pp-wave correspondence, could lead to a better understanding of string interactions .

- The setting for the present talk is type IIB string theory, which admits supersymmetric solutions of the type $AdS_5 \times M_5$ where M_5 is a Sasaki-Einstein space.

- Unfortunately, the pp-wave metric, as usually derived from $AdS_5 \times M_5$, describes a noncompact null direction x^-.



- In this talk, I will show that there is a novel scaling limit of a particular AdS background, in which one ends up with a pp-wave with a compact light-cone direction.

  The radius of the null direction is a finite, controllable parameter of this background.

- This particular AdS background has a dual 4d conformal gauge theory. The above scaling limit will act on this gauge theory, leading to a dual gauge theory/pp-wave pair.

- In the gauge theory, our scaling limit will play a role similar to the now-familiar double scaling limit in the usual BMN picture:

$$N \to \infty, \quad J \to \infty, \qquad \frac{J}{\sqrt{N}} \text{ fixed}$$

  except that our limit will be taken on the theory rather than on the observables under study.

- The gauge theory in question is an $\mathcal{N} = 2$ superconformal “moose” or “quiver” theory in the large moose limit.

- Several fascinating aspects of the gauge theory/pp-wave correspondence will emerge as we explore this background.

  We will find gauge theory operators that can be identified with a string ground state in every sector of fixed DLCQ momentum k.

  We will also find operators that describe modes of the string winding m times on the DLCQ direction.

  These operators satisfy the relation

$$\sum_i n_i = L_0 - \overline{L}_0 = km$$

- The DLCQ theory can be T-dualized into a type IIA/M-theory background which describes a non-relativistic string/membrane bound in a harmonic-oscillator potential.

  Thus, the gauge theory "deconstructs" nonrelativistic IIA/M-theory in this limit.

2. Setting: Large Quiver Theories and PP Wave Limit

- The gauge theory that we will study is obtained by placing N_1 $D3$-branes transverse to the 6-dimensional space $\mathsf{R}^2 \times (\mathsf{C}^2/\mathsf{Z}_{N_2})$.
- The orbifold group Z_{N_2} acts on $R^2 \times \mathsf{C}^2$ by:

$$(z_1, z_2, z_3) \to (z_1, \omega z_2, \omega^{-1} z_3), \qquad \omega = e^{\frac{2\pi i}{N_2}}$$

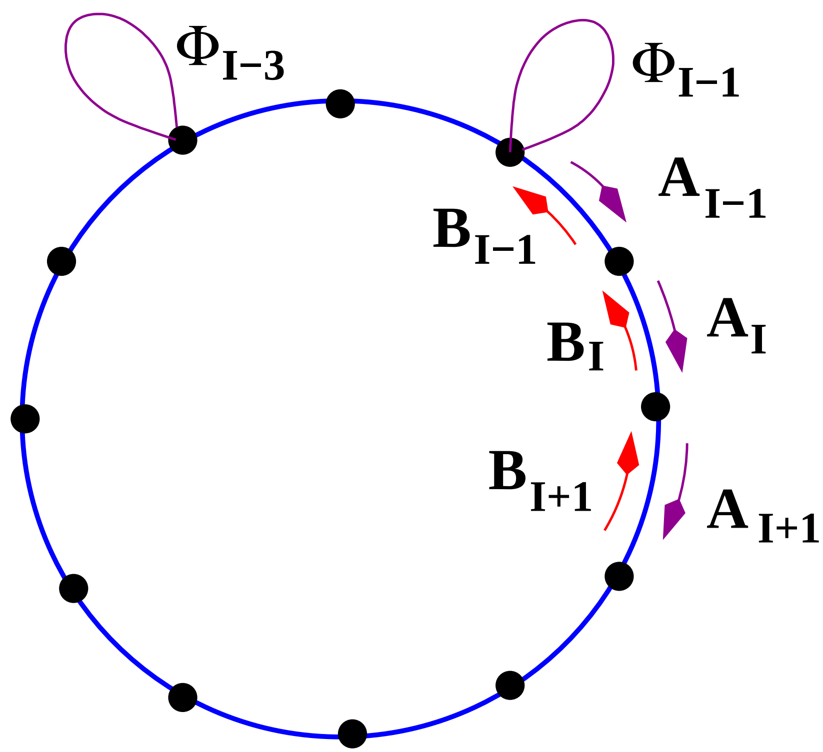
- The theory on the brane world-volume is a $\mathcal{N} = 2$ superconformal field theory in four dimensions.
- The R-symmetry group is $U(1)_R \times SU(2)_R$.
- The gauge group is $SU(N_1)^{(1)} \times SU(N_1)^{(2)} \times \cdots SU(N_1)^{(N_2)}$.
- The fields in the vector multiplet for each factor of the gauge group are denoted $(A_{\mu I}, \Phi_I, \Psi_{aI})$, with $I = 1, 2, \ldots, N_2$ and $a = 1, 2$.

