

Probe Fivebranes in Matrix Theory

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Collaboration with

Samuel Kovacik, Veselin Filev and Denjoe O'Connor

[arXiv:1605.05597]

1. Introduction

M(atrix) Theory (BFSS model)

Defined by

[de Wit–Hoppe–Nicolai '88,
Banks–Fischler–Shenker–Susskind '96]

- D0-brane quantum mechanics
- Matrix regularization of super-membrane theory

$$X_M(\tau, \sigma_1, \sigma_2) \rightarrow \hat{X}_M(\tau)$$

$N_c \times N_c$ matrix

Non-perturbative formulation of M-theory

- Correct supergraviton interactions
- M2 is realized as a classical configuration.
(Non-commutative geom.)

1. Introduction

Gauge/gravity duality for BFSS

[Itzhaki–Maldacena–Sonnenschein–Yankielowicz '98]

Thermal
BFSS
(D0 QM)



IIA SUGRA
around black 0-branes

$$\frac{\lambda}{U^3 N_c^{\frac{4}{7}}} \sim g_s^{\frac{4}{7}}$$
$$\frac{U^3}{\lambda} \sim \left(\frac{\alpha'}{R^2} \right)^2$$

Hawking temperature: $T \sim \frac{1}{L} \left(\frac{u_0}{L} \right)^{\frac{5}{2}}$

U : energy scale
 R : curvature radius
 $\lambda = g_{YM}^2 N_c$

L : length scale

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Hanada–Hyakutake–Ishiki–Nishimura '14

Correct T and g_s expansion with α' correction from BFSS

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When we go back to M-theory description,

How does M5 play a role in Matrix Theory?

cf) transverse M5

... M5 charges in BMN model

[Maldacena–Sheikh Jabbari–Raamsdonk '02]

longitudinal M5

... BD model

[Berkooz–Douglas '96]

(\rightarrow D4 in IIA)

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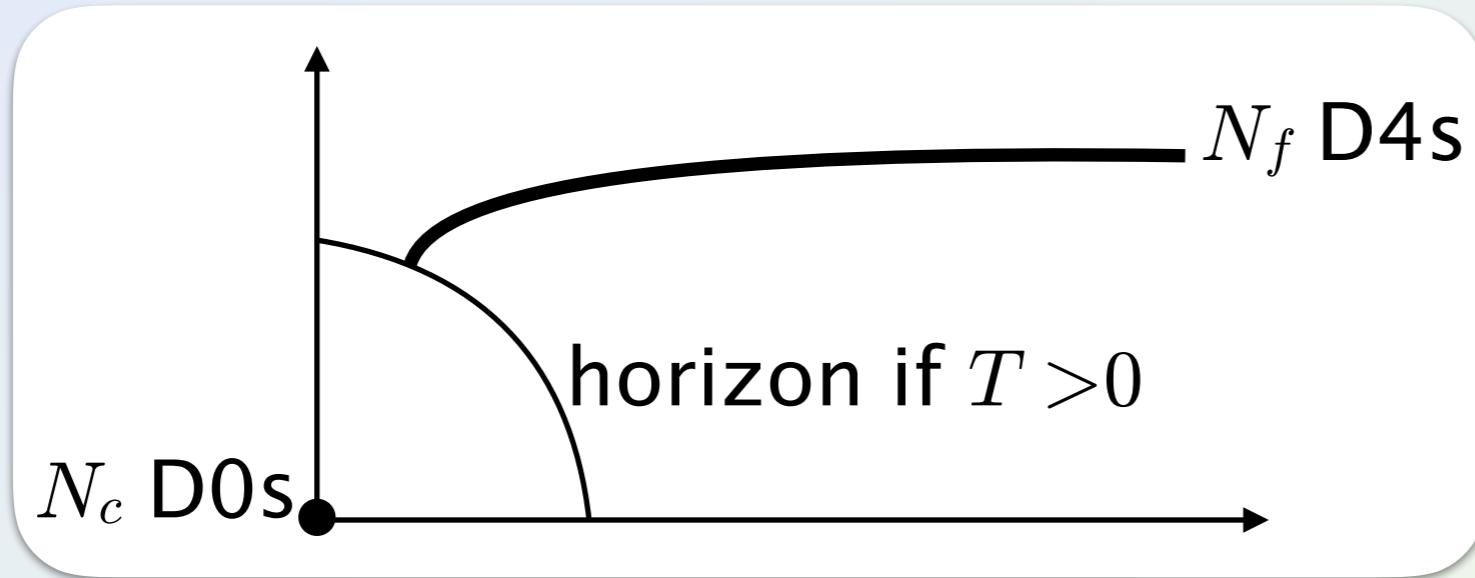
Let's compute BD model
by Monte Carlo simulation.

