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Measurement of CP asymmetries in $B^0 \to \phi K^0$ and $B^0 \to K^+K^-K^0_s$ decays

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We measure the time-dependent CP asymmetry parameters in $B^0 \to K^+K^-K^0$ based on a data sample of approximately 227×10^6 B-meson pairs recorded at the $\Upsilon(4S)$ resonance with the *BABAR* detector at the PEP-II B-meson Factory at SLAC. We reconstruct two-body B^0 decays to $\phi(1020)K_S^0$ and $\phi(1020)K_L^0$, and the three-body decay $K^+K^-K_S^0$ with $\phi(1020)K_S^0$ excluded. For the $B^0 \to \phi K^0$ decays, we measure $\sin2\beta_{\rm eff}(\phi K^0) = +0.50 \pm 0.25({\rm stat})^{+0.07}_{-0.04}({\rm syst})$. The $B^0 \to K^+K^-K_S^0$ decays are dominated by K^+K^- S wave, as determined from an angular analysis; we measure $\sin2\beta_{\rm eff}(K^+K^-K_S^0) = +0.55 \pm 0.22({\rm stat}) \pm 0.04({\rm syst}) \pm 0.11(CP)$, where the last error is due to the uncertainty in the fraction of CP-even contributions to the decay amplitude. We find no evidence for direct CP violation.

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In the standard model (SM) of particle physics, the decays $B^0 \to K^+K^-K^0$ [1] are dominated by $b \to s\bar{s}s$ gluonic penguin amplitudes, but can also be affected by amplitudes that are suppressed by elements of the Cabibbo-Kobayashi-Maskawa (CKM) quark mixing matrix [2]. These CKM-suppressed amplitudes cannot be precisely known in a model-independent way [3], but are in general expected to be small [4]. Let $2\beta_{\rm eff}$ be the CP-violating phase difference between decays with and without mixing, and $\beta = \arg(-V_{cd}V_{cb}^*/V_{td}V_{tb}^*)$ where V_{ij} are elements of the CKM quark mixing matrix. The difference $|\beta - \beta_{\rm eff}|$ is expected to be nearly zero, with theoretical uncertainties of a few degrees for $B^0 \to \phi K^0$ [5]. Larger uncertainties exist for $B^0 \to K^+K^-K_S^0$ with $B^0 \to \phi K_S^0$ decays excluded, due in part to an extra CKM-suppressed tree amplitude contribution [4].

Since additional decay diagrams with non-SM particles and interactions introducing new CP-violating phases may contribute to $\beta_{\rm eff}$, measurements of $\sin2\beta_{\rm eff}$ in these channels and their comparisons with the SM expectation are sensitive probes for physics beyond the SM [4]. The value of $\sin2\beta$ has been measured in $B^0 \to J/\psi K_S^0$ [6,7] with an average of 0.742 ± 0.037. The *BABAR* and Belle collaborations have measured $\sin2\beta_{\rm eff}$ in ϕK^0 [$+0.47 \pm 0.34^{+0.08}_{-0.06}$ with 114×10^6 $B\bar{B}$ pairs [8] and $-0.96 \pm 0.50^{+0.09}_{-0.11}$ with 152×10^6 $B\bar{B}$ pairs (ϕK_S^0 only) [9], respectively], and in $K^+K^-K_S^0$ excluding ϕK_S^0 ($+0.57 \pm 0.26 \pm 0.04^{+0.17}_{-0.00}$ with 122×10^6 $B\bar{B}$ pairs [10] and $+0.51 \pm 0.26 \pm 0.05^{+0.18}_{-0.00}$ with 152×10^6 $B\bar{B}$ pairs [9], respectively).

At B factories, the neutral B mesons are exclusively produced in pairs. We select events for which one B ($B_{\rm rec}$) is reconstructed as $B^0 \to K^+K^-K^0$ and the other ($B_{\rm tag}$) is partially reconstructed as either B^0 or $\bar{B}^0$. We define $\Delta t = t_{\rm rec} - t_{\rm tag}$ to be the difference between the proper decay times of the B mesons. The decay rate $f_+(f_-)$ for the final state f when the $B_{\rm tag}$ decays as a B^0 ($\bar{B}^0$) is given by

$$f_{\pm}(\Delta t) = \frac{e^{-|\Delta t|/\tau_{B^0}}}{4\tau_{B^0}}[1 \pm S_f \sin(\Delta m_d \Delta t) \mp C_f \cos(\Delta m_d \Delta t)], \quad (1)$$

