The **bosonic matrix model** with 9 matrices has a **first order phase transition** at finite temperature

Thermal Phase Transition in Yang-Mills matrix models

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The Model

We study the **1D gauged bosonic matrix model** with d=9 matrices, which is the bosonic version of the famous **BFSS matrix model**[1], related to the gauge/gravity duality. This model is also obtained as the high-temperature limit of the 2D maximal supersymmetric Yang-Mills compactified on S^1, which has a dual gravitational description.

$$S = N \int_0^\beta dt\, \mathrm{Tr} \left\{ \frac{1}{2} (D_t X_I)^2 - \frac{1}{4} [X_I, X_J]^2 \right\}$$

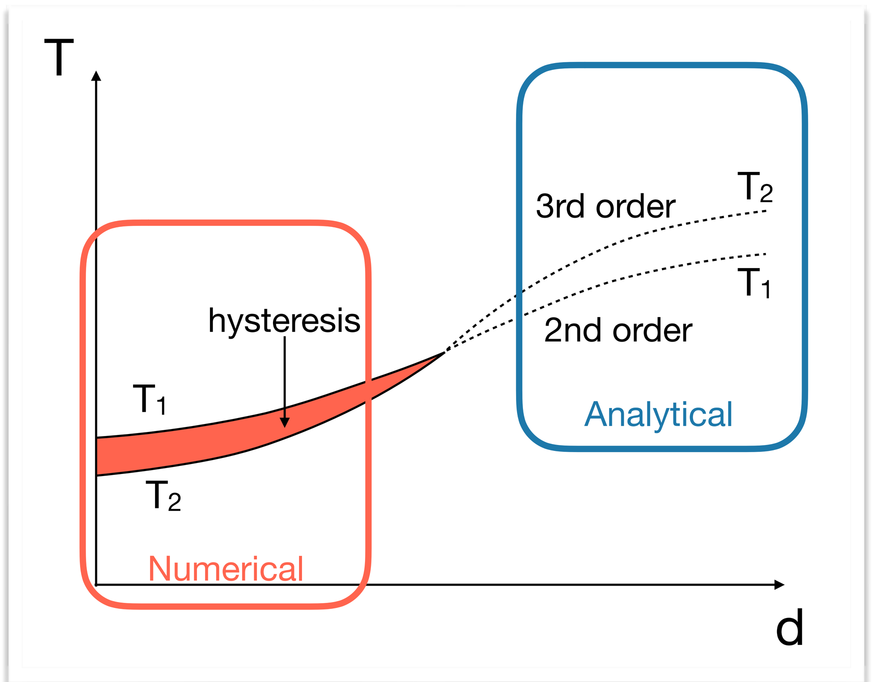
Phase transitions

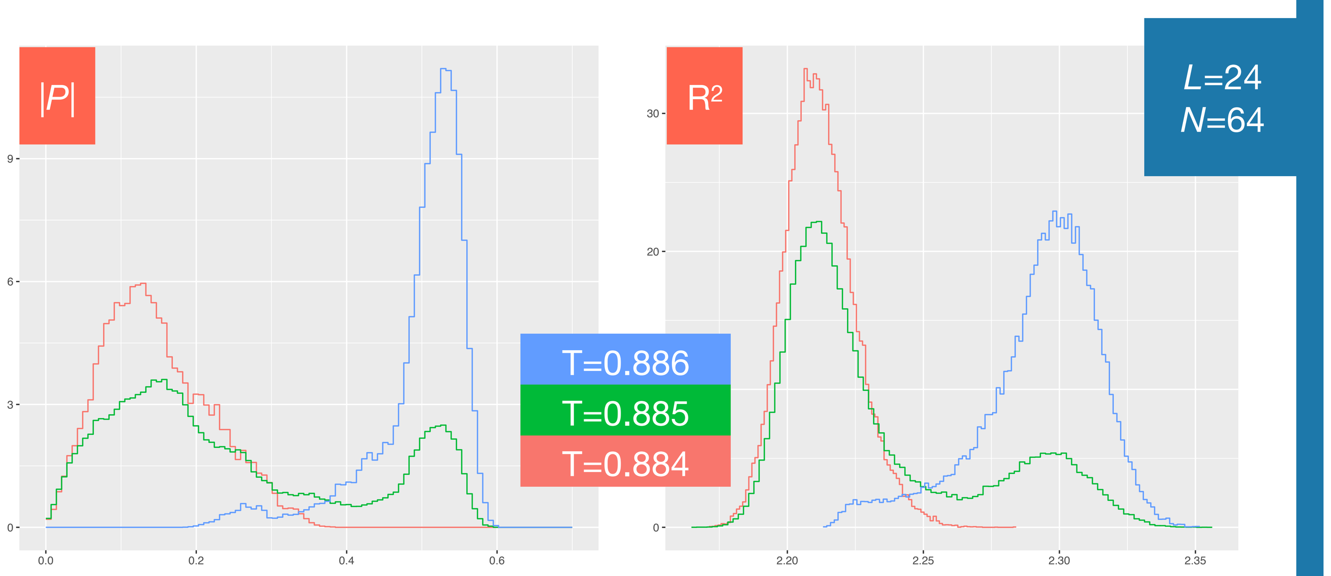
The phase transition in this model has been studied before[2] at finite **matrix size *N***, and finite **lattice spacing *L*$^{-1}$**. This 1D bosonic model admits an analytical treatment at large N and large number of matrices d[3].