2. BD model

D0 quantum mechanics with probe D4

$SO(9)$ symmetry breaks down to $SO(5) \times SO(4)$.

[Berkooz–Douglas '96]

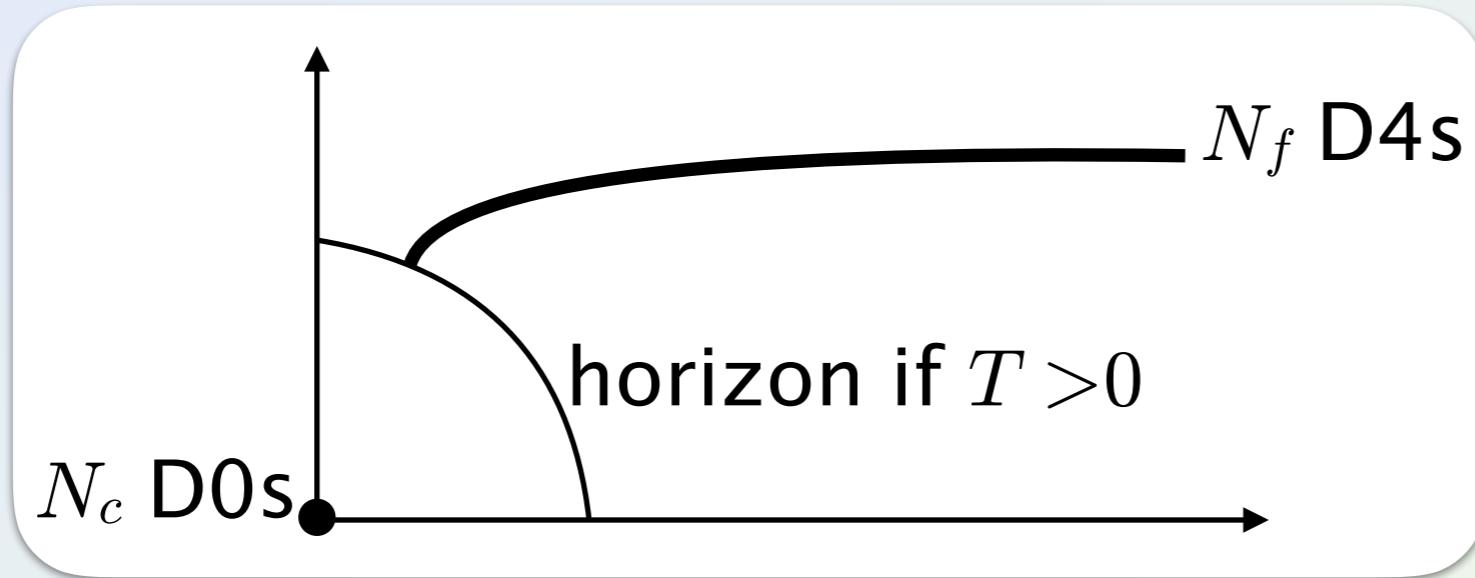


quench approx.
 $N_f \ll N_c$

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field contents:

D0–D0 strings

X^M : $N_c \times N_c$ Hermitian

Ψ : 2 $N_c \times N_c$ symplectic Majoranas

D0–D4 strings

Φ_ρ : $N_c \times N_f$ complex

χ : $N_c \times N_f$ Weyl

(in the meaning of $SO(5)$ spinor)

$$M = \underbrace{1, \dots, 5}_{SO(5)}, \underbrace{6, \dots, 9}_{SO(4)}$$

$\rho, \dot{\rho} = 1, 2 : SU(2) \times SU(2) \sim SO(4)$ sym.

3. Monte Carlo simulation of BD model

[Filev-O'Connor '15]

