FCNC processes into extra dimensional models

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We have studied manifestation of NP in rare processes. Our attention was devoted to lepton flavour violation processes and top quark rare decays. We have estimated lepton flavour violation processes rates and concluded that three body decays and $\mu-e$ conversion seem more favourable then radiative decays.

Success of the Standard Model (SM) do not weaken theoretical arguments in favour of New Physics (NP), which is aticipated at the TeV scale. The task to find and identify NP seems to us to be as a most important challenge for High Energy Physics. In spite of successes of SM of particle physics and SM of cosmology (based on traditional theory of General Relativity), there are profound experimental and theoretical reasons to suppose that both of them are incomplete. From the experimental point of view to this opinion hint, for example, the small but non vanishing neutrino masses and small but non vanishing value for cosmological constant, the presence of dark matter, dark energy and baryon assimmetry of the Universe. Theoretical problems include hierarchy problem, supersimmetry breaking, replication of fermion generations and highly hierarchical structure of fermion mass matrixes, CP – conservation in QCD etc.

Very important is the quuestion on how to identify the manifestation of NP and how to give the preference to some special kind of SM expansion. As a most promissing extentions of the SM are considered SUSY extentions, based on the idea of supersimmetry [1] and approaches with large extra dimensions [2], though there are also more radical ways beyond SM.

In the framework of extra dimensional models with the fundamental gravity scale around ~TeV the NP is expected to manifest itself around this scale. As soon as indicated scale will be tested, for example at LHC energies, NP must manifest itself. The question is only in which form it manifests itself. The most direct way to manifest and analyze experimental patterns of NP could consist in the direct production of the new particles like supersimmetric or Kaluza-Klein (KK) resonances. Another possibility consists in the indirect manifestation of the effects beyond SM. Before showing in the direct production processes, beyond SM effects could manifest themselves in the rare decays through the various loop effects. The importance of such a possibility is hard to be overestimated. To differ various NP scenarios, we are in need to investigate their influence on the aromatodynamics.

Exciting time is for fundamental physics, after the LHC experiments announced about discovery of neutral Higgs particle on July the 4th. Many in the community expect a new paradigm to emerge around the TeV scale, be it some variant of SUSY or of Technicolour or something even more radical, like extra (space) dimensions. Those novel structures can manifest themselves directly through the production of new quanta or the topology of events or indirectly by inducing forces that modify rare weak decays. Such indirect searches are not a luxury. We consider it likely that to differentiate between different scenarios of New Physics, one needs to analyze their impact on flavor dynamics.

Lepton flafour violation (LFV) processes first arise in the Standard Model (SM) with neutrino mixing at the one loop level with the exchange by W-bosons and leptons. In the charged lepton sector the branching ratios for LFV processes are suppressed by factor m_ν^2 / M_W^2 and bounded by neutrino oscillation experiments. These processes are very sensitive to the New Physics (NP) beyond the SM (BSM), because of some possible mechanism which enhance them. In some extensions of the SM the rates of LFV processes enhance and become close to the modern experimental limitations. The NP can manifest themselves directly through the production of new quanta or the topology of events or indirectly by inducing forces that modify rare LFV processes. Such indirect searches are not a luxury. We consider it likely that to differentiate between different scenarios of NP, one needs to analyze their impact on flavor dynamics.

The goal of this note is just the analysis of LFV processes via intermediate black hole in the large extra dimension scenario. Namely, our attention will be devoted to $\mu \to e\gamma$, $\mu \to ee\bar{e}$ decays and muonium (μ^+e^-) to antimuonium (μ^-e^+) oscillation. Black holes of the effective Planck range M_{Pl}~1 Tev naturally arisen in extra dimension theories[2]. Morevever, LHC is considered as a factory for TeV scale black holes (M_{bh}~1TeV).

LFV processes are intensively investigated in large extra dimension scenarios. As these studied show in case when theoretical approaches are not enriched other way than simply adding extra dimension to the SM, there is hard to get theoretical predictions close to experimental bounds.

From common theoretical sense it is expected that LFV processes would possible enhance in case when particles running in the appropriate loops have close masses [3]. Loop amplitudes with comparable masses of intermediate particles running in the loop seem to be quite large because the generic quadratic suppression factor is changed to a linear one. Such a situation with comparable masses in principle is realizable in the models with extra dimensions. On the other hand it is not obvious without specific calculations how would be changed the SM estimate of the above processes in the models with extra dimensions. Some details of the models can enhance suitable amplitudes and others can cause suppression. On general grounds, one expects an enhancement of the amplitudes, but this expectation is not fulfilled because of the almost degeneracy of the massive neutrino towers modes from different generations. This is not necessarily the last word, though; the black hole can inspire LFV processes and anhance them [4].

We accept the conjecture that black holes violate global symmetries [4] including lepton number. So, black holes could manifest themselves in LFV processes as intermediate states and enhance them. We assume that black holes with mass lighter than effective Planck mass have a zero charges (electric, color) and zero angular moment in the classical case and this future is adopted by quantum gravity too.

Let us mention that usual hierarchy of LFV processes $\mu \to e\gamma$, $\mu \to 3e$ seems like $Br(\mu \to e\gamma) > Br(\mu \to 3e)$. It is not excluded vice-versa situation in some BSM approaches, which could be interesting from the point of view NP. On the other hand , the search for $l \to 3l$ decays could be more favourable by some experimental reasons even if $Br(l \to 3l)$ is a little less than $Br(l_i \to l_j\gamma)$. In this aspect even more intriguing would be situation with the hierarchy $Br(l \to 3l) > Br(l_i \to l_j\gamma)$. This case is just the situation which could be predicted by the case of LFV via intermediate black hole processes $Br(\mu \to 3e) > Br(\mu \to e\gamma)$.

Before their direct detection NP effects may manifest themselves in rare processes. One can conclude that we have good chance to discover NP in LFV processes. If extra dimensions scenario realize at O(1 TeV) level, it is possible to discover their traces in LFV processes and tree lepton LFV decay $\mu \to ee\overline{e}$ and muonium-antimuonium oscillation seem favorable.

We have discussed one of the ways on the theoretical road for manifestation of NP in the top quark sector, particularly, in the top FCNC decays. As our analyses show the ED models with only one additional spatial dimension cannot raise branching ratios for top FCNC decays. Experimental observation of a few events with these decays opens the possibility for NP intervention different from the ED.

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