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Branching fractions and charge asymmetries in charmless hadronic B decays at BaBar

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Summary. — We present measurements of branching fraction and charge asymmetry in charmless hadronic B decays with η and η' mesons in the final state. All results use the final BaBar dataset corresponding to 465×10^6 $B\overline{B}$ pairs.

PACS `13.25.Hw` – Decays of bottom mesons.
PACS `12.15.Hh` – Determination of Kobayashi-Maskawa matrix elements.
PACS `11.30.Er` – Charge conjugation, parity, time reversal, and other discrete symmetries.

1. – Introduction

Experimental measurements of branching fraction (BF) and CP-violating charge asymmetry in rare B decays are an important test of the Standard Model (SM) and its extensions. Several predictions are available for these quantities [1,2]. The large BF difference between $\eta'K$ and ηK seems to be explained in the SM context [3]. Rates of the decay modes to $\eta\eta$, $\eta\phi$, $\eta'\eta'$, and $\eta'\phi$ are used in flavor $SU(3)$-based calculations [2,4], to constrain the unsigned difference between the CP-violating parameter S measured in $\eta'K^0$ and ϕK^0 and $\sin 2\beta$ measured in $J/\psi K^0$. The charge asymmetry $\mathcal{A}_{\mathrm{ch}}$ is expected to be sizable in ηK^+ and suppressed in $\eta'K^+$ decays [2].

2. – Analysis technique

Results shown in this paper are based on a sample of 465×10^6 $B\overline{B}$ pairs collected at a center-of-mass energy $\sqrt{s} = 10.58\,\mathrm{GeV}$ at the PEP-II asymmetric e^+e^- collider, and recorded by the *BABAR* detector [5]. B meson is reconstructed into several final states with η or η' mesons. These states are listed in table I. B meson is kinematically characterized by $\Delta E \equiv E_B - \frac{1}{2}\sqrt{s}$ and $m_{\mathrm{ES}} \equiv \sqrt{s/4 - \vec{p}_B^2}$, where $(E_B, \vec{p}_B)$ is the B meson four-momentum vector expressed in $\Upsilon(4S)$ rest frame. Background arises primarily from random combinations of particles in $e^+e^- \to q\bar{q}$ events ($q = u, d, s, c$). We suppress this background with requirements on event shape variables and on the energy, invariant mass and particle identification signature of the decay products. For each mode, results are obtained from extended maximum likelihood fits with input variables ΔE, m_{ES}, and the output of a Fisher discriminant that combines different event shapes variables. Where useful, the masses of B daughters are included in the fit.

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TABLE I. – *Results for modes presented in this paper.*

Decay	$\mathcal{B}$ (10^{-6})	$\mathcal{B}$ UL (10^{-6})	S (σ)	A_{ch}
$\eta\pi^+$	$4.00 \pm 0.40 \pm 0.24$	–	–	$-0.03 \pm 0.09 \pm 0.03$
ηK^0	$1.15^{+0.43}_{-0.38} \pm 0.09$	1.8	3.5	–
ηK^+	$2.94^{+0.39}_{-0.34} \pm 0.21$	–	–	$-0.36 \pm 0.11 \pm 0.03$
$\eta\eta$	$0.5 \pm 0.3 \pm 0.1$	1.0	1.9	–
$\eta\omega$	$0.94^{+0.35}_{-0.30} \pm 0.09$	1.4	3.7	–
$\eta\phi$	$0.2 \pm 0.2 \pm 0.1$	0.5	1.4	–
$\eta'\pi^+$	$3.5 \pm 0.6 \pm 0.2$	–	–	$+0.03 \pm 0.17 \pm 0.02$
$\eta'K^0$	$68.5 \pm 2.2 \pm 3.1$	–	–	–
$\eta'K^+$	$71.5 \pm 1.3 \pm 3.2$	–	–	$+0.008^{+0.017}_{-0.018} \pm 0.009$
$\eta'\eta'$	$0.6^{+0.5}_{-0.4} \pm 0.4$	1.7	1.0	–
$\eta'\omega$	$1.01^{+0.46}_{-0.38} \pm 0.09$	1.8	3.6	–
$\eta'\phi$	$0.2 \pm 0.2 \pm 0.3$	1.1	0.5	–

3. – Results

In table I we report the results of BF ($\mathcal{B}$) and charge asymmetry ($\mathcal{A}_{\mathrm{ch}}$) for each decay mode [6]. The first error is statistical and second systematic. Significance (σ) is taken as $\sqrt{-2\ln \mathcal{L}_{\max}/\mathcal{L}_0}$, where $\mathcal{L}_{\max}$ ($\mathcal{L}_0$) is the value of the likelihood at its maximum (for zero signal). Bayesian upper limit at 90% CL is calculated for modes with significance less than 5σ. For the well established decay modes $\eta^{(\prime)}K^+$, $\eta'K^0$, and $\eta^{(\prime)}\pi^+$ significance is not reported. Main contributions to systematic uncertainties come from fit bias and uncertainties in the probability density functions parameterization. Daughter branching ratios uncertainty limits BF measurement in $B \to \eta'K$ decay modes.

4. – Conclusions

We reported measurements for several charmless hadronic B decays. In $B \to \eta K^+$ we find evidence of direct CP violation at 3.3σ level.

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