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On the running of gauge couplings in string theory

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String theories naturally give rise to infinite towers of states whose degeneracies grow exponentially as functions of mass. These infinite towers of states are ultimately responsible for many of the finiteness properties for which string theory is famous. Recently, a framework was developed in which the effects of all of these states can be incorporated in a self-consistent way when calculating quantities relevant for low-energy phenomenology, such as the masses of the Higgs fields that arise in such theories. This formalism also gives rise to an "on-shell" effective field theory description in which the final results are expressed in terms of contributions from only the on-shell, level-matched physical string states, and in which these quantities also exhibit an EFT-like "running" as a function of an effective spacetime mass scale. In this talk I'll discuss hot to apply this formalism to calculate the running of the gauge couplings within closed string theories. Unlike previous calculations in the literature, our calculation fully respects the underlying closed-string modular invariance and expresses many of the final results in terms of contributions from only the on-shell physical string states. We find, however, that the calculation of the gauge couplings differs in one deep way from the calculation of the Higgs mass: while the latter results depend on the supertraces over only the on-shell string states, the former results have a different modular structure which causes them to depend on supertraces over the off-shell string states as well. Taken together, our results yield the expected logarithmic running of the gauge couplings at certain energy scales. However, they also yield a number of intrinsically stringy behaviors that transcend what might be expected within an effective field theory approach.

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