Thermal phase structure of a supersymmetric matrix model

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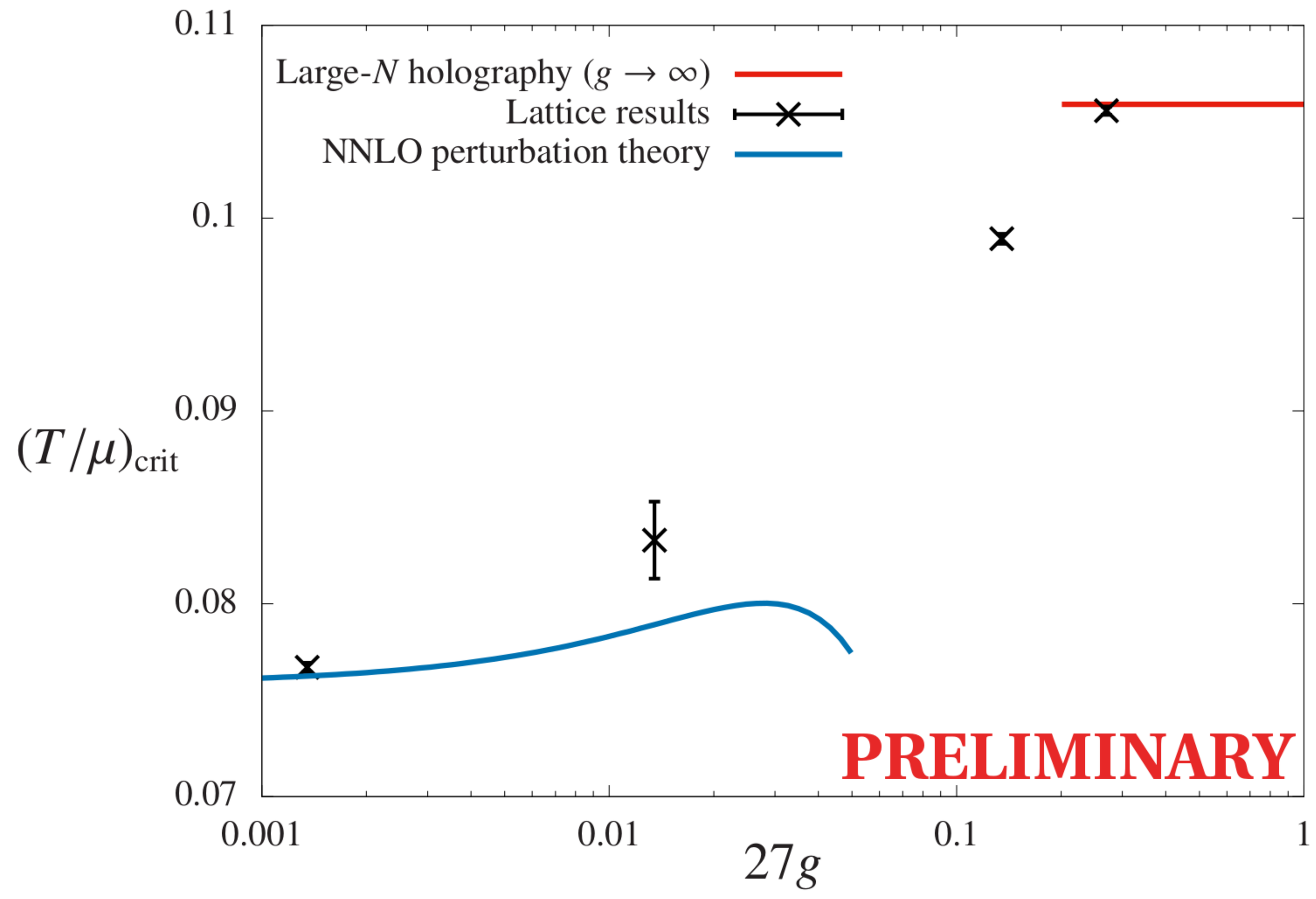
Phase diagram from lattice calculations

System: Berenstein–Maldacena–Nastase deformation of maximally supersymmetric Yang–Mills quantum mechanics

Fix dim'less coupling $g \equiv \lambda/\mu^3 = g_{YM}^2 N/\mu^3$, find dim'less transition temperature $(T/\mu)_{\text{crit}}$

Goal: Interpolate between $g \to 0$ perturbation theory and large-N $g \to \infty$ holographic prediction

