Entanglement along a massless flow: the tricritical Ising model

Federico Rottoli[1*]
David Horváth[1], Filiberto Ares[1], Pasquale Calabrese[1,2]

[1]SISSA and INFN, Trieste
[2]ICTP, Trieste

Entanglement entropy and twist fields

- The entanglement entropies

$$S = -\operatorname{Tr} \rho_A \log \rho_A, \qquad S_n = \frac{1}{1-n} \log \left[\operatorname{Tr} \rho_A^n\right]$$

can be computed via the replica trick

$$\operatorname{Tr} \rho_A^n = \left\langle \mathcal{T}_n(0) \widetilde{\mathcal{T}}_n(\ell) \right\rangle.$$

with *twist fields* $\mathcal{T}_n$.

- The symmetry resolved entropies are computed from the *composite twist fields* $\mathcal{T}^\mu$

$$\mathcal{T}_n^\mu = :\mathcal{T}_n \, \mu: \ .$$

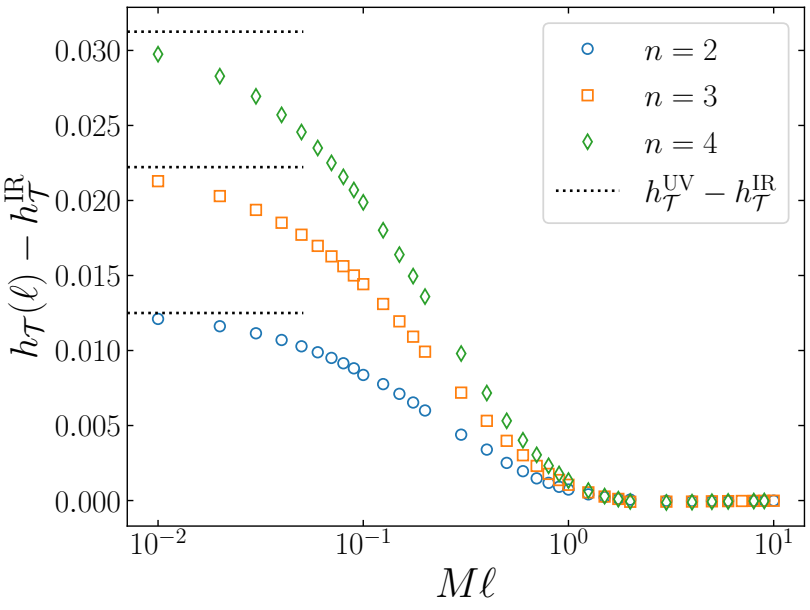
Twist field form factors

- Via the form factor bootstrap we obtain the form factors of both standard $\mathcal{T}_n$ and composite twist fields $\mathcal{T}_n^\mu$ up to 4-particles

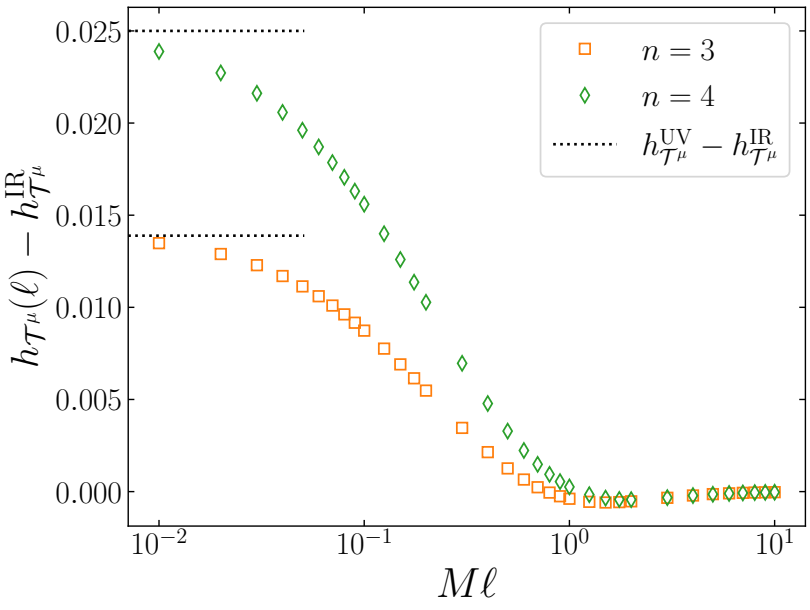
$$F_{r,l}^{\mathcal{T}|j_1\dots j_1'\cdots}(\theta_1,\dots;n) = \langle 0|\,\mathcal{T}_n\,|\theta_1,\dots,\theta_1',\dots\rangle_{j_1\dots,j_1'\dots}$$

- The form factors have an even number of left- or right-movers.
- All those with only left- or right-movers are identical to the ones in massive Ising.
- At 4-particle order: $F_{2,2}^{\mathcal{T}|j_1 j_2 j_1' j_2'}$ couples left- and right-movers.

