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Holographic entanglement beyond classical gravity

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The Renyi entropies and entanglement entropy of 1+1 CFTs with gravity duals can be computed by explicit construction of the bulk spacetimes dual to branched covers of the boundary geometry. At the classical level in the bulk this has recently been shown to reproduce the conjectured Ryu-Takayanagi formula for the holographic entanglement entropy. We study the one-loop bulk corrections to this formula. The functional determinants in the bulk geometries are given by a sum over certain words of generators of the Schottky group of the branched cover. For the case of two disjoint intervals on a line we obtain analytic answers for the one-loop entanglement entropy in an expansion in small cross-ratio. These reproduce and go beyond anticipated universal terms that are not visible classically in the bulk. We also consider the case of a single interval on a circle at finite temperature. At high temperatures we show that the one-loop contributions introduce expected finite size corrections to the entanglement entropy that are not present classically. At low temperatures, the one-loop corrections capture the mixed nature of the density matrix, also not visible classically below the Hawking-Page temperature.

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