- In addition, there are hypermultiplets (A_I, B_I, χ_{aI}).

- For fixed index I, the A_I and B_I are bi-fundamentals of $SU(N_1)^{(I)} \times SU(N_1)^{(I+1)}$:

$$A_I : (1, \ldots, N_1, \overline{N}_1, \ldots, 1), \qquad B_I : (1, \ldots, \overline{N}_1, N_1, \ldots, 1)$$

- This can be represented in a "moose" or "quiver" diagram:



- The holographic dual is type IIB string theory on $AdS_5 \times S^5/Z_{N_2}$.
- The AdS_5 space has a radius given by:

$$R^2 = \sqrt{4\pi g_s^B \alpha'^2 N_1 N_2}$$

  where g_s^B is the type IIB string coupling.

- We are interested in a scaling limit when both N_1 and N_2 become large together, with the ratio N_1/N_2 fixed.
- We will see that $N_2 \to \infty$ is like the "continuum limit" $J \to \infty$ (cf. Maldacena's talk).

- To obtain the Penrose limit, one has to focus on the trajectory of a lightlike worldline based at the origin of AdS_5.

- Because of the singular nature of the compact manifold, the result depends on the choice of this trajectory.

- We parametrize the complex coordinates of the transverse space in terms of angles:

$$z_1 = R \sin\alpha \, e^{i\theta}, \quad z_2 = R\cos\alpha\cos\gamma \, e^{i\chi}, \quad z_3 = R\cos\alpha\sin\gamma \, e^{i\phi}$$

- The orbifold is obtained by demanding that χ and ϕ are periodic modulo 2π, and in addition have a combined periodicity under

$$\chi \to \chi + \frac{2\pi}{N_2}, \qquad \phi \to \phi - \frac{2\pi}{N_2} \; .$$

- Now we can write the metric of $AdS_5 \times S^5/\mathsf{Z}_{N_2}$:

$$ds^2 = R^2\Big[-\cosh^2 \rho dt^2 + d\rho^2 + \sinh^2 \rho \, d\Omega_3^2 \\ + d\alpha^2 + \sin^2 \alpha \, d\theta^2 + \cos^2 \alpha \, \left(d\gamma^2 + \cos^2 \gamma \, d\chi^2 + \sin^2 \gamma \, d\phi^2 \right) \Big]$$

- To take the pp-wave limit, define new coordinates r, x, y by:

$$r = \rho R, \qquad x = \alpha R, \qquad y = \gamma R$$

and introduce the lightcone coordinates

$$x^+ = \frac{1}{2} (t + \chi) \, , \qquad x^- = \frac{R^2}{2} (t - \chi)$$

- In the limit $R \to \infty$ the metric reduces to

$$\begin{aligned} ds^2 &= -4dx^+dx^- - (r^2 + x^2 + y^2) \, dx^{+2} + dr^2 + r^2 d\Omega_3^2 \\ &\quad + dx^2 + x^2 d\theta^2 + dy^2 + y^2 d\phi^2 \\ &= -4dx^+dx^- - \sum_{i=1}^{8} (x^i)^2 \, dx^{+2} + \sum_{i=1}^{8} dx^{i2} \end{aligned}$$

- Although we obtained the standard pp-wave metric in the Penrose limit, there is actually an important difference: the lightlike direction x^- is compact.

- To see this, note that the combined periodicity of the angles χ, ϕ translates into the following periodicity on the new coordinates:

$$x^+ \to x^+ + \frac{\pi}{N_2}, \qquad x^- \to x^- + \frac{\pi R^2}{N_2}, \qquad \phi \to \phi - \frac{2\pi}{N_2}$$

- Since $R^2 = \sqrt{4\pi g_s^B \alpha'^2 N_1 N_2}$, we find that:

$$\frac{R^2}{N_2} \; = \; 2\alpha' \sqrt{\pi g_s^B \frac{N_1}{N_2}} \; \equiv \; 2R_-$$

  Thus as $N_1, N_2 \to \infty$ together, x^- is periodic with period $2\pi R_-$, where:

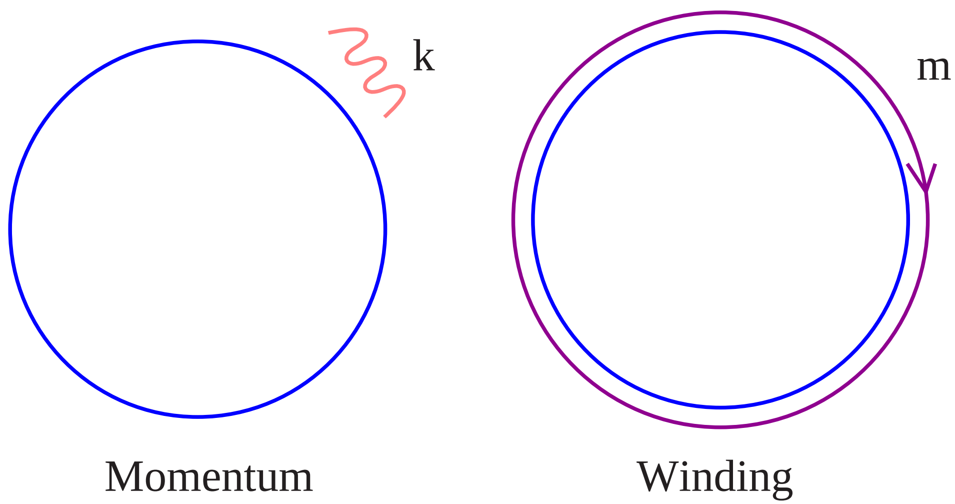
$$R_- \equiv \frac{\alpha'}{2} g_{\mathsf{YM}} \sqrt{\frac{N_1}{N_2}}$$