where τ_{B^0} is the B^0 lifetime and Δm_d is the B^0–$\bar{B}^0$ mixing frequency. The parameter S_f is nonzero if there is CP violation in the interference between decays with and without mixing, while a nonzero value for C_f would entail direct CP violation. In the limit where the CKM-suppressed amplitudes do not contribute, the SM predicts no direct CP violation ($C_f = 0$) since the dominant decay amplitudes have the same CP-violating phase, and that $S_f = -\eta_f \times \sin2\beta_{\rm eff}$. For $B^0 \to \phi K_S^0$ decays, the effective eigenvalue $\eta_f = -1$; for $B^0 \to \phi K_L^0$ $\eta_f = +1$. For $B^0 \to K^+K^-K_S^0$ decays, $\eta_f = 2f_{\rm even} - 1$, where $f_{\rm even}$ is the fraction of CP-even contributions to the $B^0 \to K^+K^-K_S^0$ amplitude. Then the value of η_f depends on the angular momentum of the K^+K^- system: it is -1 for relative P wave and $+1$ for S wave.

In this paper, we present a measurement of $\sin2\beta_{\rm eff}$ with almost twice the number of events as for the previous *BABAR* results [8,10]. We reconstruct B^0 candidates in two independent modes, ϕK^0 (with the K^0 either a K_L^0 or a K_S^0) and $K^+K^-K_S^0$ (with the ϕ mass region excluded). K_S^0's are detected via their $\pi^+\pi^-$ decay only. We extract the CP asymmetry parameters using extended maximum-likelihood fits. Using an angular moment analysis [11], we extract the K^+K^- P-wave fractions in the data. These fractions are used to check the assumption that $\eta_f = -1$ for ϕK_S^0 and $+1$ for ϕK_L^0 by bounding the S-wave contamination in the ϕ mass region, and to measure η_f for $K^+K^-K_S^0$.

This analysis is based on 227×10^6 $B\bar{B}$ pairs collected with the *BABAR* detector [12] at the PEP-II asymmetric-energy e^+e^- storage rings at SLAC, operating at the $\Upsilon(4S)$ resonance [center-of-mass (c.m.) energy $\sqrt{s} = 10.58$ GeV]. In Ref. [12] we describe the silicon vertex tracker (SVT) and drift chamber (DCH) used for track and vertex reconstruction, the electromagnetic calorimeter (EMC) and instrumented flux return (IFR) used for K_L^0 reconstruction, and the detector of internally reflected Cherenkov light (DIRC), which, together with the EMC, the IFR, and the ionization dE/dx from the SVT and DCH, is used for particle identification.

The B^0-candidate reconstruction and selection is similar to that described in Refs. [8,10]. We consider a K^+K^- pair to be a ϕ candidate if its invariant mass is within 15 MeV/c^2 (about 3 times the apparent width in the

K^+K^- invariant mass spectrum) of the central ϕ mass value [13]. For a given $B^0\overline{B}^0$ meson pair, we obtain Δt from the measured distance between the fully reconstructed $B_{\rm rec}$ meson decay point and the $B_{\rm tag}$ decay point along the beam direction, and the known boost of the $\Upsilon(4S)$ system ($\beta\gamma = 0.56$). A multivariate tagging algorithm determines the flavor of the $B_{\rm tag}$ meson [6] and classifies it in one of seven mutually exclusive tagging categories.

We use two kinematic variables to discriminate between signal B decays and combinatorial background. The energy difference between the measured e^+e^- c.m. energy of the B candidate and $\sqrt{s}/2$ is ΔE. Its distribution peaks at zero for signal, with a width of about 20 MeV for ϕK_S^0 and $K^+K^-K_S^0$. The width is only about 3 MeV for ϕK_L^0, because for this mode we constrain the B^0 candidate's mass to the nominal value [13]. The beam-energy-substituted mass, $m_{\rm ES}$, is used for candidates without a K_L^0. It is defined as $m_{\rm ES} \equiv \sqrt{(s/2 + \mathbf{p}_i \cdot \mathbf{p}_B)^2/E_i^2 - \mathbf{p}_B^2}$, where the B momentum $\mathbf{p}_B$ and the four-momentum of the initial state (E_i, $\mathbf{p}_i$) are defined in the laboratory frame. It peaks at the B^0 mass for signal, with a width of about 3 MeV. For ϕK_S^0 candidates, we require $|\Delta E| < 100$ MeV and $m_{\rm ES} > 5.21$ GeV$/c^2$; for ϕK_L^0 candidates, we require $|\Delta E| < 80$ MeV; and for $K^+K^-K_S^0$ candidates, we require $|\Delta E| < 200$ MeV and $m_{\rm ES} > 5.2$ GeV$/c^2$.

