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The upper bound of holographic n-partite information

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To analyze the holographic multipartite entanglement structure, we study the upper bound for holographic n-partite information I_n that n-1 fixed boundary subregions A,B,... participate together with an arbitrary region E for n=3,4,5. In all cases that we study, we could find regions E that make I_n tends to the information upper bound. For n=3, we prove that the upper bound of conditional mutual information I(A:B|E) is given by a quantity which we name the entanglement of holographic purification EoHP(A:B). For n=4,5, we find that the upper bound of I_n is finite in CFT_{1+1} but has UV divergences in higher dimensional CFT, which reveals a fundamental difference in the entanglement structure between CFT_{1+1} and higher dimensional CFTs. Moreover, the relationship between the convexity of regions A,B,... and multipartite entanglement they participate is also revealed in higher dimensional case. We argue that (I_n) fully accounts for multipartite entanglement in these upper bound critical points, in contrast to usual cases where I_n is not a perfect measure for multipartite entanglement. These results suggest that fewer-partite entanglement in holography fully emerges from more-partite entanglement, and any n-1 small convex regions are fully n-partite entangling in general.

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