- Since the lightlike direction x^- is periodic, the corresponding light-cone momentum p^+ is quantized in units of $\frac{1}{R_-}$.

- In other words, we are doing a Discrete Light-Cone Quantization (DLCQ) of the string on a pp-wave background.

- As is well-known, the theory then splits into sectors, labelled by the discrete number of light-cone quanta k. This is always a positive integer.

- There can also be winding modes of the string on the null direction, which we label by an integer m.



3. Proposal: Gauge Theory Description of DLCQ String

- We now address the construction of string states in the DLCQ pp-wave background starting from the moose/quiver gauge theory.

- The first step is to identify the desired quantum numbers. Recall that

$$H = 2p^- = \Delta - J_\chi$$

where J_χ generates rotations of the angle χ that appears in:

$$x^+ = \frac{1}{2}(t+\chi), \qquad x^- = \frac{R^2}{2}(t-\chi)$$

- What is this generator in the gauge theory? It is easy to see that

$$J_\chi = N_2 J + J'$$

where

$$J: \quad A_I \to e^{\frac{i\beta}{2N_2}} A_I, \quad B_I \to e^{-\frac{i\beta}{2N_2}} B_I \qquad \text{(global non–R symmetry)}$$

$$J': \quad A_I \to e^{\frac{i\beta}{2}} A_I, \quad B_I \to e^{\frac{i\beta}{2}} B_I \qquad \text{(R–symmetry)}$$

- Thus we have:

$$H = 2p^- = \Delta - N_2 J - J'$$
$$2p^+ = \frac{\Delta + N_2 J + J'}{R^2}$$

- Note that the fundamental fields have no anomalous dimensions in this theory. So the dimensions Δ are their free-field values.

- Thus we find:

	Δ	J	J'	H
A_I	1	$\frac{1}{2N_2}$	$\frac{1}{2}$	0
B_I	1	$-\frac{1}{2N_2}$	$\frac{1}{2}$	1
Φ_I	1	0	0	1
$\overline{A}_I$	1	$-\frac{1}{2N_2}$	$-\frac{1}{2}$	2
$\overline{B}_I$	1	$\frac{1}{2N_2}$	$-\frac{1}{2}$	1
$\overline{\Phi}_I$	1	0	0	1

- Now we can construct the gauge theory operator that corresponds to the ground state of the dual string theory.

- It must have $H = 0$, therefore it has to be constructed out of the A_I alone.

- As these fields are bi-fundamentals, the simplest gauge-invariant operator that can be made out of them is:

$$\mathrm{tr}\,(A_1 A_2 \cdots A_{N_2})$$

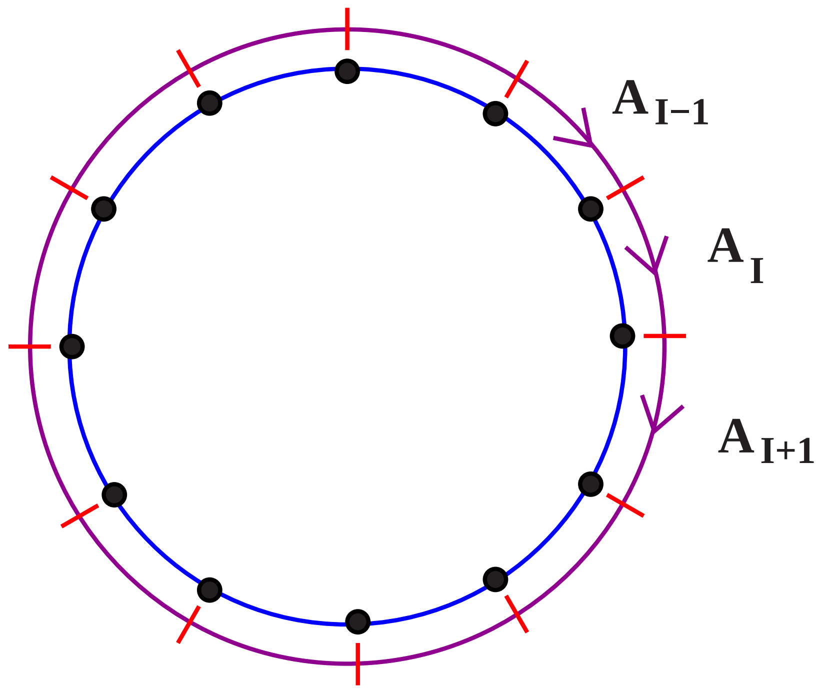
- This operator has $H = 0$ and $\Delta = N_2$. This implies that