Comparing gauge groups SU(N) with $N = 8, 12, 16$ lattice sizes $N_\tau = 8, 12, 16, 24$

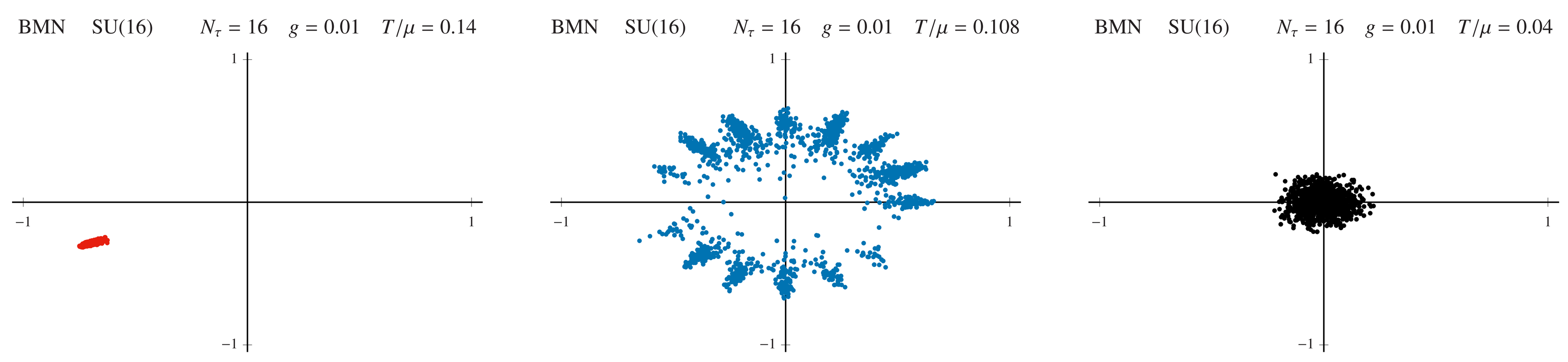


Confinement transition observables

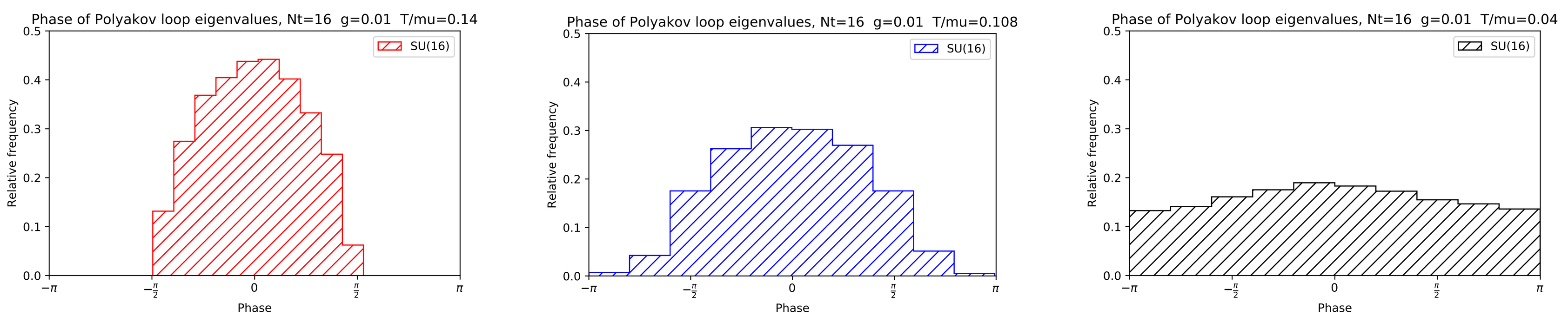
Polyakov loop (PL) trace **large** for high T/μ

Tunnels among Z_N vacua around critical T/μ

Vanishes for low T/μ (in large-N limit)



