DIMENSIONAL REDUCTION OF MAGNETIZED DBI COMPACTIFICATION

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OUTLINE

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2. Setup And Results
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1, Magnetic Flux Compactification

- String theory is a widely acceptable unified theory.
- String theory is consistent at 10-dimensional space time.
    - The extra 6-dimensions are compactified with several compact spaces.
- There are many methods to compactify.

    Ex) Calabi-yau manifold, orbifold, flux compactification,…

- Flux compactification provide us with many benefits
  1. We can get a four dimensional Chiral theory.
  2. Three generation structure is given by the strength of the flux.
  3. The zero-mode wavefunctions behave like a Gaussian and so we can construct realistic Yukawa couplings.

     Ex) Hierarchie structure, the order of CKM matrices,…
- Indeed, flux compactification models are well studied and very realistic models have been discovered.

  (H. Abe, K. S. Choi, T. Kobayashi and H. Ohki, JHEP 0906, 080 (2009) , etc)
- These couplings are computed from dimensional reduction of super Yang-Mills theory.
- However, we may have stringy corrections with magnetic flux background

2, Setup And Results

- In order to evaluate such corrections, we study non-Abelian DBI action, which describe D-brane dynamics;

$$L_{DBI} = c_0 \,\mathrm{STr} \sqrt{\det \left(\delta_{mn} + \frac{1}{(2\pi\alpha')^2} F_{mn} \right)}$$

(A. A. Tseytlin, Nucl.Phys. B501 (1997) 41-52)

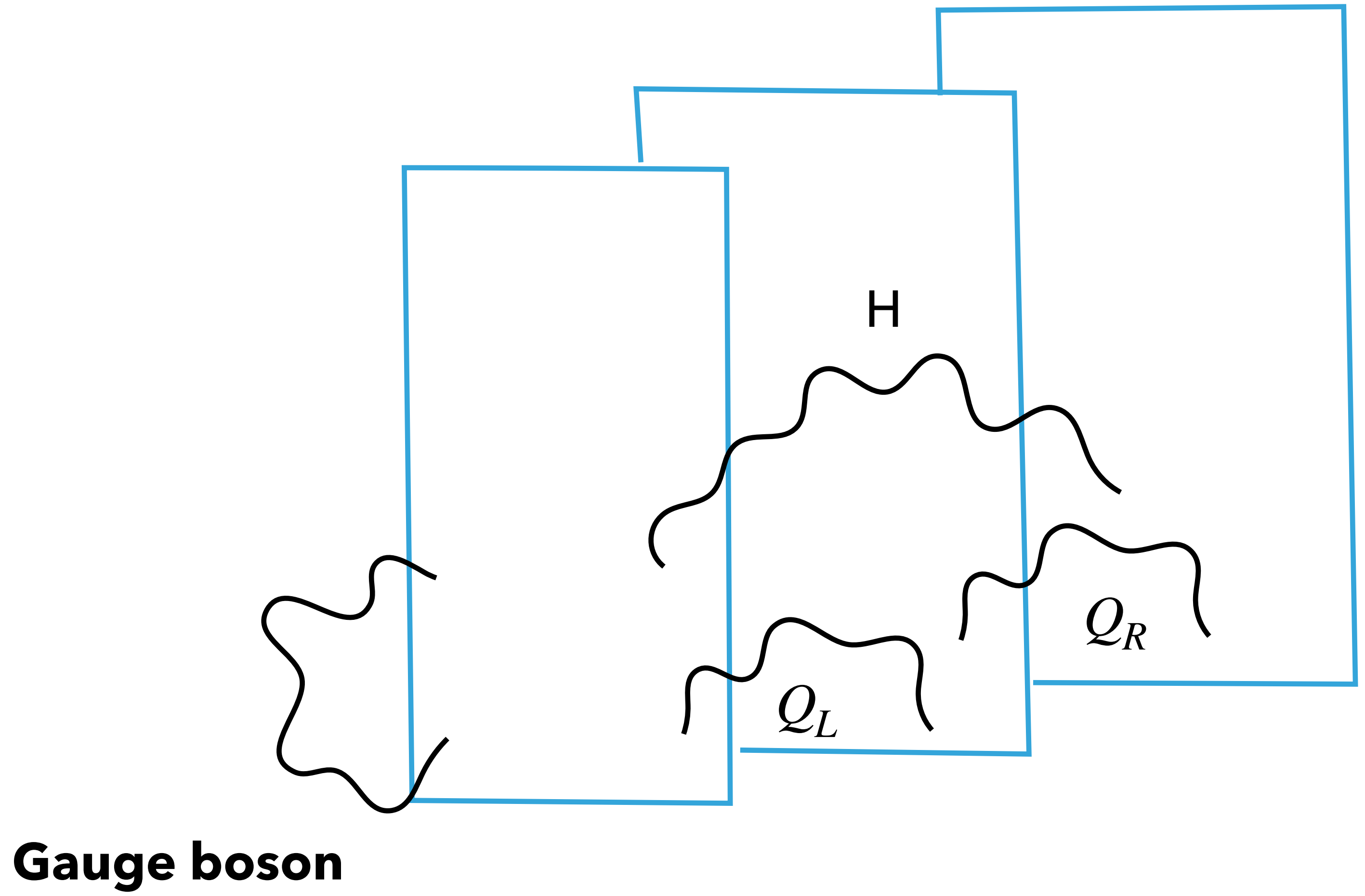
- We study only bosonic part of Lagrangian.

