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Electroweak penguins in isospin-violating B_s decays

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The 2.5σ discrepancy between theory and experiment observed in the difference $\Delta A_{\rm CP} = A_{\rm CP}(B^- \to \pi^0 K^-) - A_{\rm CP}(\bar{B}^0 \to \pi^+ K^-)$ can be explained by a new electroweak (EW) penguin amplitude. Motivated by this result, we have analyzed the purely isospin-violating decays $\bar{B}_s \to \phi\pi^0$ and $\bar{B}_s \to \phi\rho^0$, which are dominated by EW penguins. Our results extend the analysis in [1] and have recently been published in [2]. Here we give a brief overview of the outcome.

We show that in presence of a new EW penguin amplitude the two B_s branching ratios can be enhanced by an order of magnitude without violating any constraints from other hadronic B decays. This makes them very interesting modes for LHCb and Super B factories. We perform both a model-independent analysis and a study within realistic New Physics (NP) models such as a modified-Z^0-penguin scenario, a model with an additional Z' boson and the MSSM, including a fit to $B \to \pi K$ data and the relevant experimental constraints throughout. In the model-independent case we study effective $b \to s\bar{q}q$ couplings and distinguish between several possible chirality structures. Constraints arise from a large number of hadronic B decays such as $B \to \pi K^{(*)}, \rho K^{(*)}, \phi K^{(*)}$ etc. The preferred fit regions are rather large and allow for order-of-magnitude enhancements (see plots). In concrete models the new amplitude can often be correlated with other flavour phenomena, such as semileptonic B decays and B_s-$\bar{B}_s$ mixing, which set stringent constraints on the enhancement of the two B_s decays. In particular we find that, contrary to claims in the literature, EW penguins in the MSSM can reduce the discrepancy in $\Delta A_{\rm CP}$ only marginally. Consequently no visible enhancement of $\bar{B}_s \to \phi\pi^0, \phi\rho^0$ is expected for this model. As byproducts of our work we update the Standard Model (SM) predictions to $BR(\bar{B}_s \to \phi\pi^0) = 1.6^{+1.1}_{-0.3} \cdot 10^{-7}$ and $BR(\bar{B}_s \to \phi\rho^0) = 4.4^{+2.7}_{-0.7} \cdot 10^{-7}$ and perform a state-of-the-art analysis of $B \to \pi K$ amplitudes in QCD factorisation (QCDF).

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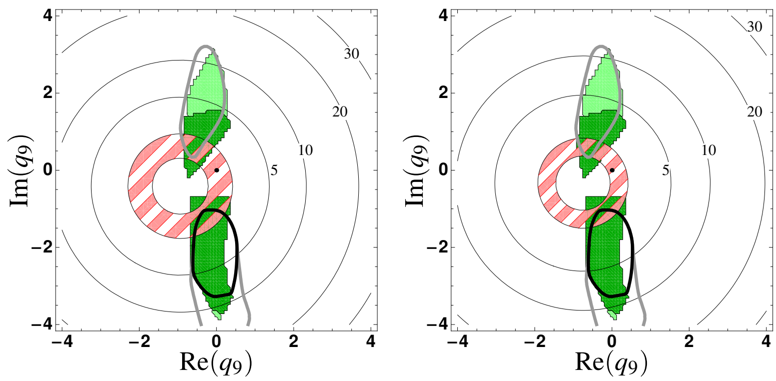
Amplitude structure of $\bar{B}_s \to \phi\pi^0$ and $\bar{B}_s \to \phi\rho^0$: The two decay modes discussed here are *pure* $\Delta I = 1$ transitions, which means that there are no QCD penguin contributions at all. Calculating both amplitudes in QCDF the dominant SM contribution comes from a Z^0 penguin with pollution from a CKM- and colour-suppressed tree amplitude and possibly from OZI-suppressed singlet annihilation. We provide convenient approximate expressions for the amplitudes in [2].

Effects of new EW penguin amplitudes: We study the effects of new EW penguin amplitudes in different ways:

a) We parameterise the new amplitudes in a model-independent way via complex numbers q_i. Here we show the enhancement factors (circles) of $BR(\bar{B}_s \to \phi\pi^0)$ (left) and $BR(\bar{B}_s \to \phi\rho^0)$ (right) w.r.t. the SM as a function of q_9, corresponding to an EW $b_L \to s_L \bar{q}_L q_L$ penguin. For $|q_9| = 1$ the corresponding SM penguin receives a 100% correction. Dark green areas are allowed by constraints from hadronic B decays while the solid black lines mark the preferred (1σ) region of the $B \to \pi K$ fit. Lighter areas and lines only take into account observables particularly sensitive to isospin-violation. The hatched rings mark the theoretical uncertainty of the SM branching ratios. We see that an order-of-magnitude enhancement is possible for both branching ratios. The same is true for several right-handed and mixed NP amplitudes.



b) We calculate the new amplitudes in concrete NP models. We find that flavour-changing Z-couplings cannot produce large effects because of tight constraints from semileptonic B decays. These constraints can be relaxed in Z' models since the Z' couplings to leptons are unknown. The most important constraint in this model comes from $B_s - \bar{B}_s$ mixing, it allows for enhancements of up to a factor of ~ 5 in the B_s decays. In the MSSM we find that no large isospin-violating effects are possible at all, neither in ΔA_{CP} nor in the two B_s decays.

Conclusion: We strongly encourage experimental efforts towards a measurement of $\bar{B}_s \to \phi\pi^0$ and $\bar{B}_s \to \phi\rho^0$ at LHCb and Super B factories.

References

[1] L. Hofer, D. Scherer, L. Vernazza, *Search for New Physics in Electroweak Penguins via B_s Decays*, *Acta Phys. Polon.* **B3** (2010) 227-233.

[2] L. Hofer, D. Scherer, L. Vernazza, *$\bar{B}_s \to \phi\rho^0$ and $\bar{B}_s \to \phi\pi^0$ as a handle on isospin-violating New Physics*, `arxiv:1011.6319`.