✦**Analytical** results at large d predict two transitions at close temperatures T_1 and T_2, one of 2nd order and one of 3rd order. **Is *d*=9 large enough?**

✦**Numerical** results at N=32 suggest a qualitatively similar picture. **Is *N*=32 large enough?**

We discovered a **different** phase structure in the **large-*N*** limit at d=9, with a single 1st order transition:





Numerical results

★Monte Carlo method to obtain **high-statistics** samples of the system's configurations at various values of the parameters (N,L,T).

★**Order parameter** for the transition $|P|$, as well as the energy E and the "extent of space" R^2 are monitored.

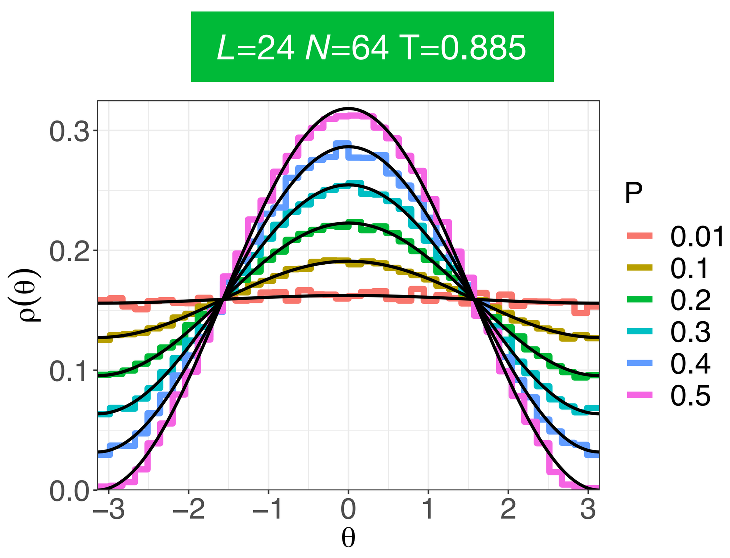
When N>32, the behavior of all observables becomes sharper around the transition. Indicates the **possibility of a discontinuity or "jump" between phases**.

We check this by looking at histograms: we see a **clear doubly-peaked distribution**, corresponding to two phases, confined and deconfined. **Hysteresis analyses** also support this claim all the way to N=64 and L=32.

