Using $\Lambda_b \to \Lambda\mu^+\mu^-$ data within a Bayesian analysis of $|\Delta B| = |\Delta S| = 1$ decays†

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The tensions between theory and experiment for $P_{s}^{\prime}$, one of the angular observables in the kinematic distribution of the decay $B \to K^{*}(\to K\pi)\mu^+\mu^-$, have sparked much interest in the determination of the short-distance couplings in flavor-changing neutral currents of the form $b \to s f^+\ell^-$. Several competing global analyses that use the available data on such rare decays of $B$ mesons to various degrees find that a negative shift in one of the Wilson coefficients, $C_9$, improves the agreement with the data. However, it remains unclear whether this effect is caused by physics beyond the Standard Model, or merely by uncontrolled hadronic contributions.

The baryonic rare decay $\Lambda_b \to \Lambda(\to p\pi^-)\mu^+\mu^-$ offers complementary constraints compared to the commonly used mesonic channels. A recent lattice QCD calculation of the relevant $\Lambda_b \to \Lambda$ form factors enables us to evaluate the $\Lambda_b \to \Lambda(\to p\pi^-)\mu^+\mu^-$ observables with high precision. In this work, we studied the constraining power of the $b$-baryon decay in a global analysis of $|\Delta B| = |\Delta S| = 1$ decays. Our analysis includes the following observables:

- For the baryonic decay $\Lambda_b \to \Lambda(\to p\pi^-)\mu^+\mu^-$ we used the LHCb measurements of the differential branching fraction $(B)_{15,20}$, the lepton-side forward-backward asymmetry $(A^L_{FB})_{15,20}$, and the hadron-side forward-backward asymmetry $(A^H_{FB})_{15,20}$, all in the bin $15\text{ GeV}^2 \leq q^2 \leq 20\text{ GeV}^2$.

- For the decay $\bar{B}_s \to \mu^+\mu^-$, we included the time-integrated branching ratio from a combined analysis of the CMS and LHCb collaborations.

- We use the Belle and Babar measurements of the branching ratio of the inclusive mode $B \to X_s\ell^+\ell^-$ in the bin $1\text{ GeV}^2 \leq q^2 \leq 6\text{ GeV}^2$.

We performed a Bayesian analysis of several scenarios, including the Standard Model (where only nuisance parameters are fitted) and scenarios in which subsets of the Wilson coefficients are allowed to float. The 2D-marginalized posterior for the $C_9$-$C_{10}$ scenario is shown in Fig. 1. The best-fit point has $C_9 - C_{10}^{SM} = +1.6^{+2.7}_{-0.9}$, which is opposite in sign compared to the global fits of mesonic-only decays. Furthermore, the posterior odds favor the Standard Model over the scenarios in which Wilson coefficients are allowed to float. The uncertainties in our analysis of $\Lambda_b \to \Lambda(\to p\pi^-)\mu^+\mu^-$ are currently dominated by experiment, and will be reduced with higher-statistics results and a full angular analysis expected in the near future.

References
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† Condensed from the article in Phys. Rev. D 94, 013007 (2016)
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