



Contribution ID: 86

Type: **Talk (30 min)**

Negative tripartite information after quantum quenches in integrable systems

Monday, 4 September 2023 15:50 (30 minutes)

We build the quasiparticle picture for the tripartite mutual information (TMI) after quantum quenches in spin chains that can be mapped onto free-fermion theories. A nonzero TMI (equivalently, topological entropy) signals quantum correlations between three regions of a quantum many-body system. The TMI is sensitive to entangled multiplets of more than two quasiparticles, i.e., beyond the entangled-pair paradigm of the standard quasiparticle picture. Surprisingly, for some nontrivially entangled multiplets the TMI is negative at intermediate times. This means that the mutual information is monogamous, similar to holographic theories. Oppositely, for multiplets that are “classically” entangled, the TMI is positive. Crucially, a negative TMI reflects that the entanglement content of the multiplets is not directly related to the Generalized Gibbs Ensemble (GGE) that describes the post-quench steady state. Thus, the TMI is the ideal lens to observe the weakening of the relationship between entanglement and thermodynamics. We benchmark our results in the XX chain and in the transverse field Ising chain. In the hydrodynamic limit of long times and large intervals, with their ratio fixed, exact lattice results are in agreement with the quasiparticle picture.

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Session Classification: Bologna Workshop CFT-IM