Gauge/gravity agreement in Mass-susceptibility plot

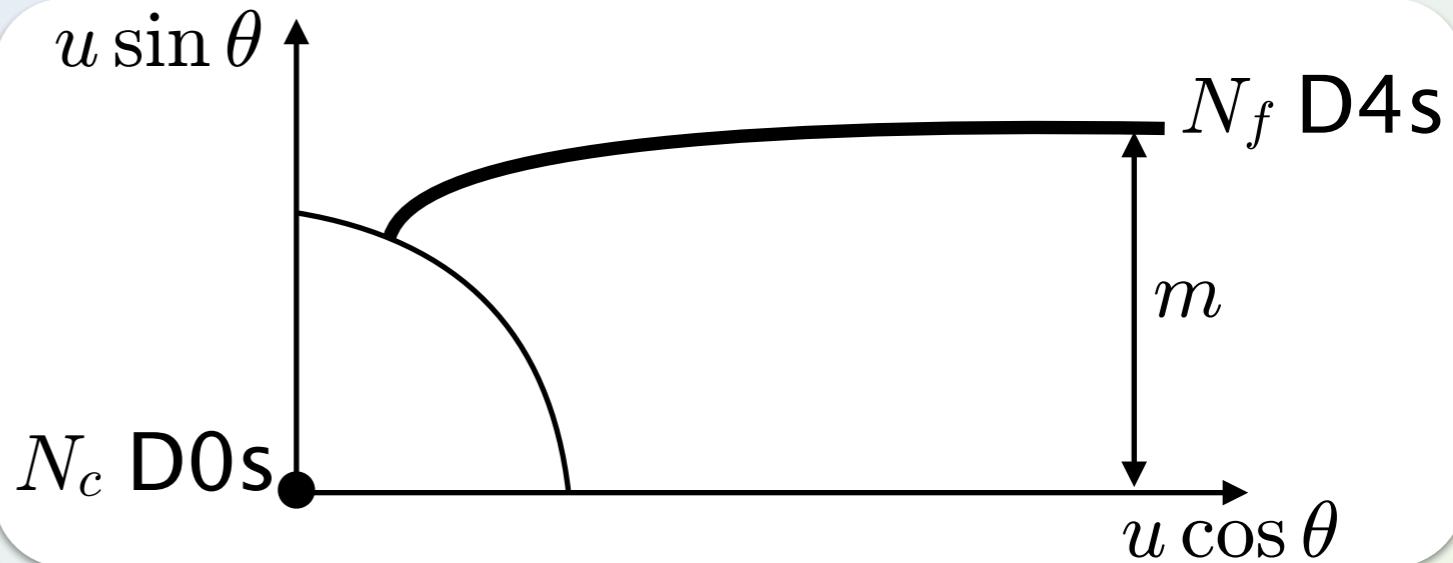
Gauge theory side

$$c = \frac{\partial F}{\partial m} \quad (F = -\beta^{-1} \ln Z)$$

Gravity side

classical sol. of DBI eom:

$$\sin[\theta(u)] = \tilde{m} \frac{u_0}{u} + \tilde{c} \frac{u_0^3}{u^3} + \dots$$



