Looking forward to new lattice results

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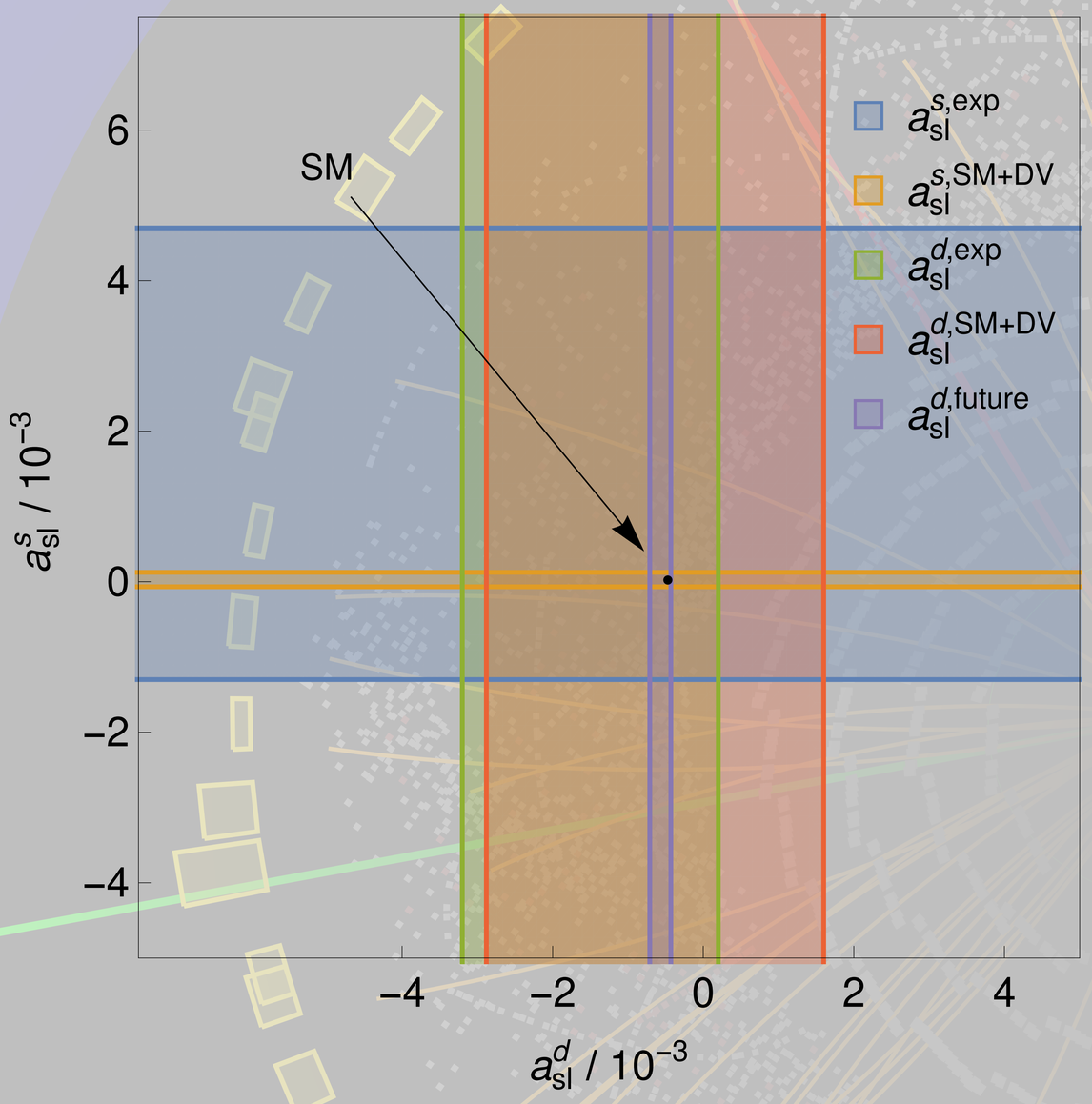
Duality Violation

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_{sl} 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).

B Meson Lifetime Ratio

Very strong NP bounds can be obtained using the lifetime ratio $\tau(\mathrm{B_s^0})/\tau(\mathrm{B_d^0})$, as there is strong cancellation in the SM calculation. The most recent theory calculation of $\tau(\mathrm{B_s^0})/\tau(\mathrm{B})$ is 1.00050 ± 0.00108. Around 80% of this error comes from lattice calculation of colour-suppressed bag parameters $\epsilon_{1,2}$.

