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$|V_{cb}|$, LFU and $SU(3)_F$ symmetry breaking in $B_{(s)} \to D^{(*)}_{(s)}\ell\nu_\ell$ decays using Lattice QCD and Unitarity

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We present an application of the unitarity-based dispersion matrix (DM) approach of Ref. [1] to the extraction of the CKM matrix element $|V_{cb}|$ from the experimental data on the exclusive semileptonic $B_{(s)} \to D^{(*)}_{(s)}\ell\nu_\ell$ decays [2-4]. The DM method allows to achieve a non-perturbative, model-independent determination of the momentum dependence of the semileptonic form factors. Starting from lattice results available at large values of the 4-momentum transfer and implementing non-perturbative unitarity bounds [5], the behaviour of the form factors in their whole kinematical range is obtained without introducing any explicit parameterization of their momentum dependence. We consider the four exclusive semileptonic $B_{(s)} \to D^{(*)}_{(s)}\ell\nu_\ell$ decays and extract $|V_{cb}|$ from the experimental data for each transition [2-4]. The average over the four channels is $|V_{cb}| = (41.4 \pm 0.8)\cdot 10^{-3}$, which is compatible with the latest inclusive determination at 1σ level. We address also the issue of Lepton Flavour Universality by computing pure theoretical estimates of the τ/ℓ ratios of the branching fractions for each channel. In the case of a light spectator quark we obtain $R(D^*) = 0.275(8)$ and $R(D) = 0.296(8)$, which are compatible with the corresponding experimental values within 1.3σ. In the case of a strange spectator quark we obtain $R(D_s^*) = 0.2497(60)$ and $R(D_s) = 0.298(5)$. The different values for $R(D_s^*)$ and $R(D^*)$ may reflect $SU(3)_F$ symmetry breaking effects, which seem to be present in some of the lattice form factors, especially at large values of the recoil.

[1] M. Di Carlo, G. Martinelli, M. Naviglio, F. Sanfilippo, S. Simula, and L. Vittorio, *Unitarity Bounds for Semileptonic Decays in Lattice QCD*, Phys. Rev. D 104, 054502 (2021), arXiv:2105.02497 [hep-lat].

[2] Martinelli, G. and Simula, S. and Vittorio, L., *$|V_{cb}|$ and $R(D^{(*)})$ using lattice QCD and unitarity*, arXiv:2105.08674[hep-ph].

[3] Martinelli, G. and Simula, S. and Vittorio, L., *Exclusive determinations of $|V_{cb}|$ and $R(D^*)$ through unitarity*, arXiv:2109.15248 [hep-ph].

[4] G. Martinelli, M. Naviglio, S. Simula, and L. Vittorio, *$|V_{cb}|$, Lepton Flavour Universality and $SU(3)_F$ symmetry breaking in semileptonic $B_s \to D_s^{(*)}\ell\nu_\ell$ decays through unitarity and lattice QCD*, arxiv:2204.05925 [hep-lat].

[5] G.Martinelli, S.Simula and L.Vittorio, *Constraints for the semileptonic $B \to D^{(*)}$ form factors from lattice QCD simulations of two-point correlation functions*, Phys. Rev. D 104 (2021) no.9, 094512 doi:10.1103/PhysRevD.104.094512 [arXiv:2105.07851 [hep-lat]].

In-person participation

Yes

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