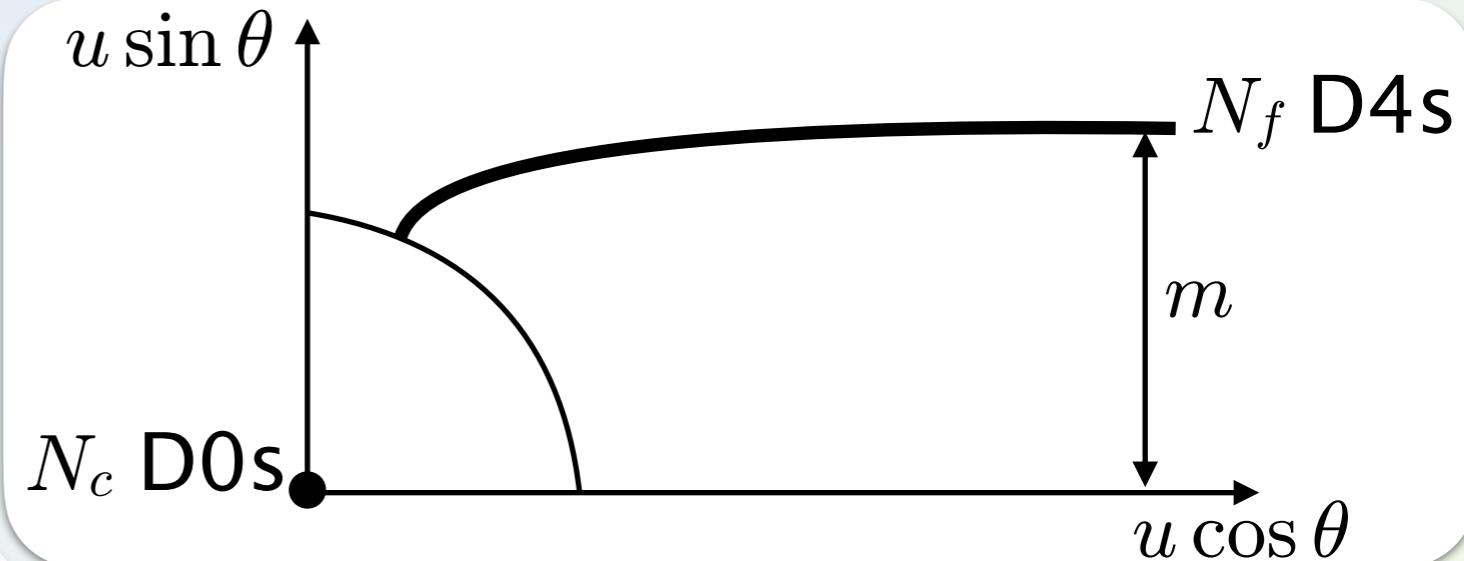
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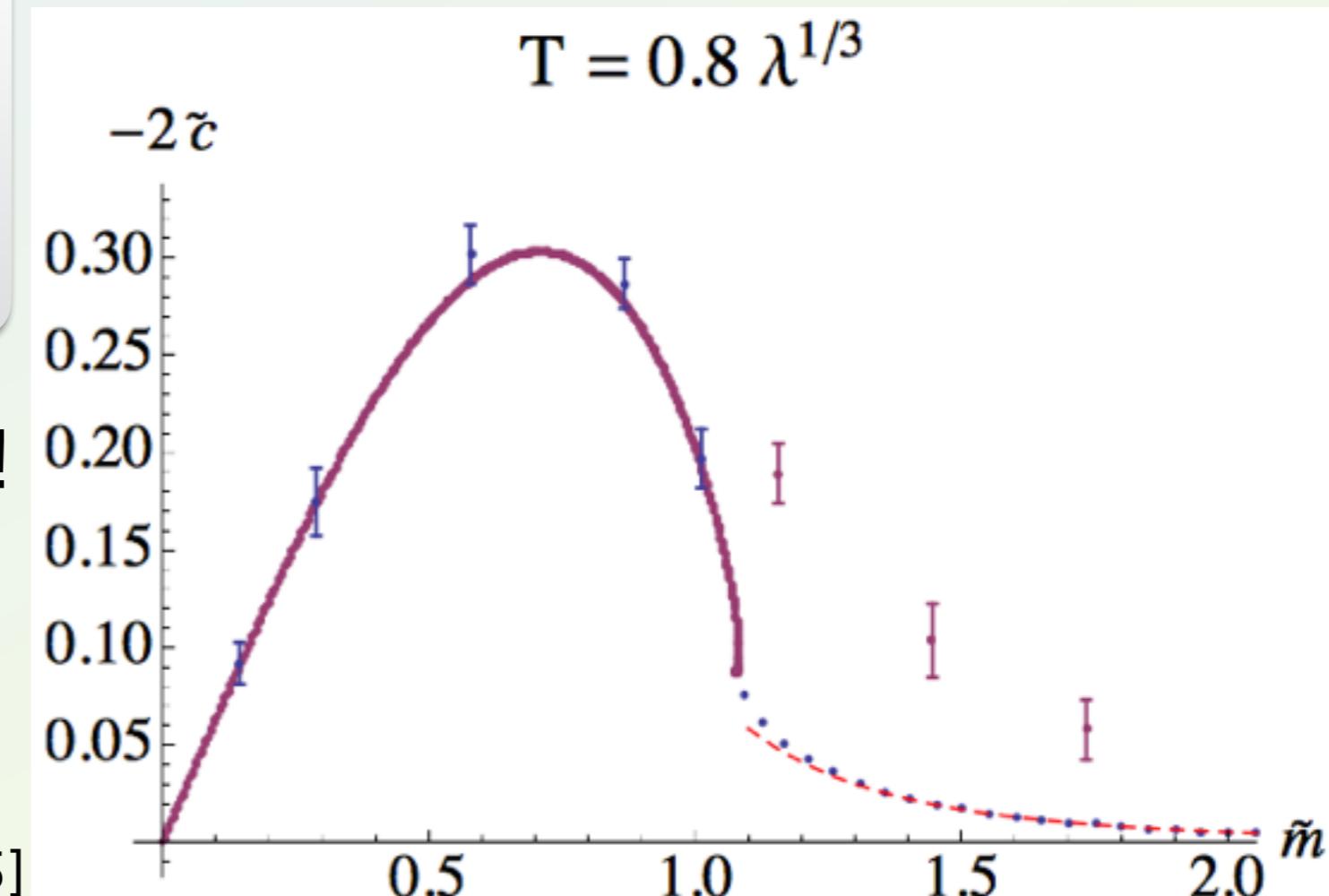
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Agreement at small mass!
(deconfined phase)

