CHARM BEYOND THE STANDARD MODEL

PROBING POSSIBLE MANIFESTATIONS OF NEW DYNAMICS IN CHARM TRANSITIONS.

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Abstract

CP violation has been observed in the K and B meson systems and can possibly be accommodated within the KM ansatz in the Standard Model. However, it has been argued for long that to generate the observed matter-antimatter asymmetry, CP violation in excess of what can be accommodated within the SM is necessary. With current results from CDF and LHCb on the asymmetry in $D^0 \to \pi^+\pi^-$ and $D^0 \to K^+K^-$ the ambiguity on whether D physics can or is showing hints of new dynamics has been given a new life. While there are reasonable arguments that the role of new dynamics in these asymmetries is apparent, it can also be well argued that what we see can possibly be accommodated within the SM. As this is one of the very few tangible signals of possible new dynamics, it has become increasing important that charm comes under rigorous experimental scrutiny once again.

SM contribution to rare charm decays are tiny and hence they stand ripe for the intervention of new dynamics. These modes are dominated by long distance contributions and for new dynamics to produce any enhancements to the decay rates, the short distance contribution to these modes have to be enhanced by orders of magnitude, a task which is difficult in most new dynamics scenarios. Of course, there is a way out.

Asymmetries are insensitive to long distance contributions and are usually driven by short distance physics. There are certain scenarios of new dynamics in which asymmetries like the forward-backward asymmetry ($A^{c}_{\rm FB}$) and the CP asymmetry in the forward-backward asymmetry ($A^{\rm CP}_{\rm FB}$) can be enhanced by orders of magnitude above SM expectations in the inclusive decay modes $D \to X_u l^+ l^-$. Although $A^{c}_{\rm FB}$ remains around a modest value of 1% in these scenarios, $A^{\rm CP}_{\rm FB}$ can be as large as $O(10^2)$.

Three body final states are also important modes that can show hints of new dynamics and are richer in experimental observables than two body modes where only the decay rates and the difference in those of conjugate states can be probed. Some three body decay modes of both the charged and the neutral D meson system can show CP violation and a detailed 2D Dalitz plot analysis needs to be done. Although, this comes at a premium of statistics, a lot more can be learnt about the nature of new dynamics from this kind of an analysis. Also, CP asymmetries thus measured do not depend on the relative production of conjugate states, a case which is important in an environment where there are inherent production asymmetries. For four body decay modes, one can look into T-odd correlations. This can be done with a pair of pseudoscalars and a pair of leptons in the final state or with a hadronic final state