$$2p^+ = 2\frac{N_2}{R^2} = \frac{1}{R_-}$$

- Hence we can identify it with the string ground state in the sector with one unit of DLCQ momentum (and no winding):

$$|k = 1, m = 0\rangle = \frac{1}{\sqrt{\mathcal{N}}}\,\mathrm{tr}\,(A_1 A_2 \cdots A_{N_2})$$

- Pictorially, this operator is a "string" of fields that are "winding" around the quiver diagram.



- But in the string theory this is a momentum state!

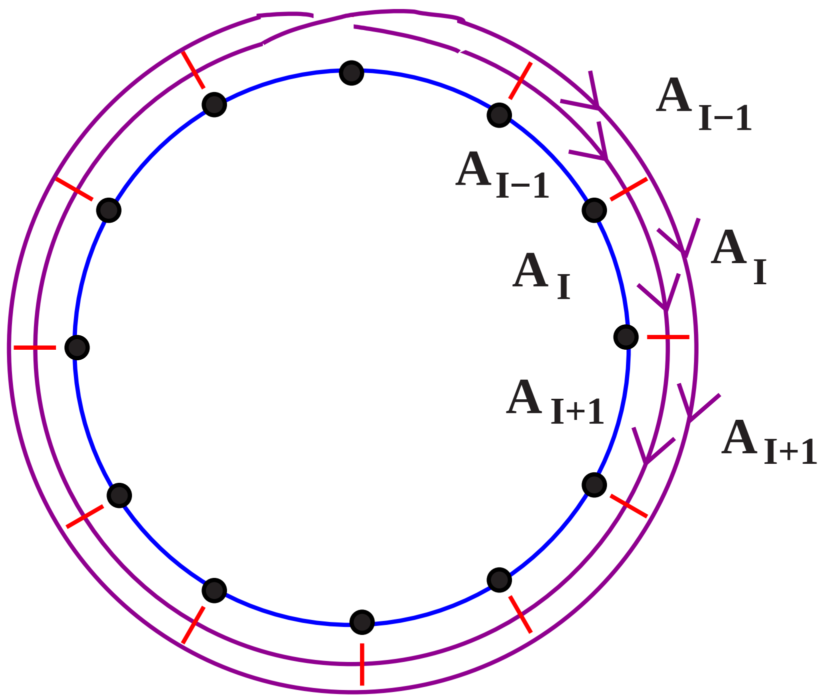
  We will see later that this has a beautiful physical interpretation.

- Now it is easy to construct all the DLCQ momentum states. We have:

$$|k, m = 0\rangle = \frac{1}{\sqrt{\mathcal{N}^k}} \mathrm{tr}\left(A_1 A_2 \cdots A_{N_2}\right)^k$$

for any positive integer k. They all have $H = 0$.

- For example, the state $|k = 2, m\rangle$ looks like:



- The next step is to construct the zero-mode string oscillator states. These should have light-cone Hamiltonian $H = 1$.

- From the table, it is clear that we can admit precisely one insertion of:

