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Gluing Black Hole Entropies Across Dimensions

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We investigate quantum corrections to the supersymmetric entropy of BPS black holes in 4d N=2 effective field theories, derived from Type IIA string theory on a Calabi–Yau threefold. These corrections arise from an infinite series of higher-derivative F-terms modifying the two-derivative supergravity action. Within the large volume regime, we analyze their moduli dependence as well as the implications for black hole entropy. Our results reveal a clear-cut connection between the perturbative entropy expansion parameter and the ratio of the black hole horizon to the (dual) M-theory Kaluza-Klein scale, allowing us to resum the series into a well-defined expression valid beyond the latter energy cutoff. By closely examining the D0-D2-D4 and D2-D6 BPS systems, we show how perturbative quantum effects resolve the apparent UV divergences, leading to a consistent entropy function for all values of the expansion parameter. Moreover, in certain cases, we recover the exact microstate counting of the corresponding five-dimensional black string via circle decompactification. Notably, non-perturbative corrections do not alter our conclusions, further supporting the robustness of our findings.

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