- We expand this DBI Lagrangian with respect to α' at second order and carry out the symmetric operation;

$$L_{DBI} = c_1 \,\mathrm{Tr}\left[F_{mn}^2 - \frac{1}{3}(2\pi\alpha')^2\left(F_{mn}F_{rn}F_{ml}F_{rl} + \frac{1}{2}F_{mn}F_{rn}F_{rl}F_{ml} - \frac{1}{4}F_{mn}F_{mn}F_{rl}F_{rl} - \frac{1}{8}F_{mn}F_{rl}F_{mn}F_{rl}\right) + (\alpha'^4)\right]$$

- This second term at $(\alpha')^2$ provide new contributions.

- More precisely, we consider D5-brane U(3) DBI action and compactify with the 2-dimensional torus .



- We compute corrections on gauge couplings, Kahlar metrics and the Yukawa couplings.

- We introduce the magnetic fluxes m_α and the fluctuation $\phi^{\alpha\beta}$ into the gauge fields $F^{\alpha\beta}$ on the torus;

$$F_{z\bar{z}} \equiv F = \partial\overline{\phi} - \overline{\partial}\phi - ig[\phi, \overline{\phi}] + \frac{i\pi}{\tau_I} m_\alpha \delta_{\alpha\beta}$$

- Substituting this expression into the DBI action and we can obtain the several quantities;
- We generalize the results to U(3) D9-brane $T^2 \times T^2 \times T^2$ compact model.

- **Gauge kinetic function** is given by the coefficients of 4-dimensional gauge kinetic terms and the $(\alpha')^2$ correction terms;
  - D5-brane

$$g^{\mu\nu} g^{\rho\sigma} \left(1 + \underline{\frac{1}{8} \frac{\alpha'^2 m_a^2}{\tau_I^2} \left(\frac{2}{R^2} \right)^2} \right) F_{\mu\nu}^{aa} F_{\rho\sigma}^{aa} + \cdots$$

  - D9-brane

$$g^{\mu\rho} g^{\rho\sigma} \left(1 + \underline{\sum_i \frac{1}{8} \left(\frac{2}{R_i^2} \right)^2 \frac{\alpha'^2 (m_a^i)^2}{(\tau_I^i)^2}} \right) F_{\mu\nu}^{aa} F_{\rho\sigma}^{aa} + \cdots$$

- The gauge couplings are modified by these terms.