$$\Phi_I, \overline{\Phi}_I, B_I, B_I$$

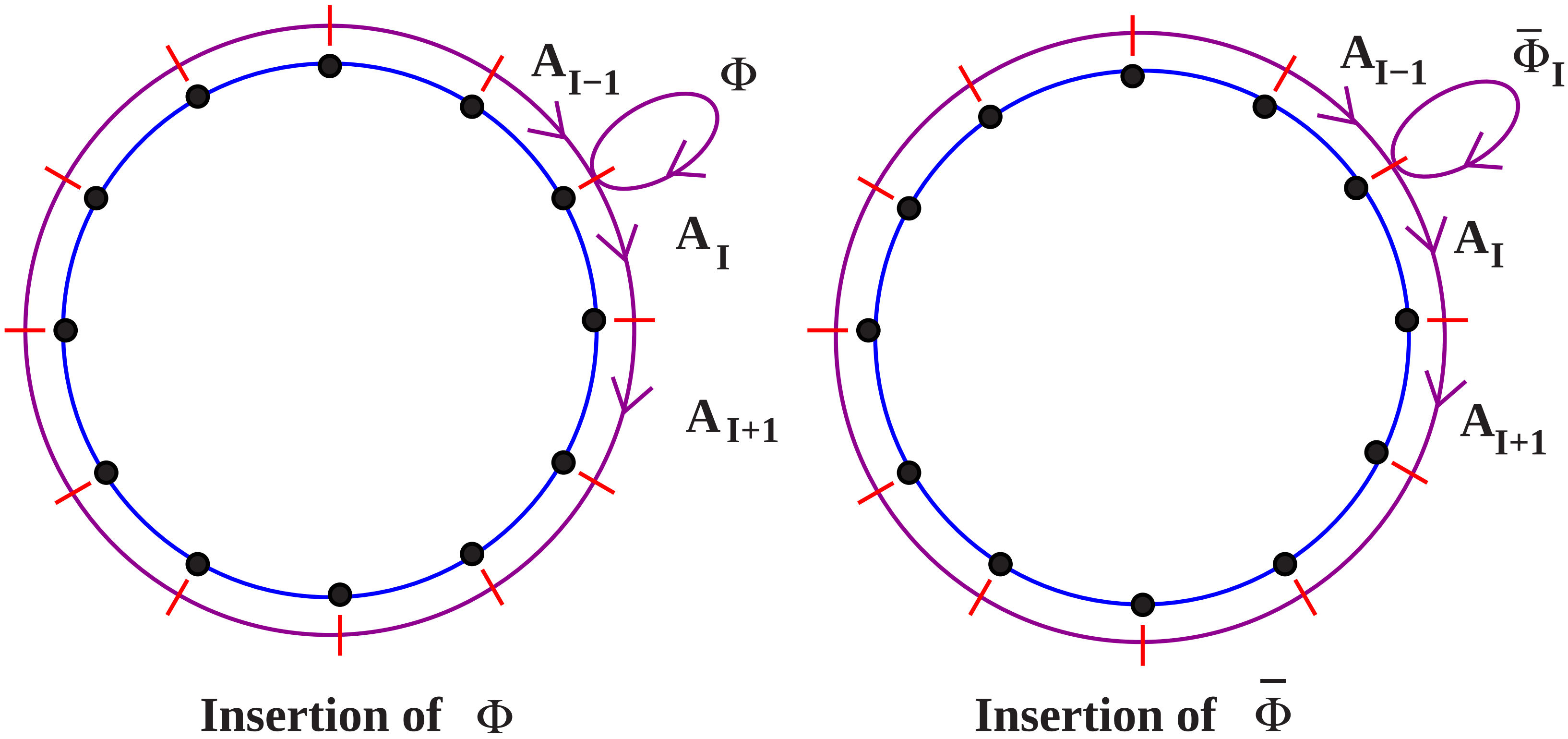
each of which has $H = 1$.

- The representations of these fields:

$$\Phi : \text{adjoint}, \qquad B : \text{bi}-\text{fundamental}$$

constrain what gauge-invariant operators can be written down.

- Some of the $H = 1$ operators constructed in this way are illustrated as follows:



- For example, on the $k = 1$ DLCQ ground state we can build the operator:

$$\mathrm{tr}\,(A_1 A_2 \cdots A_{I-1} \Phi_I A_I \cdots A_{N_2})$$

- Invariance under the orbifold group Z_{N_2} is achieved by summing over the insertion point. Thus we propose:

$$a^\dagger_{\Phi,0}|k = 1, m = 0\rangle \sim \sum_{I=1}^{N_2} \mathrm{tr}\,(A_1 A_2 \cdots A_{I-1} \Phi_I A_I \cdots A_{N_2})$$

and similarly for $\overline{\Phi}, A_I B_I, \overline{B}_I$.

- Another four are given by:

$$\partial_i\, \mathrm{tr}\,(A_1 A_2 \cdots A_{N_2})$$

Thus for $k = 1$, we have identified the 8 zero-mode bosonic oscillators of the string. For general k, the construction is analogous.

- String oscillators with nonzero mode number can be obtained by inserting phases.
- However, we will see that in our model, this automatically introduces winding states as well.
- In DLCQ string theories, it is well-known that the constraint $L_0 - \overline{L}_0 = 0$ is replaced, in the sector of momentum k and winding m, by:

$$L_0 - \overline{L}_0 = km$$

- This leads to the identification:

$$a^{\dagger}_{\Phi,m}|k=1,m\rangle = \sum_{I=1}^{N_2} \mathrm{tr}\left(A_1 A_2 \cdots A_{I-1} \Phi_I A_I \cdots A_{N_2}\right) \omega^{mI}$$

where

$$\omega = e^{\frac{2\pi i}{N_2}}$$

- The general winding state in the sector of DLCQ momentum 1 is then:

$$\prod_{i=1}^{M} a^{\dagger}_{\Phi,n_i}|k=1,m\rangle = \sum_{l_M\geq\cdots\geq l_2\geq l_1}^{N_2} \mathrm{tr}\,(A_1\cdots A_{l_1-1}\Phi_{l_1}\cdots A_{l_i-1}\Phi_{l_i}A_{l_i}\cdots A_{N_2})\,\omega^{\sum n_i l_i}$$

  where the winding number m is defined as the sum of the mode numbers n_i:

$$m \equiv \sum_i n_i.$$

- The gauge theory operators that describe the sector with DLCQ momentum $k > 1$ are generalizations of the above. For example,

$$a^{\dagger}_{\Phi,n}|k=2,m\rangle = \sum_{I=1}^{2N_2} \mathrm{tr}\,(A_1\cdots A_{I-1}\Phi_I A_I\cdots A_{N_2}A_1A_2\cdots A_{N_2})\,\omega^{nI}$$

  where now

$$\omega = e^{\frac{2\pi i}{2N_2}} \quad \text{and} \quad m = \frac{n}{2}$$

  It is easy to show that the above state vanishes for odd n, an important consistency check.

