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

**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, 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.

$$ S = N \int_0^\beta d\tau \left\{ \frac{1}{2} (D X)^2 - \frac{1}{4} |X| X^2 \right\} $$

**Phase transitions**

The phase transition in this model has been studied before 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 $d$. 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:

$$ P \approx \frac{1}{N} u U $$

where $U = \exp\left(\sum_a d_k \phi^a\right)$

**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 $U(1)$ group with $M$=$N$ is deconfined: partial deconfinement.

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