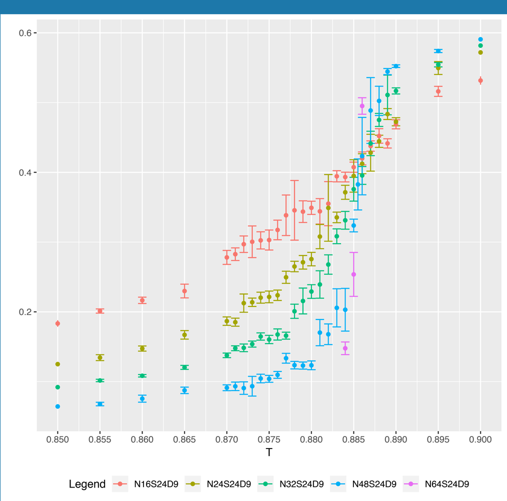
The hysteresis corresponds to an unstable phase where the $U(M)$ group with M<N is deconfined: *partial deconfinement*[4].

The distribution of the Polyakov loop eigenvalues is non uniform and non gapped:

$$\rho_p(\theta) = \frac{1}{2\pi}\left(1 + \frac{M}{N}\cos\theta\right)$$

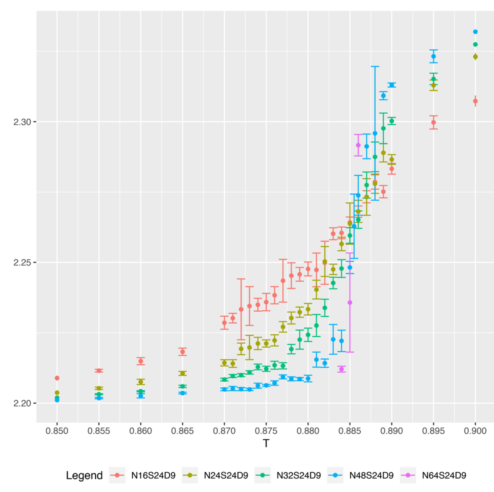


1. T. Banks, W. Fischler, S. H. Shenker, and L. Susskind, "*M theory as a matrix model: A Conjecture*," Phys. Rev. D55 (1997) 5112–5128
2. N. Kawahara, J. Nishimura, and S. Takeuchi, "*Phase structure of matrix quantum mechanics at finite temperature*," JHEP 10 (2007) 097
3. G. Mandal, M. Mahato, and T. Morita, "*Phases of one dimensional large N gauge theory in a 1/D expansion*," JHEP 02 (2010) 034
4. M. Hanada, G. Ishiki, and H. Watanabe, "*Partial Deconfinement*," JHEP 03 (2019) 145.