- We see that the DLCQ winding states, represented as gauge theory operators, look like momentum states on the large moose.

- And we already saw that the DLCQ momentum states look like winding states on the large moose.

- This is suggestive of T-duality.

4. Dual: Non-Relativistic Strings and Membranes

- One can gain more insight into our construction by performing a T-duality over the lightlike DLCQ direction.

- The periodicity of the x^- direction is a remnant of the combined periodicities in the angles χ and ϕ, exhibited earlier.

- Before taking the limit $N_1, N_2 \to \infty$, the periodic direction was space-like. Hence one can perform a T-duality along this direction.

- Let us go back to the original $AdS_5 \times S^5/Z_{N_2}$ metric and write down only the terms in the t and χ directions (i.e., ignoring the transverse space):
$$ds^2 = R^2 \left[-\cosh^2 \rho \, dt^2 + \cos^2 \alpha \cos^2 \gamma \, d\chi^2 \right]$$

- Now we make the original replacements for $\chi, \rho, \alpha, \gamma$ in terms of the pp-wave-adapted coordinates:
$$x^- = \frac{R^2}{2} (t - \chi) \, , \qquad r = \rho R, \qquad x = \alpha R, \qquad y = \gamma R$$

- We do not yet take the limit $R \to \infty$, so the metric becomes:

$$ds^2 = R^2 \left(\cos^2 \frac{w}{R} \cos^2 \frac{y}{R} - \cosh^2 \frac{r}{R} \right) dt^2 - 4 \cos^2 \frac{w}{R} \cos^2 \frac{y}{R}\, dt\, dx^- + \frac{4}{R^2} \cos^2 \frac{w}{R} \cos^2 \frac{y}{R} (dx^-)^2$$

- This procedure has introduced a small g_{--} in the metric, and we can now T-dualize. We end up with the metric:

$$ds^2 = -R^2 \cosh^2 \frac{r}{R}\, dt^2 + \frac{R^2}{\cos^2 \frac{w}{R} \cos^2 \frac{y}{R}} (dx^9)^2$$

along with a B-field and dilaton:

$$B_{t\,9} = -R^2, \qquad g_s^A = \frac{\sqrt{\alpha'} R}{R_- \cos \frac{w}{R} \cos \frac{y}{R}}$$

Here $2x^9$ is the T-dual of x^-.

- Note that x^9 now has period $2\pi\frac{\alpha'}{R_-}$, with as before:

$$R_- = \frac{\alpha'}{2} g_{\text{YM}} \sqrt{\frac{N_1}{N_2}}$$

- There are also Ramond-Ramond fields that we do not write here.

- Evidently some components of the metric, and the B-field and string coupling, become infinite as $R \to \infty$.

- However, string propagation on this background is finite. The reason is that the B-field is a critical electric field and cancels the leading divergent piece in the string world-sheet action:

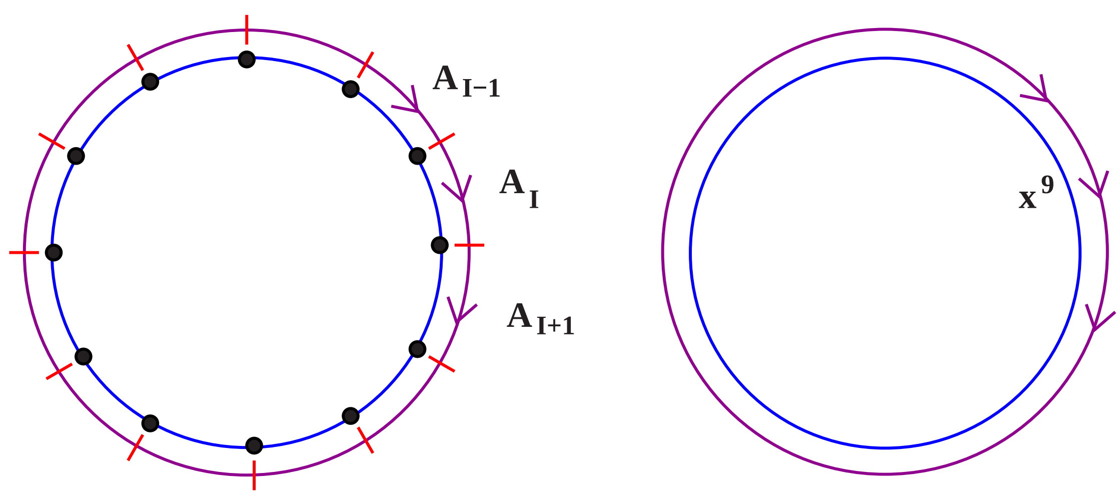
$$\sqrt{-\det(g)} + B \quad = \quad R^2 \frac{\cosh \frac{r}{R}}{\cos \frac{w}{R} \cos \frac{y}{R}} - R^2 \quad \simeq \quad \frac{1}{2} \sum_{i=1}^{8} (x^i)^2 + \mathcal{O}\left(\frac{1}{R^2}\right)$$