The dominant background is continuum $e^+e^- \to q\bar{q}$ ($q = u, d, s, c$) events; these tend to be jetlike in the e^+e^- c.m. frame, while B decays tend to be spherical. To enhance discrimination between signal and continuum, we use Fisher discriminants ($\mathcal{F}$) to combine four event-shape-related variables [8,10]. The other background originates from B decays. For the ϕK^0 final state, opposite-CP contributions from the $K^+K^-K^0$ final state (K^+K^- S wave) are estimated from data with a moment analysis [11] (see below) to be less than 6.6% at 95% confidence level. The mode ϕK_L^0 has additional background. Its dominant CP contamination is from the mode $\phi K^{*0} \to \phi K_L^0\pi^0$, for which we expect approximately eight events in the region $|\Delta E| < 10$ MeV. In the final likelihood fit we explicitly parametrize backgrounds from B decays both with and without charm.

For the $K^+K^-K_S^0$ mode, we apply invariant mass cuts to suppress background from B decays that proceed through a $b \to c$ transition, namely, those containing D^0, J/ψ, χ_{c0}, or $\psi(2S)$ decaying into K^+K^-, or D^+ or D_s^+ decaying into $K^+K_S^0$. Finally, to suppress B decays into final states with pions, we require the rate for a charged pion to be misidentified as a kaon to be less than 2%.

A total of 4300, 8238, and 27 368 events have a candidate that passes the ϕK_S^0, ϕK_L^0, or $K^+K^-K_S^0$ selection criteria, respectively. From simulation, we find the final selection efficiencies for signal to be 40%, 20%, and 26%, respectively.

We extract the $K^+K^-K_S^0$, ϕK_S^0, and ϕK_L^0 event yields and CP parameters with two extended maximum-likelihood fits. One is to the $K^+K^-K_S^0$ candidates; the other is to both the ϕK_S^0 and ϕK_L^0 candidates, with the assumption that $C_{\phi K_S^0} = C_{\phi K_L^0}$ and $S_{\phi K_S^0} = -S_{\phi K_L^0}$. We verified the fit procedure for the ϕK^0 mode with samples of ϕK^+ and $J/\psi K^0$ events. We found for the former a null asymmetry as expected, and for the latter results that are consistent with previous measurements [6]. We verified the fit procedure for the $K^+K^-K_S^0$ mode with a sample of $K_S^0K_S^0K^+$ events, for which we found a null asymmetry as expected.

The likelihood function used in each extended maximum-likelihood fit to its N_k candidates tagged in category k is

$$\mathcal{L}_k = e^{-N_k'} \prod_{i=1}^{N_k} \left\{ N_S \epsilon_k \mathcal{P}_{i,k}^S + N_{C,k} \mathcal{P}_{i,k}^C + \sum_{j=1}^{n_B} N_{B,j} \epsilon_{j,k} \mathcal{P}_{i,j,k}^B \right\} \tag{2}$$

where N_k' is the sum of the signal, continuum, and n_B B-background yields tagged in category k; N_S is the number of ϕK_S^0, ϕK_L^0, or $K^+K^-K_S^0$ signal events; ϵ_k is the fraction of signal events tagged in category k; $N_{C,k}$ is the number of continuum background events tagged in category k; $N_{B,j}$ is the number of B-background events of class j; and $\epsilon_{j,k}$ is the fraction of B-background events of class j tagged in category k. Each B-background class comprises similar B decays. The B-background event yields are fixed parameters and are zero for the ϕK_S^0 sample. The total likelihood $\mathcal{L}$ is the product of the likelihoods for each tagging category.

