Subregion Entanglement and Complexity in Thermally Perturbed CFTs

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Abstract: We compute the holographic entanglement entropy and subregion complexity of spherical boundary subregions in the uncharged and charged AdS black hole backgrounds, with the change in these quantities being defined with respect to the pure AdS result. This calculation is done perturbatively in the parameter R/zh, where zh is the black hole horizon and R is the radius of the entangling region. We provide analytic formulae for these quantities as functions of the boundary spacetime dimension d including several orders higher than previously computed. We observe that the change in entanglement entropy has definite sign at each order and subregion complexity has a negative sign relative to entanglement entropy at each of those orders (except at first order or in three spacetime dimensions, where it vanishes identically).

Combining pre-existing work on entanglement thermodynamics, the "complexity equals volume" conjecture, and the conjectured relationship between Fisher information and bulk entanglement, suggests a relation analogous to the first law of thermodynamics in which entanglement plays the role of heat and complexity plays the role of work. The relation between work and complexity is non-universal and order-dependent indicating that there may exist additional information-theoretic quantities appearing at higher orders.

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References

[1] A. Bhattacharya, K.T Grosvenor and S. Roy, arXiv 1905.02220.