- This is just the non-relativistic string propagating in a background with a Newtonian potential of harmonic-oscillator type.

- It is well-known that in a critical electric field with the above scaling, closed strings winding in the direction of the field are light, while the others are are heavy.

- So the non-relativistic closed string (NRCS) that we have arrived at, has only positive windings over the circle.

- The interpretation of our gauge-theory operators winding round the moose is now clear. They are deconstructing these winding states of the NRCS:



Operators winding around moose

NR string winding around spatial circle

- The string of A's had vanishing energy for any winding number, like the light winding strings of NRCS theory.
- The string of $\overline{A}$'s winding the other way gives infinitely energetic states as $N_2 \to \infty$, like the NRCS strings winding the wrong way.
- Insertions of phases give the (quantized) momentum states of the NR closed string on x^9. These can have either sign of momentum.

5. Comments: Parameters and Couplings

(i) Effective 't Hooft coupling:

In the $\mathcal{N}=4$ case, this is:

$$\lambda' = \frac{g_{\mathsf{YM}}^2 N}{J^2}$$

In the quiver theory we expect:

$$N \longrightarrow N_1 N_2, \qquad J \longrightarrow k N_2$$

hence

$$\lambda' = \frac{g_{\mathsf{YM}}^2}{k^2}\frac{N_1}{N_2} = \left(\frac{2R_-}{k}\right)^2$$

where we recall that

$$R_- \equiv \frac{1}{2} g_{\mathsf{YM}} \sqrt{\frac{N_1}{N_2}} \qquad (\text{in } \alpha' = 1 \text{ units})$$

(ii) Genus expansion parameter:

In the $\mathcal{N}=4$ theory, this is:

$$g_2 = \frac{J^2}{N}$$

In the quiver theory, the corresponding object should be:

$$g_2 = k^2\,\frac{N_2}{N_1} \sim \frac{N_2}{N_1}$$

This can be checked directly by computing all-genus correlators in the free quiver gauge theory. For example, one finds:

$$\langle 0|\mathrm{tr}\,(A_1 A_2 \ldots A_{N_2})^k\,\mathrm{tr}\,(\overline{A}_{N_2}\overline{A}_{N_2-1}\ldots\overline{A}_1)^{k'}|0\rangle = \frac{\delta_{k,k'}}{|x|^{2N_2}}\sum_{l=1}^{k}\left(\frac{\Gamma(N_1+l)}{\Gamma(N_1+l-k)}\right)^{N_2}$$

As $N_1, N_2 \to \infty$ with fixed ratio, this reduces to:

$$\frac{\delta_{k,k'}}{|x|^{2N_2}} \times 2 \sum_{l=1}^{\frac{k}{2}} \cosh\left\{(l - \frac{(k+1)}{2})\, k \frac{N_2}{N_1}\right\}$$

This has an expansion in powers of

$$\left(\frac{N_2}{N_1}\right)^2$$

as expected.

(iii) Effective coupling:

In the $\mathcal{N} = 4$ theory there is a combination that describes the effective coupling between states of the same $\Delta - J$ (at small λ'):

$$g_{\text{eff}} = g_2\sqrt{\lambda'} = g_{\text{YM}}\frac{J}{\sqrt{N}}$$

The corresponding effective coupling in the quiver case would then be:

$$g_{\text{eff}} = g_{\text{YM}}\, k\sqrt{\frac{N_2}{N_1}}$$

Let us compare this with the type IIA NR closed string coupling, given by the familiar (NCOS) formula:

$$g_{\text{NR}} = g^2_{\text{NCOS}} = g_s^A\sqrt{\frac{\det(g+B)}{\det g}}$$

If we evaluate this on our background, we find a spatially varying coupling:

$$g_{\text{NR}} = \frac{g_s^B}{R_-}\sqrt{\sum_{i=1}^{8}(x^i)^2}$$

- Since the string is trapped in a harmonic potential, the states are confined to a finite region, and the coupling constant will reduce to:

$$g_{\mathsf{NR}} \sim \frac{g_s^B}{R_-} \sim g_{\mathsf{YM}}\sqrt{\frac{N_2}{N_1}} = g_{\mathsf{eff}}$$

  We see that the effective coupling among a subclass of gauge theory states can be identified with the effective coupling between the winding NR closed strings.