The probability density functions (PDFs) $\mathcal{P}_k^S$, $\mathcal{P}_k^C$, and $\mathcal{P}_{j,k}^B$, for signal, continuum background, and B-background class j, respectively, are the products of the PDFs of the discriminating variables. The signal PDF is thus given for the $K^+K^-K_S^0$ sample by $\mathcal{P}(m_{\rm ES}) \cdot \mathcal{P}(\Delta E) \cdot \mathcal{P}(\mathcal{F}) \cdot \mathcal{P}(\Delta t; \sigma_{\Delta t})$, for the ϕK_S^0 sample by $\mathcal{P}(m_{\rm ES}) \cdot \mathcal{P}(\Delta E) \cdot \mathcal{P}(\mathcal{F}) \cdot \mathcal{P}(m_{KK}) \cdot \mathcal{P}(\cos\theta_H) \cdot \mathcal{P}(\Delta t; \sigma_{\Delta t})$, and for the ϕK_L^0 sample by $\mathcal{P}(\Delta E) \cdot \mathcal{P}(\mathcal{F}) \cdot \mathcal{P}(m_{KK}) \cdot \mathcal{P}(\cos\theta_H) \cdot \mathcal{P}(\Delta t; \sigma_{\Delta t})$, where θ_H is the angle between the K^+ candidate and the parent $B_{\rm rec}$ flight direction in the K^+K^- rest frame. The quantity $\sigma_{\Delta t}$ is the uncertainty in the measurement of Δt for a given event. The time-dependent CP parameters defined in Eq. (1), diluted by the effects of mistagging and the Δt resolution, are contained in $\mathcal{P}_k^S(\Delta t, \sigma_{\Delta t})$. As in our $J/\psi K_S^0$ analysis [6], the Δt-resolution function for signal and B-background events is a sum of three Gaussian distributions, which have two distinct means as well as three distinct widths. The widths are the error of the measured Δt scaled by three independent factors.

In the fits to data, we leave unconstrained the parameters describing the CP asymmetry, the Δt-resolution functions, the tagging characteristics, and the event yields. We also leave unconstrained the means of the signal m_{ES} and ΔE Gaussian PDFs, the widths of the signal ΔE PDFs, the mean of the signal m_{KK} PDF (which is parametrized by a relativistic P-wave Breit-Wigner function), and all parameters of the $K^+K^-K^0_S$ candidates' signal PDF for $\mathcal{F}$. We take from simulation any other parameters of the m_{ES}, ΔE, $\mathcal{F}$, $\cos\theta_H$, and m_{KK} PDFs for signal and B background. The parameters describing the signal and B-background Δt-resolution function are determined by a simultaneous fit to an independent sample of reconstructed B^0 decays to flavor eigenstates, with more than 100 000 events [6]. We use the world-averaged values for τ_{B^0} and Δm_d [13]. The fits to the ϕK^0 and $K^+K^-K^0_S$ candidates have a total of 35 and 34 free parameters, respectively.

We use an angular moment analysis based on the $\cos\theta_H$ distribution to extract the $K^+K^-K^0_S$ CP content, and also to bound the S-wave contamination in the ϕ mass region. In this approach, we expand the decay distribution for a given K^+K^- invariant mass in terms of moments $\langle P_\ell \rangle$ of conveniently normalized Legendre polynomials $P_\ell(\cos\theta_H)$:

$$|\mathcal{A}(m_{KK})|^2 = \sum_\ell \langle P_\ell \rangle \cdot P_\ell(\cos\theta_H), \qquad (3)$$

where $\mathcal{A}(m_{KK})$ is the mass-dependent decay amplitude. We normalize $P_\ell(\cos\theta_H)$ such that the integral of $P_\ell(\cos\theta_H)^2$ over $\cos\theta_H$ from -1 to 1 equals unity. We extract the moments by summing over all events:

$$\langle P_\ell \rangle = \sum_j P_\ell(\cos\theta_{H,j}) \mathcal{W}_j / \varepsilon_j, \qquad (4)$$

where $\mathcal{W}_j$ is the weight for event j to belong to the signal decay and is calculated by the sPlot technique of Ref. [14]. The efficiency ε_j is evaluated from a large MC sample in bins of m_{KK} and $\cos\theta_H$. Limiting ourselves to the two lowest partial waves, we can write the total decay amplitude in terms of the S-wave (CP-even) and the P-wave (CP-odd) amplitudes,

$$\mathcal{A}(m_{KK}) \approx \mathcal{A}_S(m_{KK}) P_0(\cos\theta_H) + e^{i\phi_p} \mathcal{A}_P(m_{KK}) P_1(\cos\theta_H), \qquad (5)$$

