Letter of Interest on Lepton universality and lepton flavor conservation tests with dineutrino modes

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Abstract

It was recently shown that charged dilepton couplings can be directly linked to dineutrino couplings via flavor-summed dineutrino observables when SU(2)-invariance is assumed to hold [1]. This relation can be used to perform tests of lepton universality (LU) and charged lepton flavor conservation (cLFC) for $|\Delta c| = |\Delta u| = 1$ transitions. Model-independent upper limits on dineutrino branching ratios, which can be achieved with e^+e^-–facilities, such as BES III, Belle II and also future colliders like the FCC-ee running at the Z, have been already worked out [1]. As the Standard Model (SM) predictions for rare charm dineutrino modes lie well below the future experimental prospects, any experimental signal would cleanly hint to physics beyond the SM and, in addition, the SU(2)-link would allow to disentangle the type of new physics (NP) behind it. Our goal is to provide a detailed study exploiting this link in the charm sector, showing its potential as well as providing NP predictions for different SM extensions [2].

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FCNC transitions such as rare decays of heavy quarks represent a very promising avenue to search for physics beyond the SM: as the leading order contributions in the SM appear with loop and CKM-suppressions, new physics, which does not have to follow the same structures, can show up with mass scales at the TeV and above.

Rare decays into dineutrinos $q \to q' \nu \bar{\nu}$ constitute a special case of FCNC transitions, due to both its strong suppression and the fact that a SM extension is needed to explain neutrino masses. On the experimental side, dineutrino modes are challenging as the neutrinos cannot be reconstructed, requiring a clean environment such as an e^+e^--facility to perform missing energy measurements. In particular, $c \to u \nu \bar{\nu}$ transitions are strongly Glashow-Iliopoulos-Maiani (GIM)-suppressed in the SM leading to tiny branching ratios and their observation with current experimental sensitivities would cleanly signal NP [3].

A link between charged dilepton and dineutrino couplings emerges in dineutrino observables when imposing SU(2)-invariance [1], which is independent of the details of the Pontecorvo-Maki-Nakagawa-Sakata (PMNS) matrix and makes tests of LU and cLFC possible. In Ref. [1] model-independent upper limits were presented for rare charm dineutrino transitions. The presented model-independent approach utilized an additional SU(2)-link between $c \to u$ and $s \to d$ transitions. The bounds in [1] are based on high-p_T searches [4, 5] and highlight the connections between different sectors as well as approaches of NP searches in flavor physics. At this point it is worth noting the unique role of charm physics as a clean environment to unravel possible NP contributions behind present anomalies, which are currently seen in the down-sector. Notably, lepton universality violation is hinted in semileptonic rare b-decays; it is not unlikely that the very same phenomenon has manifestations in the charm sector as well. Therefore, we aim to provide a detailed work on the complementarity of different charm modes, as well as the study of its experimental sensitivities [2].

Upper limits on branching ratios of dineutrino modes can be either obtained using constraints on (leptonic) couplings from high-p_T or employing low energy bounds, where the latter provide much stronger limits in some modes, but allow for cancellations of contributions with different chiralities. Therefore, further investigations in this direction are needed [2]. Additionally, we plan to investigate the inclusion of light right-handed neutrinos in our effective theory. These will change the limits on branching ratios and will be compared to the previous limits where only SM-like neutrinos are considered.

References

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