The Standard Model in External Gravity and the Dilaton

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Gravity couples to the Standard Model, in the weak gravitational field limit, via its energy momentum tensor (EMT) $T^{\mu\nu}$. This interaction is responsible for the generation of the radiative breaking of scale invariance [1–3], which is mediated, at leading order in the gauge coupling ($O(g^2)$), by a triangle diagram: the TVV' vertex (see [4–7]), where V, V' denote two gauge bosons. The computation of the vertex is rather involved, due to the very lengthy expression of the EMT in the electroweak theory, but also not so obvious, due to the need to extract the correct external constraints which are necessary for its consistent definition. In the case under exam they correspond to the TAA, TAZ and TZZ vertices, where A is the photon and Z the neutral massive electroweak gauge boson. The explicit computation of these radiative corrections (i.e. of the anomalous action) finds two direct applications. The first has to do with the analysis of anomaly mediation as a possible mechanism to describe the interaction between a hypothetical hidden sector and the fields of the Standard Model. One of the results of our analysis, in this context, is that anomaly mediation is described by the exchange of anomaly poles in each gauge invariant sector of the perturbative expansion. This feature, already present in the QED and QCD cases, is indeed confirmed by the direct computation in the entire electroweak theory. One of the main implications of our analysis, in fact, is that this picture remains valid even in the presence of mass corrections due to symmetry breaking, for a graviton of large virtuality and a conformally coupled Higgs sector. A second area where these corrections may turn useful is in the case of an electroweak theory formulated in scenarios with large extra dimensions (LED), with a reduced scale for gravity. In this case the virtual exchanges of gravitons provide sizeable corrections to electroweak processes - beyond tree level - useful for LHC studies of these models, in the case of the $q\bar{q}$ annihilation channel. In these extensions a graviscalar (radion) ϕ degree of freedom is induced by the compactification, which is expected to couple to the anomaly (ϕT^μ_μ) as well as to the scaling-violating terms. This prescription is based on the replacement of the classical trace of the matter EMT by its quantum average. This interaction can be thought as being mediated by an effective massless dilaton, coupled to the trace anomaly equation (and to its mass corrections).

The interaction of the SM with external gravity is the starting point, more generally, for the analysis of the coupling of a dilaton, interepreted as a Goldstone mode of a spontaneously broken scale invariance, with the fields of the Standard Model. We have already pointed out that the dilaton can be interpreted both as a fundamental scalar degree of freedom as well as a possible effective one. These points are under investigation.

REFERENCES

1. M. Duff, Nucl.Phys. **B125**, 334 (1977).
2. S. L. Adler, J. C. Collins, and A. Duncan, Phys. Rev. **D15**, 1712 (1977).
3. D. Z. Freedman, I. J. Muzinich, and E. J. Weinberg, Ann. Phys. **87**, 95 (1974).
4. M. Giannotti and E. Mottola, Phys. Rev. **D79**, 045014 (2009), arXiv:0812.0351.
5. R. Armillis, C. Corianò, and L. Delle Rose, (2009), arXiv:0910.3381.
6. R. Armillis, C. Corianò, L. Delle Rose, and L. Manni, (2010), arXiv:1003.3930.
7. R. Armillis, C. Corianò, and L. Delle Rose, Phys.Rev. **D82**, 064023 (2010), arXiv:1005.4173.