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Non-unitary TQFTs from 3D $\mathcal{N} = 4$ rank 0 SCFTs

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We propose a novel procedure of assigning a pair of non-unitary topological quantum field theories (TQFTs), $\mathrm{TFT}_{\pm}[\mathcal{T}_{\mathrm{rank}\ 0}]$, to a (2+1)D interacting $\mathcal{N} = 4$ superconformal field theory (SCFT) $\mathcal{T}_{\mathrm{rank}\ 0}$ of rank 0, i.e.\ having no Coulomb and Higgs branches. The topological theories arise from particular degenerate limits of the SCFT. Modular data of the non-unitary TQFTs are extracted from the supersymmetric partition functions in the degenerate limits. As a non-trivial dictionary, we propose that $F = \max_\alpha \left(-\log|S_{0\alpha}^{(+)}|\right) = \max_\alpha \left(-\log|S_{0\alpha}^{(-)}|\right)$, where F is the round three-sphere free energy of $\mathcal{T}_{\mathrm{rank}\ 0}$ and $S_{0\alpha}^{(\pm)}$ is the first column in the modular S-matrix of $\mathrm{TFT}_{\pm}$. From the dictionary, we derive the lower bound on F, $F \geq -\log\left(\sqrt{\frac{5-\sqrt{5}}{10}}\right) \simeq 0.642965$, which holds for any rank 0 SCFT. The bound is saturated by the minimal $\mathcal{N} = 4$ SCFT proposed by Gang-Yamazaki, whose associated topological theories are both the Lee-Yang TQFT. We explicitly work out the (rank 0 SCFT)/(non-unitary TQFTs) correspondence for infinitely many examples.

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