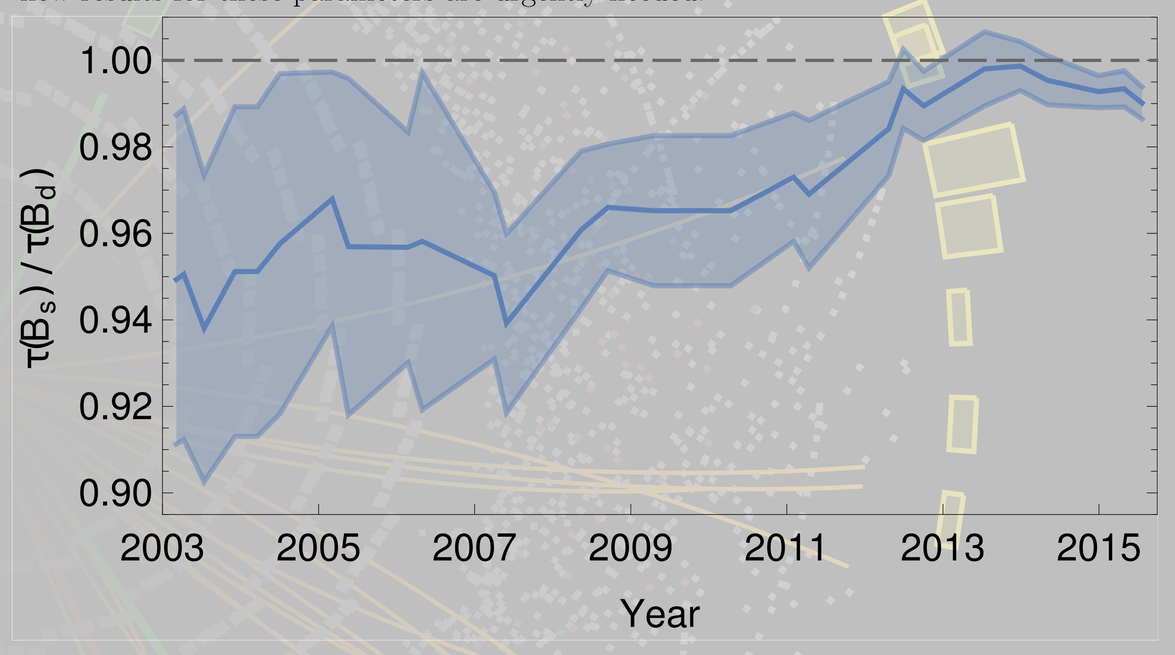
$$\left\langle B \left| (\bar{\mathrm{b}}\gamma_\mu(1-\gamma^5)T^a q) \otimes (\bar{q}\gamma^\mu(1-\gamma^5)T^a \mathrm{b}) \right| B \right\rangle = f_\mathrm{B}^2 M_\mathrm{B}^2 \epsilon_1$$

$$\left\langle B \left| (\bar{\mathrm{b}}(1-\gamma^5)T^a q) \otimes (\bar{q}(1-\gamma^5)T^a \mathrm{b}) \right| B \right\rangle = f_\mathrm{B}^2 M_\mathrm{B}^2 \epsilon_2$$

Last result comes from 2001 proceedings [2]:

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

Experimental error has drastically shrunk over the last 15 years, as seen below, and so new results for these parameters are urgently needed.



Charm Lifetimes

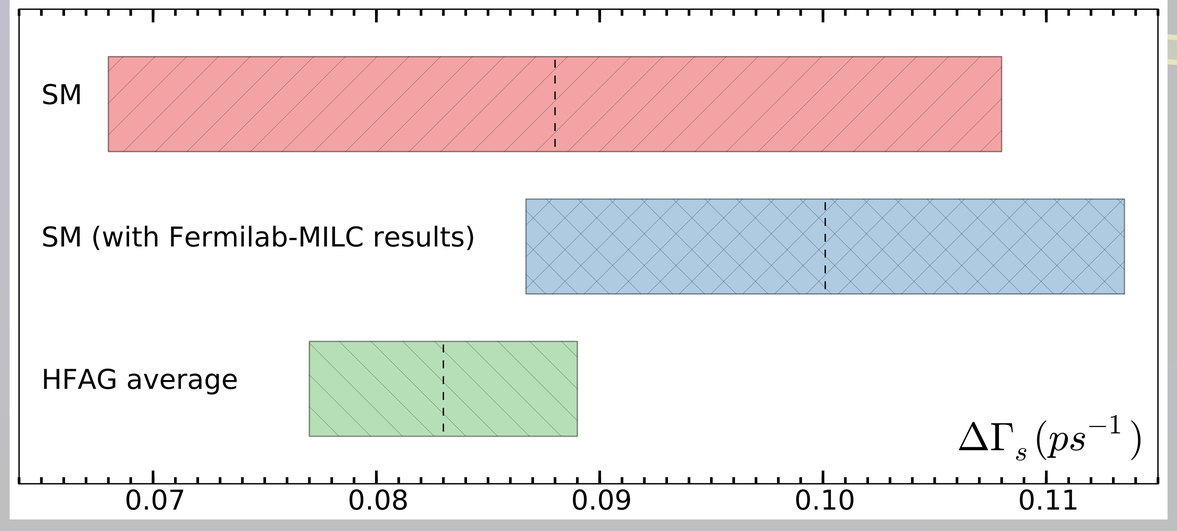
The status of the Heavy Quark Expansion (HQE) in charm sector is almost unknown – an ideal testing ground is charm meson lifetimes. The most recent results are very promising [4]

$$\left.\frac{\tau(\mathrm{D^+})}{\tau(\mathrm{D^0})}\right|_\mathrm{HQE} = 2.2 \pm 1.7 \qquad \left.\frac{\tau(\mathrm{D^+})}{\tau(\mathrm{D^0})}\right|_\mathrm{exp.} = 2.536 \pm 0.019$$

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

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.

References

[1] T. Jubb, M. Kirk, A. Lenz and G. Tetlalmatzi-Xolocotzi, Nucl. Phys. B **915** (2017) 431 [arXiv:1603.07770 [hep-ph]].

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[4] A. Lenz and T. Rauh, Phys. Rev. D **88** (2013) 034004 [arXiv:1305.3588 [hep-ph]].

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