One-dimensional subsectors in 3d supersymmetric gauge theories

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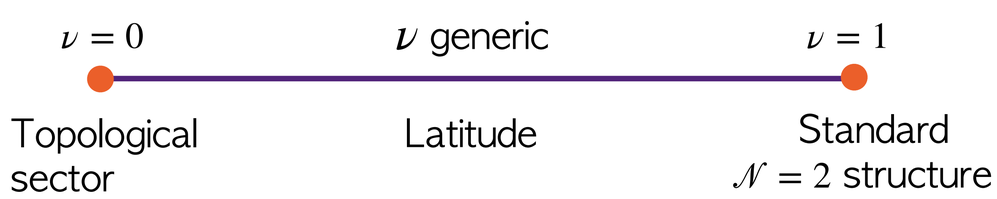
Goals and motivations

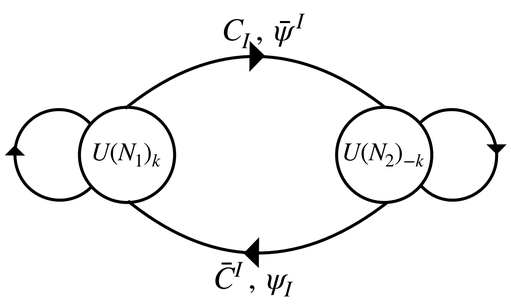
What can we learn from 1d subsectors in 3d $\mathcal{N}=4$ QFTs?

- Example of an exactly solvable subsector of a SCFT
- Compute exact CFT data
- Physics of conformal defects
- Dualities for line operators beyond mirror symmetry

Observables related to an *alternative interpolating supercharge* $\mathcal{Q}(\nu)$



The ABJM model



- Quiver Chern-Simons matter theory with $\mathcal{N}=6$ SUSY
- AdS/CFT: dual to M-theory on $AdS_7 \times S^7/\mathbb{Z}_k$

The topological sector

Set of local operators whose correlators on a line are position independent. Based on $Q=\mathcal{Q}(0)$.

- Q-exact twisted translation $\hat{P}=P+R_+=\{Q,\tilde{Q}\}$
- Operators are in the Q-cohomology iff Δ=r-charge
- Move them on the line using the twisted translation

$$\mathcal{O}(0,0,x)=e^{-ix\hat{P}}O_{h.w.}(0)e^{ix\hat{P}}$$

A special example: Operators of dimension 1 sit in the *conserved current* multiplet. For $\mathcal{N}=6$ SUSY (ABJM) they are part of the *stress tensor* multiplet.

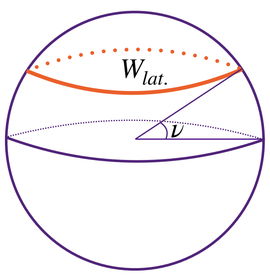
$$\mathcal{J}(x)=\mathrm{Tr}\left(U^I C_I(x) V_J \bar{C}^J(x)\right) \quad U^I=(0,1,0,x)\,,\ V^J=(0,-x,0,1)$$

The latitude Wilson loop

BPS Wilson loop in ABJM

$$W=\mathrm{Tr}_R\ Pexp\left(-i\oint_\gamma d\tau\left(\dot{x}^\mu A_\mu-\frac{2\pi i}{k}M_J^I C_I \bar{C}^J\right)\right)$$

The latitude loop



$$M_J^I=\begin{pmatrix} -\nu & e^{-i\tau}\sqrt{1-\nu^2} & 0 & 0 \\ e^{i\tau}\sqrt{1-\nu^2} & \nu & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

- 2 supercharges preserved, including $\mathcal{Q}(\nu)$
- ν deformation w.r.t. to the $\mathcal{N}=2$ Wilson loop ($\nu=1$)
- Vev from a conjectured ν-deformed matrix model

Cohomological Ward Identity

Couple flavor symmetries to background gauge fields: we get **real mass deformations**. Related with the $\Delta=1$ topological operators by the *Ward identity* [1]

$$\frac{\partial}{\partial m}S_{mass}[m]=4\pi r^2\oint_{S^1_\varphi}\mathcal{J}(\varphi)+\{Q,\dots\}$$

An application: c_T in ABJM , i.e. the coefficient of the two point function of the stress tensor

$$\langle T_{\mu\nu}(x)T_{\rho\sigma}(0)\rangle=\frac{c_T}{64}I_{\mu\nu\rho\sigma}$$

Exact results when we combine with localization!

$$c_T=-64\langle\int d\tau_1\mathcal{J}(\tau_1)\int d\tau_2\mathcal{J}(\tau_2)\rangle=-\frac{64}{\pi^2}\frac{\partial^2}{\partial m^2}\log Z[m]\Big|_{m=0}$$

Localization for the latitude

The matrix model: 1-loop determinants from a ν-squashing deformation [2]

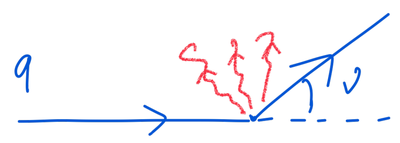
$$\langle W_{lat}\rangle=\langle \mathrm{Tr}_R\ e^{2\sqrt{\nu}\pi\lambda}\rangle_{MM}$$

$$Z_{mat}^{1-loop}=\left(\prod_{i,j}2\cosh\pi\sqrt{\nu}(\lambda_i-\mu_j)\cosh\pi\frac{(\lambda_i-\mu_j)}{\sqrt{\nu}}\right)^{-1}$$

$$Z_{vec}^{1-loop}=\prod_{i<j}2\sinh\pi\sqrt{\nu}(\lambda_i-\lambda_j)\sinh\pi\frac{(\lambda_i-\lambda_j)}{\sqrt{\nu}}$$

Brehmmstrahlung: energy emitted by a slowly moving quark or 2-pt function of the *displacement*

$$\Delta E=2\pi B(\lambda)\int dt\,(\dot{v}^2)$$



In ABJM exact relation with the latitude Wilson loop

$$B_{\frac{1}{6}}=\frac{1}{4\pi^2}\frac{\partial}{\partial\nu}\log|\langle W_L(\nu)\rangle|\Big|_{\nu=1}$$

Duality for the latitude:

- ABJM at $k=1$ dual to an UV $\mathcal{N}=4$ theory

ABJM at $k=1$ ⟷ (IR duality) UV SYM + 1 fundamental and 1 adjoint hyper

- The latitude as a novel **Wilson-vortex** loop

Latitude in ABJM ⟷ (IR duality) Mixed loop in the UV theory

- Mixed loop from a vortex worldine SQM + 1d Chern-Simons!

References

[1] L. Guerrini, S. Penati, and I. Yaakov, "Generating functions for Higgs/Coulomb branch operators from 1d–3d cohomological equivalence," *JHEP*, vol. 04, p. 171, 2022.

[2] L. Griguolo, L. Guerrini, and I. Yaakov, "Localization and duality for ABJM latitude Wilson loops," *JHEP*, vol. 08, p. 001, 2021.