

Chern-Simons Theory Coupled to Bifundamental Matter

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Précis of Chern-Simons-matter

$$S = \frac{ik}{4\pi} \int \text{Tr} \left(A dA + \frac{2i}{3} A^3 \right) + \int d^3x \left(\frac{1}{2} D_\mu \phi^n D^\mu \phi^n + V(\phi^2) \right)$$

- Simple 3D QFTs with a rich structure (many recent papers by Minwalla and collaborators)
- Non-SUSY dualities: 3D bosonization of fundamental CS-matter [Aharony et al, 2011]
- Holography: encoding Vasiliev higher-spin gravity? [Giombi, Yin 2008]
- Adjoint (bifundamental) matter in $\mathcal{N} = 6$ SUSY \mapsto ABJ(M) theory [Aharony et al, 2008]

Progress on a puzzle

Puzzle: bulk dual of CS-fundamental matter?

Two hints: $1/N$ bulk coupling, light ($m \sim 1/\sqrt{kN}$) states on a torus [Banerjee et al, 2012]

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Progress: use **bifundamental matter**, as initiated in [Chang et al, 2012]

$$S = \frac{ik}{4\pi} \int \text{Tr} \left(A dA + \frac{2i}{3} A^3 \right) - \frac{ik}{4\pi} \int \text{Tr} \left(B dB + \frac{2i}{3} B^3 \right) + \int d^3x \text{Tr} \left((D_\mu \phi)^\dagger D^\mu \phi \right) + \int d^3x \left\{ \frac{\lambda_1}{3N^2} \text{Tr} \left(\phi^\dagger \phi \right)^3 + \frac{\lambda_2}{2N^2 M} \text{Tr} \left(\phi^\dagger \phi \right) \text{Tr} \left(\phi^\dagger \phi \right)^2 + \frac{\lambda_3}{6N^2 M^2} \left[\text{Tr} \left(\phi^\dagger \phi \right) \right]^3 \right\}$$

- $SU(N)_k \times SU(M)_{-k}$ CS-matter, NM degrees of freedom
- Dial $\xi = M/N$ (bulk 't Hooft coupling) to interpolate between fundamental and adjoint theories

New results

Banerjee, Radićević 2013 – forthcoming:

$\mathcal{N} = 0$ CS-bifundamentals at weak coupling, $\lambda = \frac{N}{k} \ll 1$

- ✓ on \mathbb{R}^3 , two-loop Feynman diagram calculation
 - ↳ line of CFTs at any ξ

$$\lambda_i^* = c_i(\xi)\lambda^2$$

- ✓ on $\mathbb{R} \times T^2$, dimensionally reduce to quantum mechanics
 - ↳ perturbation theory in ξ gives a **gapped** spectrum

$$m = \xi\sqrt{\lambda\pi} + O(\xi^2)$$

Outlook

- CS theory coupled to bifundamental matter bridges the gap between vector models and adjoint matter theories with well-understood bulk duals
- Bulk duals of the newly found CFTs — connecting Vasiliev gravity and string theory (Einstein gravity)?
- New QFT calculations needed for CS-bifundamentals: correlation functions, free energy and phase structure. . .