Tesis Doctoral

Departamento de Física Teórica

"A Glance into Flavour Physics with Effective Field Theories and Machine Learning"

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Abstract:

In the last years there has been a growing interest in the study of deviations from the predictions of the Standard Model of particle physics in the context of Flavour Physics. This dissertation is devoted to the study of these deviations, with special focus on those involving B mesons.

The interest on deviations from the Standard Model predictions is twofold: theoretical questions not yet solved and recent experimental measurements showing this kind of deviations. In our research we study two classes of these experimentally-interesting observables: the semileptonic decays of B mesons into K or K* mesons and a pair of charged leptons through flavour-changing neutral currents, characterized by the RK(*) ratios between the muonic and the electronic branching ratios; and the semileptonic decays of B mesons into D or D* mesons, a charged lepton and a neutrino through flavour-changing charged currents, characterized by the RD(*) ratios between the tauonic and the light branching ratios. We use the framework of Effective Field Theories, being able to obtain constraints on New Physics contributions to the Wilson coefficients of the effective Lagrangian from the experimental results. A global fit, including observables from all affected sectors, is considered. The sheer number of observables involved makes mandatory the use of numerical calculations, and in the most extreme cases, even using Machine Learning tools such as regression trees and SHAP (SHAPley Additive exPlanation) values. We use for the first time in the flavour context a Montecarlo analysis to extract the confidence intervals and correlations between observables, showing that it constitutes a suitable strategy to use in this kind of analysis. Although most of the dissertation deals with the framework of Effective Field Theories, we have also extrapolated our results to specific models of New Physics; leptoquarks and W' and Z' bosons. We have also performed a more in-deep analysis of a model for Axion-Like Particles, pseudoscalars that could appear as pseudo-Nambu-Goldstone bosons for new global U(1) symmetries. Unlike the traditional approaches, we have examined the case where the Axion-Like Particles have a non-trivial flavour structure in their couplings to quarks and leptons.

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