High Energy Theory/ Gravity Group

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1. Vacuum stability of the effective potential and Yukawa couplings

The research interests of the group cover the theory of the fundamental interactions, with application to astroparticle theory, gravity and cosmology, together with general aspects of quantum field theory.
In the context of elementary particle theory, the activity of 2015 has concerned some high precision studies of the Higgs potential of extensions of the Standard Model (SM) under the constraint of their perturbative stability, building on previous analysis. This research has been carried out assuming the presence of a $U(1)_{B-L}$ extra neutral current in the electroweak sector, with a scalar potential which is minimally enlarged by the inclusion of one additional complex scalar beside the Higgs doublet. Such studies are motivated by the strong sensitivity of the renormalization group evolution of the couplings of the potential of the SM to small variations (in the GeV range) of the mass of the top quark. In the absence of any new interaction above the electroweak scale it appears to be metastable. We have elaborated on the realistic possibility that such behaviour is a precursor of new physics. We have shown that other Yukawa couplings largely affect the stability issue if one includes a realistic mechanism for the generation of the SM neutrinos masses such as a Type I seesaw. In this case such generalized models allow not only metastable phases, as in the SM case, but also completely stable ones, up to the Planck scale. Extensions of these analysis to more general scenarios, based on Grand Unification schemes are underway.

2. Holographic Cosmology

Holographic models of the universe are reaching a significant level of phenomenological predictivity and for this reason we have performed a study of some specific correlation functions in the ADS/CFT (Anti-De Sitter/Conformal Field Theory) correspondence using a boundary field theory, with the goal of testing the gravitational power spectrum predicted by such models in three space dimensions. This study has required the computation of some specific correlation functions of the boundary field theory at two-loop level. At the same time a numerical comparison of the perturbative result at weak coupling using the most recent Planck data has been performed (work in collaboration with Prof. Kostas Skenderis, University of Southampton).

3. Radiative effects in lensing

We have extended previous studies of gravitational lensing in the context of quantum field theory in a weak gravitational background. We have shown that radiative effects in the propagation of SM particles (photons and neutrinos) in gravitational backgrounds allow to define a modified expression of the angular deflection exerted by a black hole on an incoming beam as a function of its impact parameter. This analysis is performed in a classical gravitational background in the weak field limit. In particular, it has been shown that the use of such perturbative expansions provides results which are in agreement with those predicted by General Relativity. This agreement has been verified down to scattering regions involving values of the impact parameter which are comparable with the event horizon of a Schwarzschild black hole. The study shows that the inclusion of such contributions brings in a violation of the equivalence principle, because of the energy dependence of the deflection. We have studied the impact of these results on the classical formalism of gravitational lensing, introducing semiclassical lens equations.

4. Triplet Higgs

Extensions of the SM with the inclusion of a triplet Higgs have been investigated by us in the case of a supersymmetric theory. We have focused our attention on the phenomenological implications of a scenario derived from the next to minimal supersymmetric Standard Model (NMSSM) with the inclusion of a superfield in the form of a triplet of $SU(2)$ in the corresponding superpotential. The model, termed the TNMSSM, has a wider parameter space compared to the NMSSM which is largely compatible with the most recent LHC bounds from ATLAS and CMS. Particular attention has been devoted to the analysis of the structure of the final states generated within such a model. As in the NMSSM the superpotential includes also a SM singlet superfield. Both the triplet and singlet scalars generate interesting mass hierarchies among the CP even and CP odd sectors of this theory, which have been described in our recent works.

REFERENCES

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