PL **eigenvalue distribution** evolves from localized to uniform

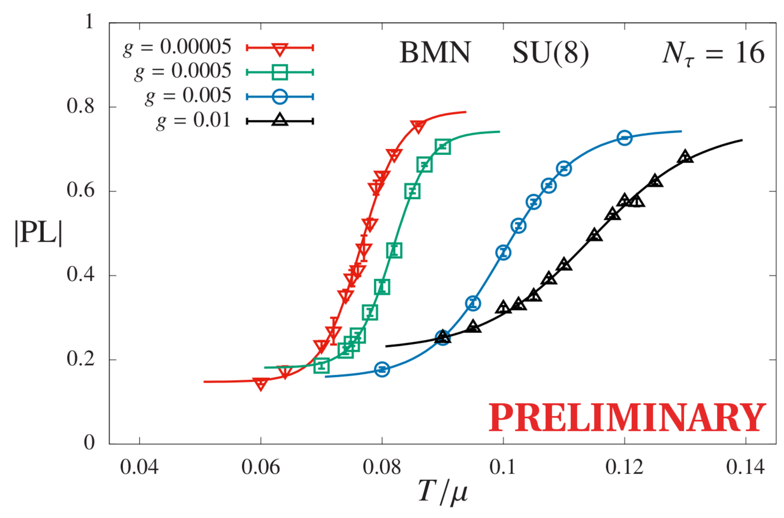


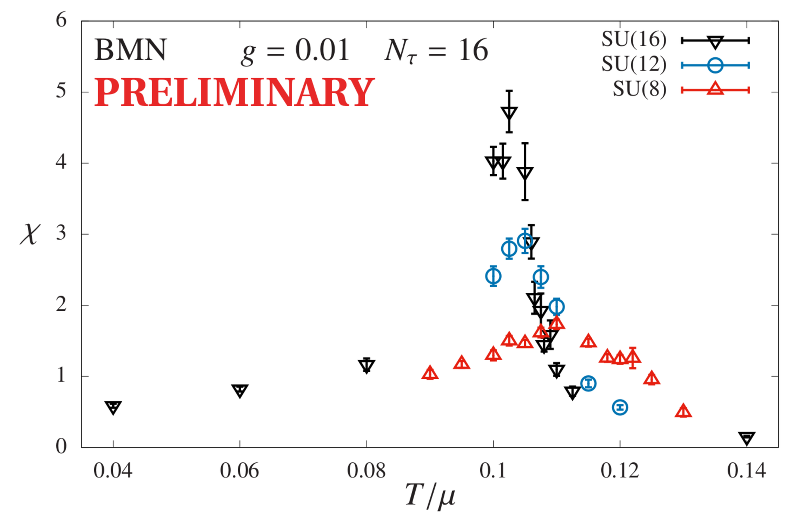
Transition signals

$(T/\mu)_{\text{crit}}$ from **interpolating** PL trace magnitude using four-parameter ansatz

$$|\text{PL}| = A - \frac{B}{1 + \exp\left[C(T/\mu - D)\right]}$$

Peaks in corresponding **susceptibility** χ match $(T/\mu)_{\text{crit}} = D$ from interpolations





Susceptibility peaks grow with N

More technical details of the system

[Berenstein–Maldacena–Nastase, hep-th/0202021]

S_0 is dim. reduction of 10d $\mathcal{N} = 1$ supersymmetric Yang–Mills with gauge group SU(N) $\longrightarrow$ 16 fermions Ψ_α and 9 scalars X_i are all $N \times N$ matrices evolving in time

S_μ is deformation splitting X_i into $3 X_{\text{I}}$ and $6 X_A$ with different masses $\longrightarrow$ lifts flat directions while preserving all 16 supersymmetries

$$S = S_0 + S_\mu$$

$$S_0 = \frac{N}{4\lambda} \int d\tau \, \text{Tr}\left[-(D_\tau X_i)^2 + \Psi_\alpha^T \gamma_{\alpha\beta}^\tau D_\tau \Psi_\beta - \frac{1}{2}\sum_{i<j}\left[X_i, X_j\right]^2 + \frac{1}{\sqrt{2}} \Psi_\alpha^T \gamma_{\alpha\beta}^i \left[X_i, \Psi_\beta\right]\right]$$

$$S_\mu = -\frac{N}{4\lambda} \int d\tau \, \text{Tr}\left[\left(\frac{\mu}{3} X_{\text{I}}\right)^2 + \left(\frac{\mu}{6} X_A\right)^2 + \frac{\mu}{4} \Psi_\alpha^T \gamma_{\alpha\beta}^{123} \Psi_\beta - \frac{\sqrt{2}\mu}{3} \epsilon_{\text{IJK}} X_{\text{I}} X_{\text{J}} X_{\text{K}}\right]$$

(with $\text{Tr}\left[T^A T^B\right] = -\delta_{AB}$)

Holography: At large N, equivalent to M-theory on "pp-wave" 11d supergravity background