Contribution ID: **313** Type: **Talk**

Electromagnetic corrections to leptonic decay rates of charged pseudoscalar mesons: finite volume effects.

Wednesday, July 27, 2016 11:50 AM (20 minutes)

In Ref.[1] we proposed a method for calculating leptonic (and semileptonic) decay rates of pseudoscalar mesons including $O(\alpha)$ electromagnetic corrections. Because of the presence of infrared divergences, this requires the calculation of contributions with both virtual and real photons. We have shown that the real photon contribution, by integrating up to photon momenta of the order of 20-30 MeV, can be calculated by treating the meson as a point-like particle. The corrections to this approximation are negligible because a very soft photon cannot resolve the internal structure of the hadron.

For the virtual contribution we need to integrate over all photon momenta and the point-like effective theory is not a valid approximation. For this reason we proposed to compute the virtual contribution by a non-perturbative lattice simulation. The logarithmic infrared divergences are properly regulated by the finite volume and are cancelled by subtracting from the non-perturbative lattice results the virtual decay rate calculated in the point-like approximation.

In this talk we discuss two main analytic results. First we give the explicit analytical expression of the finite volume virtual decay rate in the point-like approximation, necessary for the cancellation of the infrared divergences. We also show explicitly that the $O(1/L)$ finite volume corrections (FVC) to the virtual decay rate are universal, i.e. they are the same in the full theory and in the point-like effective theory. They therefore cancel in the difference of the non-perturbative decay rate and that in the point-like approximation. Structure dependent terms start to contribute to the FVC at $O(1/L^2)$ only.

With the theoretical results discussed in this talk all the ingredients are now in place to compute the decay rates at $O(\alpha)$. The numerical results from an exploratory non-perturbative lattice calculation will be presented by S. Simula in a companion talk.

[1]. N. Carrasco et al., Phys. Rev. D91 (2015) 074506.

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Session Classification: Weak Decays and Matrix Elements

Track Classification: Weak Decays and Matrix Elements