Duality Violation

Current results from theory and experiment (ATLAS, CMS, LHCb) on $\Delta \Gamma_s$ constrain quark-hadron duality violation to around 30% [1]. From this result, we can quantify whether deviations of $a_d$ from theory could be explained by duality violation, or whether they would be unambiguous signs of NP.

The future scenarios assume a reduction in the theory error – we need lattice contributions for dimension-6 and dimension-7 operators (some in progress – see talk by M. Wingate at Heavy Flavour 2016, Lattice 2016).

Improved dimension-6 operators

Most recent lattice calculation from earlier this year [3]. As an example, look at $\Delta \Gamma_s$:

Lattice has allowed us to reduce the theory error by around 1/3 – but the central value has shifted away from experiment. Calculations by more lattice groups essential for assessing this.

B Meson Lifetime Ratio

Very strong NP bounds can be obtained using the lifetime ratio $\tau(B_s)/\tau(B)$, as there is strong cancellation in the SM calculation. The most recent theory calculation of $\tau(B_s)/\tau(B)$ is $1.00050 \pm 0.00108$. Around 80% of this error comes from lattice calculation of colour-suppressed bag parameters $\epsilon_{1,2}$:

$$\langle B | (\bar{b}(1 - \gamma^5)T^a_q) \otimes (\bar{q}(1 - \gamma^5)T^a_q) | B \rangle = f_B^2 M_B^2 \epsilon_1$$

$$\langle B | (\bar{b}(1 - \gamma^5)T^a_q) \otimes (\bar{q}(1 - \gamma^5)T^a_q) | B \rangle = f_B^2 M_B^2 \epsilon_2$$

Last result comes from 2001 proceedings [2]:

$$\epsilon_1 = -0.02 \pm 0.02 \quad \epsilon_2 = 0.03 \pm 0.01$$

New results for these parameters are urgently needed.

Charm Lifetimes

The status of the Heavy Quark Expansion (HQE) in charm sector is almost unknown – an ideal testing ground is charm meson lifetimes. The most recent results are very promising [4]

$$\frac{\tau(D^+)}{\tau(D^0)}_{\text{HQE}} = 2.2 \pm 1.7 \quad \frac{\tau(D^+)}{\tau(D^0)}_{\text{exp.}} = 2.536 \pm 0.019$$

No lattice calculations of the lifetime matrix elements are available, leading to huge hadronic uncertainties seen above. Some work has been done for charm mixing matrix elements [5] – however calculation of lifetime matrix elements is crucial for precision tests of the HQE.

References