- By taking this coupling to be large, we go over to M-theory . The wound NR string becomes a non-relativistic membrane wound over the x^9, x^{10} directions.

(iv) pp-wave mass parameter μ:

In the noncompact (usual) pp-wave background, the parameter μ can be scaled to any value by rescaling

$$x^+ \to \Lambda x^+, \qquad x^- \to \Lambda^{-1} x^-$$

for some Λ.

It is also true that in a flat-space DLCQ background, the DLCQ radius can be scaled to any value (by the same procedure).

But in the DLCQ pp-wave, things are different. We can simultaneously change μ and the DLCQ radius R_- by the above scaling, but not either one separately. This is why there is one physically relevant parameter.

(v) Deconstruction:

The same quiver gauge theory that we have been discussing was studied last year in a different limit: $N_2 \to \infty$, N_1 fixed, and $\alpha' \to 0$.

It was proposed that in this limit, taken along the Higgs branch, two additional dimensions are dynamically deconstructed and one ends up with the $(2,0)$ field theory. This arises as the decoupled theory on M5-branes.

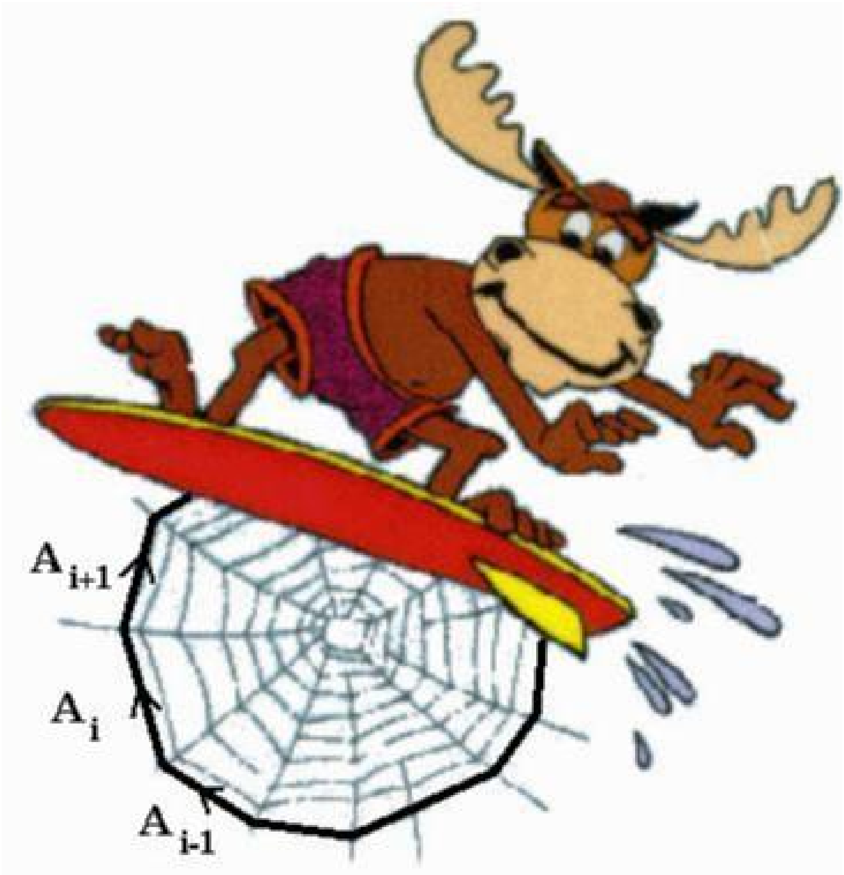
We take $N_1, N_2 \to \infty$ together with the near-horizon limit of the D3-branes. Also, we zoom in on a lightlike geodesic. This is similar to being in the Higgs branch, because we miss the orbifold singularity.

Our final result is a DLCQ pp-wave of radius $\sim \sqrt{N_1/N_2}$, or a Galilean string/membrane wrapped on a circle/torus of radius $\sim \sqrt{N_2/N_1}$.

It is not clear if conventional deconstruction can be obtained from this as $N_2/N_1 \to \infty$.

6. Conclusions

- Large quiver theories give a nontrivial generalization of the gauge/pp-wave correspondence. They describe the Discrete Light Cone Quantization of type IIB string theory on a pp-wave background.
- They also deconstruct the non-relativistic closed string/membrane. The operator wrapping the moose once is a DLCQ string bit.
- It is clearly of interest to study string interactions in this model. For small values of k, the formulae should be simpler and hopefully we can check more.
- Another open problem is to directly study the non-relativistic string in a potential and compare it with gauge theory.
- But there is a more important conceptual question: DLCQ is often associated to a fundamental formulation of a theory (as with M(atrix) Theory). Is there such a fundamental formulation – M(oose) Theory – hidden here?



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