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INCLUSIVE DIRECT CP-ASYMMETRIES IN CHARMLESS $\mathrm{B}^{\pm}$–DECAYS[a]

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Direct CP-asymmetries in inclusive decay modes can be cleanly calculated by exploiting quark-hadron duality. This is in sharp contrast to CP-asymmetries in exclusive channels, where unknown strong phases prevent a clean extraction of CKM parameters from measured CP-asymmetries. We have calculated the inclusive CP-asymmetries in $B^{\pm}$–decays into charmless final states with strangeness one or strangeness zero. In our results large logarithms are properly summed to all orders. We find

$$a_{CP}\,(\Delta S=0) \;=\; \left(2.0^{+1.2}_{-1.0}\right)\%, \qquad\qquad a_{CP}\,(\Delta S=1) \;=\; (-1.0\pm 0.5)\,\%.$$

The constraints on the apex $(\overline{\rho},\overline{\eta})$ of the unitarity triangle obtained from these two CP-asymmetries define circles in the $(\overline{\rho},\overline{\eta})$-plane. $a_{CP}\,(\Delta S=0)$ measures $\sin\gamma\cdot|V_{cb}/V_{ub}|$. The presented work has been done in collaboration with Gaby Ostermaier and Alexander Lenz.

First we define the average branching fraction in terms of the decay rate Γ:

$$\overline{Br} \;=\; \frac{\Gamma\left(B^{+}\to X\right)+\Gamma\left(B^{-}\to\overline{X}\right)}{2\Gamma_{tot}}. \tag{1}$$

In the following we are interested in inclusive final states X containing no charmed particle. Further the total strangeness S of X must be known, we will consider the cases $X = X\,(S=0)$ and $X = X\,(|S|=1)$. Similarly we define the direct CP-asymmetries as

$$A_{CP} \;=\; \frac{1}{2}\left[Br\left(B^{+}\to X\right)-Br\left(B^{-}\to\overline{X}\right)\right], \qquad\qquad a_{CP} \;=\; \frac{A_{CP}}{\overline{Br}}. \tag{2}$$

The measurement of $\overline{Br}$ in (1) and of the CP-asymmetries in (2) requires a sum over semi-inclusive final states in which the Kaons and strange baryons must be identified. Direct CP-asymmetries in exclusive decay modes are hard to access theoretically. Non-perturbative rescattering effects induce strong phases, which are difficult to estimate. On the contrary for the case of inclusive final states local quark-hadron duality allows to calculate the quantities in (1) and (2) reliably within perturbation theory. Theorist have been considering inclusive direct CP-asymmetries since 1979 [1]. Up to now the inclusive a_{CP}'s were

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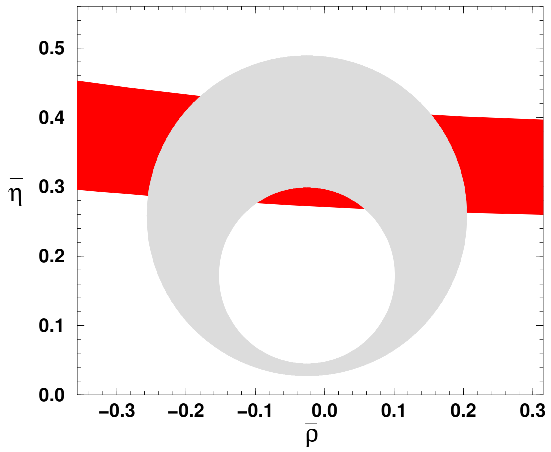

Figure 1: The lightly (darkly) shaded area shows the constraint on $(\overline{\rho}, \overline{\eta})$ stemming from $a_{CP}\,(\Delta S=0)$ ($a_{CP}\,(\Delta S=1)$), if the a_{CP}'s are measured as in (3).

believed to be small, of the order of a few permille. Yet in the predictions of [1] either large logarithms have not been summed to all orders or m_t was taken too small. This has been corrected for in our new paper[2], in which also the predictions for charmless branching ratios calculated before [3] have been improved by incorporating new QCD corrections. We find

$$a_{CP}\,(\Delta S=0) \;=\; \left(2.0^{+1.2}_{-1.0}\right)\%, \qquad\qquad a_{CP}\,(\Delta S=1) \;=\; (-1.0\pm 0.5)\,\%.$$

Here the error bars stem from the uncertainty in m_c/m_b and $\overline{\rho}, \overline{\eta}$ and from the residual dependence on the renormalization scale μ. The μ-dependence can be reduced by calculating certain two-loop diagrams. This is possible with reasonable effort and will be done, once the inclusive direct CP-asymmetries receive experimental interest.

The dependence of the a_{CP}'s on $\overline{\rho}$ and $\overline{\eta}$ is welcome in order to constrain the apex of the unitarity triangle. For a model scenario with

$$a_{CP}\,(\Delta S=0) \;=\; 2.0\,\%, \qquad\qquad a_{CP}\,(\Delta S=1) \;=\; -1.0\,\% \tag{3}$$

and an assumed total error of $20\,\%$ the constraints on $\overline{\rho}, \overline{\eta}$ are shown in figure 1. They are nice circles in the $\overline{\rho}, \overline{\eta}$-plane, whose information is complementary to the familiar circle from B-$\overline{B}$-mixing and the hyperbola from ε_K[4]. The A_{CP}'s defined in (2) are simply proportional to $\overline{\eta}$.

References

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