- **Kahler metric** is given by the coefficients of 4-dimensional scalar kinetic terms derived from the higher dimension gauge kinetic terms and the $(\alpha')^2$ correction terms;
  - D5 brane

$$4\frac{2}{(2\pi R)^2}g^{\mu\nu}\left(1-\frac{\alpha'^2(m_a^2+m_am_b+m_b^2)}{24\tau_I^2}\left(\frac{2}{R^2}\right)^2\right)(|\partial_z\phi^{ab}|^2+|\partial_z\phi^{ba}|^2)+\cdots$$

  - D9 brane

$$4\sum_j\frac{2}{(2\pi R_j)^2}g^{\mu\nu}\left(1+e^{\pi\delta_{i,j}}\sum_i\frac{\alpha'^2(m_a^2+m_am_b+m_b^2)^i}{24(\tau_I^i)^2}\left(\frac{2}{R_i^2}\right)^2\right)(|\partial_{z_j}\phi^{ab}|^2+|\partial_{z_j}\phi^{ab}|^2)+\cdots$$

- Kahler metrics has these corrections.

- **Yukawa couplings** are given by superpotential W.

$$W \sim \phi_1\phi_2\phi_3\,, \quad V = \left|\frac{\partial W}{\partial \phi_m}\right|^2$$

$$\phi_1 = A_4 + iA_5, \quad \phi_2 = A_6 + iA_7, \quad \phi_3 = A_8 + iA_9$$

  - These terms exist in D9-brane model and are derived from self-interaction terms in the 9-dimensional gauge kinetic terms and the $(\alpha')^2$correction terms;

- D9 brane

$$L_{NBI}|_{4point} \simeq 2\pi^2 g^2 \sum_{ij} g^{z_i\bar{z}_i} g^{z_j\bar{z}_j} \Bigg[1 - \frac{(2\pi\alpha')^2}{3} \Big\{ 2(M^i_\alpha)^2 + 2(M^j_\alpha)^2 + 2M^i_\alpha M^j_\alpha + 2M^i_\alpha M^i_\beta + M^i_\alpha M^j_\beta + M^j_\alpha M^i_\beta + 2M^j_\alpha M^j_\beta$$

$$+2'(M^i_\beta)^2 + 2(M^j_\beta)^2 + 2M^i_\beta M^j_\beta - \frac{1}{2}\sum_k ((M^k_\alpha)^2 + M^k_\alpha M^k_\beta + (M^k_\beta)^2) \Big\} \Bigg] [\phi_i, \overline{\phi}_j]^{\alpha\beta} [\phi_j, \overline{\phi}_i]^{\beta\alpha} + \cdots$$

- These terms correct Yukawa coupling terms.

3, Summary And Future Works

- We study the U(3) D9 or D5 brane DBI action to get the contributions of higher α'corrections.
- We compactify the 9- or 5-dimensional flat space with torus.
- We compute Kahler metric, gauge kinetic function, Yukawa couplings.
- We will compute the mass matrices of quarks and leptons and consider the modular symmetry in this models at the next works.

ABSTRACT

- We study D9-brane compactification models with magnetic fluxes.
  - String compactification models are Super Yang-Mills theory
- We calculate dimensional reduction of DBI action with magnetic flux background.
- We derive Kahler metric, Yukawa couplings, gauge kinetic functions, etc.

- **4-point interaction terms** are derived from self-interaction terms in the higher dimensional gauge kinetic terms and the $(\alpha')^2$correction terms;
  - D5 brane

$$\sum_m \left(1 - \frac{3}{8}\frac{1}{8}\left(\frac{2}{R^2}\right)\frac{\alpha'}{\tau_I^2}C'_m\right)(gg^{z\bar{z}}\phi^k(T^m)_{kl}\overline{\phi}^l)^2$$