solid red line: gravity side

points w/ error bars: BD model

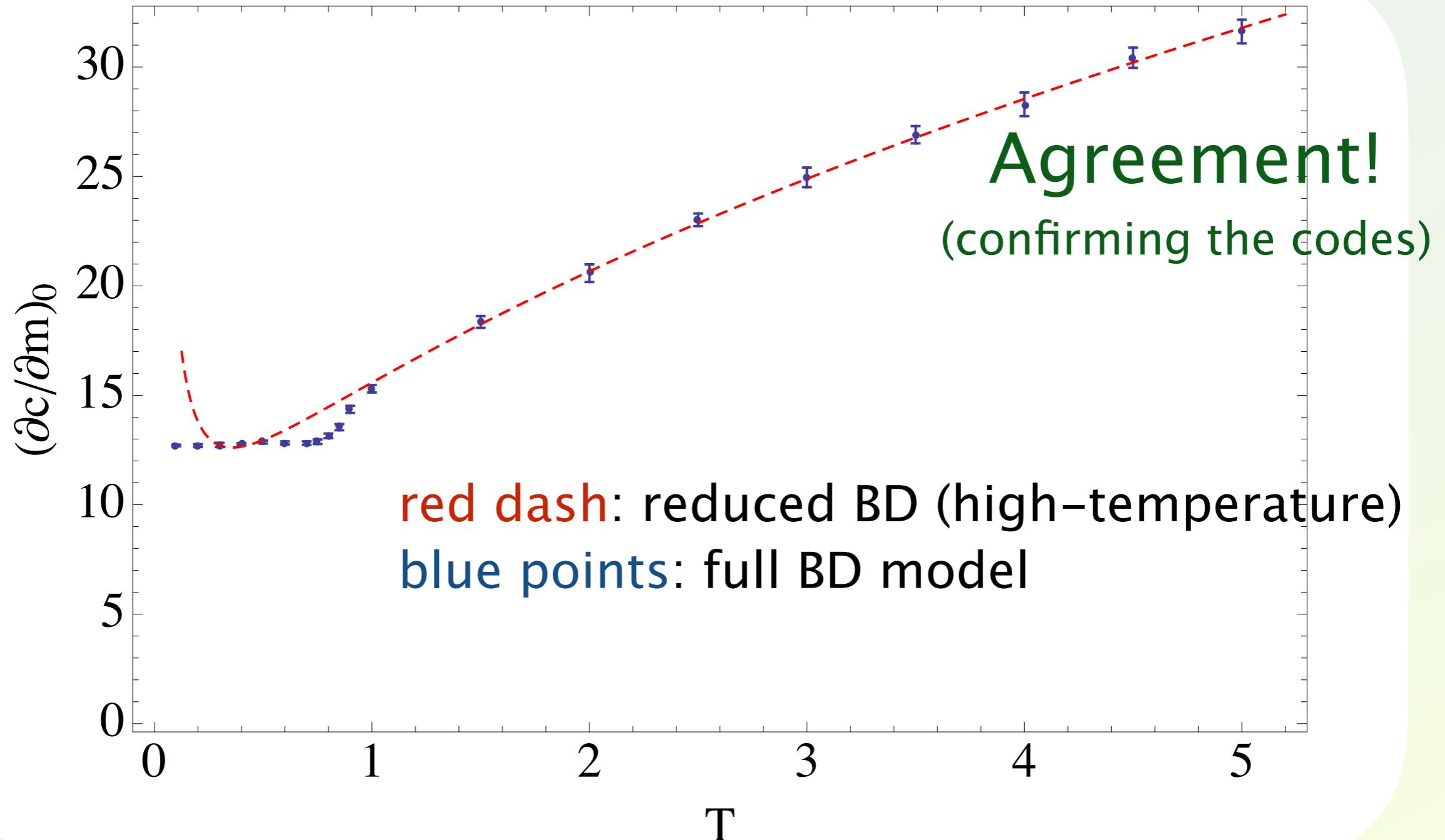


[Filev-O'Connor '15]

4. High temperature expansion

Able to analyze BD model by 0-dim. **Reduced BD model**

Result of the bosonic BD model



5. Summary & Future work

Summary

- Monte Carlo simulation of
BD model (D0 QM with probe D4)
- **Agreement between gauge & gravity sides**
for mass-susceptibility c
- Confirmation by the analysis of high temperature
regime (0-dim. reduced BD model)
- Also with supersymmetry [To appear soon as a paper]

Future work

- **Deformed BD model (KLY model)** [Kim–Lee–Yi '02]
 - … M-theory with M5 in pp-wave background