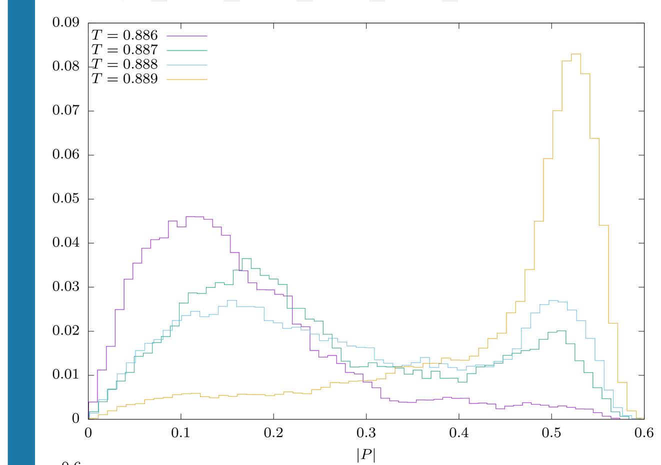


$$P \equiv \frac{1}{N} \mathrm{tr}\, U$$

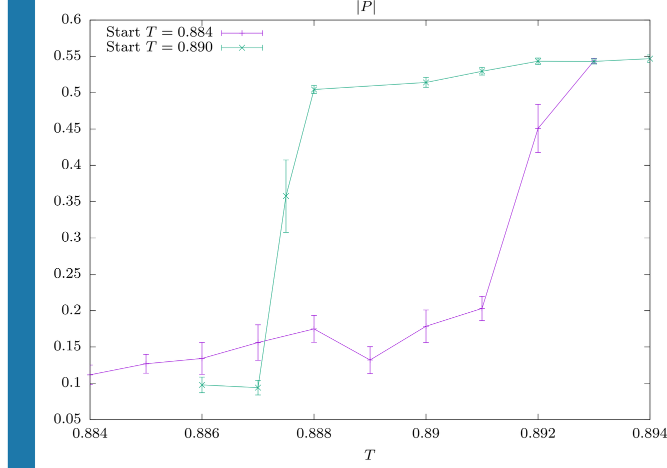
$$U \equiv \mathscr{P} \exp\left(i \int_0^\beta dt A(t) \right)$$



$$R^2 \equiv \frac{1}{N} \sum_{I=1}^{d} \mathrm{Tr}\, X_I^2$$



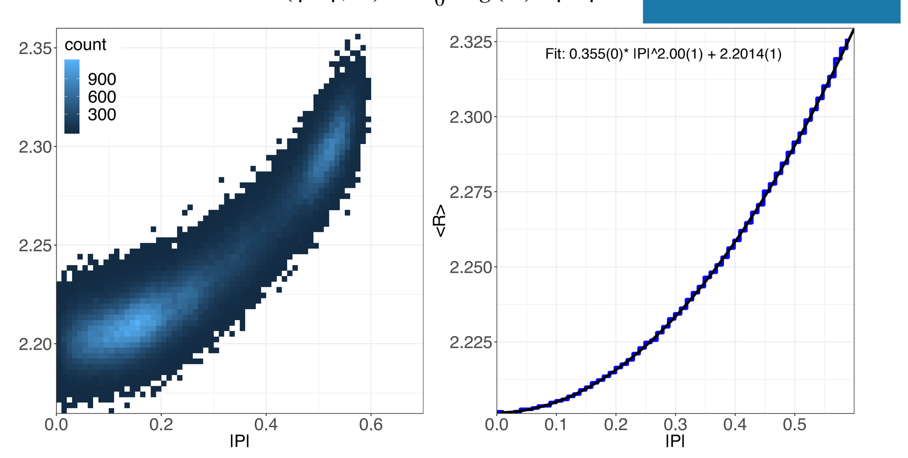
Preliminary



L=32 N=64

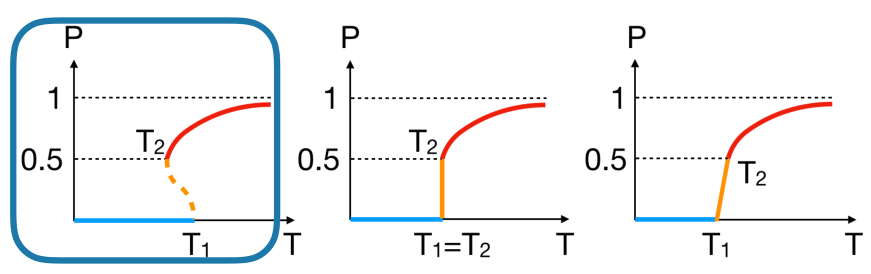
L=24 N=64 T=0.885

$$R^2(|P|, T) = R_0^2 + g(T) \cdot |P|^2$$



	$D=10$	$D=26$
T_1	0.895	0.890
T_2	0.917	0.897
ΔT_c	0.022	0.007

Large-d expansion



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*in addition, check out the nearby poster #33 by Hiromasa Watanabe for more information about *partial deconfinement*

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