Delta-sum rule



(a) Running dimension of branch point twist field $\mathcal{T}_n$



(b) Running dimension of composite twist field $\mathcal{T}_n^\mu$

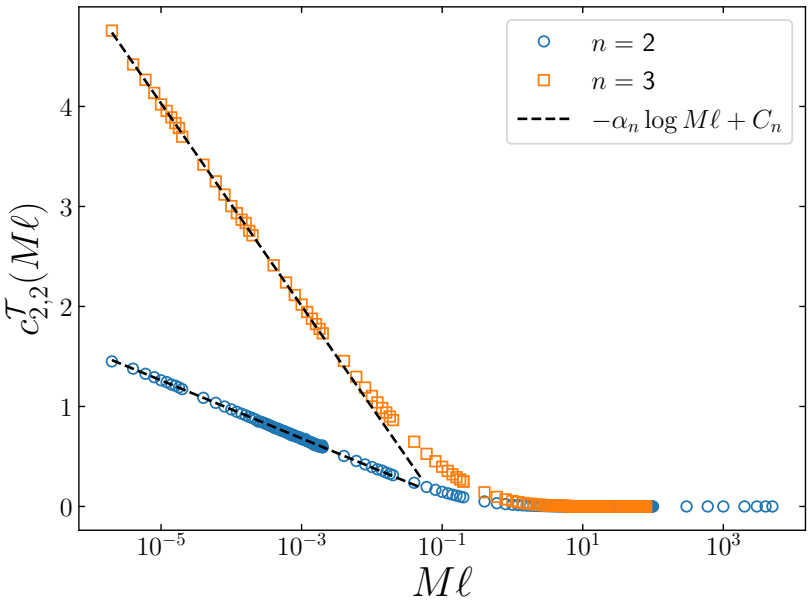
Entanglement entropy: cumulant expansion

- Spectral expansion of Rényi entanglement entropies

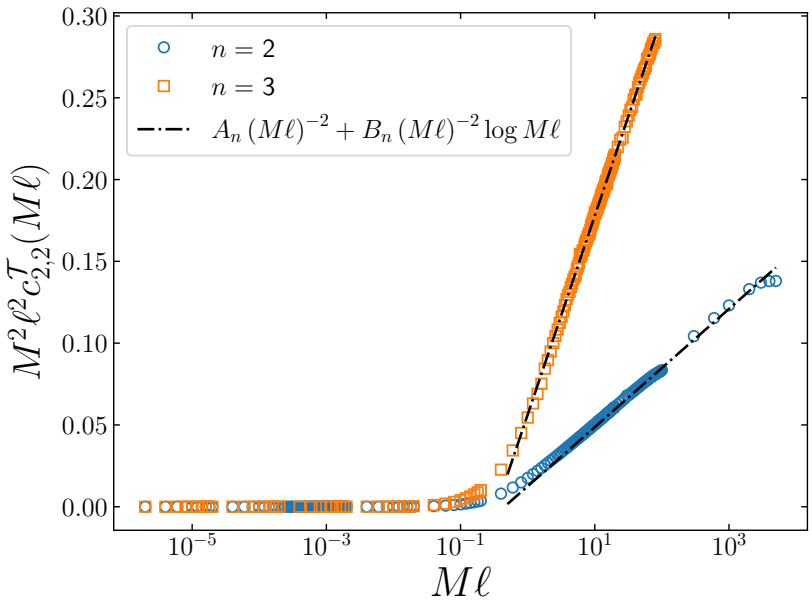
$$(1-n)S_n(M\ell) = \log \left\langle \mathcal{T}_n(0)\, \widetilde{\mathcal{T}}_n(\ell) \right\rangle \approx \sum_{r,l \text{ even}} c^{\mathcal{T}}_{r,l}(M\ell; n) + \text{const}$$

- Two different cumulants
  - non-interacting: only either right- or left-movers $c^{\mathcal{T}}_{r,0}$, $c^{\mathcal{T}}_{0,l}$
    Equal to massive Ising up to the energy: reproduce Ising CFT logarithmic entropy!
  - interacting: couples right- and left-movers: correction to IR entropy

Entanglement entropy: smallest correction



(a) Semilogarithmic plot of $c^{\mathcal{T}}_{2,2}$ for $n = 2, 3$ replicas.



(b) Semilogarithmic plot of $c^{\mathcal{T}}_{2,2}$ times ℓ^2 for $n = 2, 3$ replicas.

Thank you for your attention!