where ϕ_p is the relative phase between the real partial-wave amplitudes $\mathcal{A}_S(m_{KK})$ and $\mathcal{A}_P(m_{KK})$. If we compare Eq. (5) to Eq. (3), we can relate the moments (of order $\ell \leq 2$) to the wave intensities and thus to the total fraction of CP-even events, f_{even}, as

$$f_{\mathrm{even}} = \frac{\mathcal{A}_S(m_{KK})^2}{\mathcal{A}_S(m_{KK})^2 + \mathcal{A}_P(m_{KK})^2} = 1 - \sqrt{\frac{5}{4}} \frac{\langle P_2 \rangle}{\langle P_0 \rangle}, \qquad (6)$$

where $\mathcal{A}_S(m_{KK})^2$ and $\mathcal{A}_P(m_{KK})^2$ are the S- and P-wave intensities, respectively. In the normalization, the total number of signal events is $\sqrt{2}\langle P_0 \rangle$.

Systematic errors on the CP-asymmetry parameters are listed in Table I. We account for uncertainties in the Δt resolution, the beam-spot position, and the detector alignment. We also estimate errors due to the effect of doubly CKM-suppressed decays (DCSD) of the B_{tag} [15]. The uncertainty due to possible biases in the fit procedure is conservative and includes effects on the CP parameters of correlations among the fit variables, which have been determined with full-detector MC simulations. Uncertainties in the B^0-$\overline{B}^0$ tagging efficiency in both signal and background are also included. Finally, we account for errors due to the CP content of the background, uncertainties in the PDF parametrization, and the uncertainties of τ_{B^0} and Δm_d [13]. For each mode we add the individual contributions in quadrature to obtain the total systematic uncertainty.

We also consider the systematic error due to the CP-even fraction of the $K^+K^-K^0_S$ mode. We do not find evidence for the existence of higher moments $\langle P_\ell \rangle$, $\ell = 3 \ldots 6$, which could arise from intermediate D-wave decays into K^+K^- or decays proceeding through an isospin-1 resonance into $K^\pm K^0_S$. Nevertheless, we estimate a systematic error from the D wave by examining the $\langle P_2 \rangle$ moment in the K^+K^- mass region (1.1–1.7) GeV/c^2, corresponding to the $f_2(1270)$, $a_2(1320)^0$, and $f_2'(1525)$ resonances, and assuming that $\langle P_2 \rangle$ arises only from D wave and S-D interference. Since the moment itself is consistent with zero, we assign a systematic error of 4% based on the $\langle P_2 \rangle$ error. We account for the possible presence of $a_0(980)^+$, $a_0(1450)^+$, and $a_2(1320)^+$ in the $K^\pm K^0_S$ subsys-

TABLE I. Systematic uncertainties on the CP parameters.

Source	$S_{\phi K}$	$C_{\phi K}$	S_{KKK}	C_{KKK}
Detector effects	±0.02	±0.02	±0.02	±0.01
DCSD	±0.01	±0.03	±0.00	±0.03
Fit bias	±0.01	±0.01	±0.02	±0.01
B^0–$\overline{B}^0$ tagging	±0.01	±0.02	±0.00	±0.01
S-wave contamination	$+0.06$	±0.02	$\cdots$	$\cdots$
Other	±0.03	±0.02	±0.01	±0.01
Total	$^{+0.07}_{-0.04}$	±0.05	±0.03	±0.04

TABLE II. CP-asymmetry parameters and yields from the final extended maximum-likelihood fits, as well as the fraction of CP-even contributions to the amplitude, f_{even}, which is assumed to be zero for ϕK^0_S and unity ϕK^0_L. The first errors are statistical, and the second are systematic; the third error on $\sin2\beta_{\mathrm{eff}}$ for $K^+K^-K^0_S$ is due to the uncertainty in the CP content. The values of S and C are fit simultaneously for the ϕK^0_S and ϕK^0_L candidates; the sign of S for ϕK^0_S is shown. When finding $\sin2\beta_{\mathrm{eff}}$ for $K^+K^-K^0_S$, we constrain C_{KKK} to 0.

	ϕK^0		$K^+K^-K^0_S$
	ϕK^0_S	ϕK^0_L	(no ϕK^0_S)
$\sin2\beta_{\mathrm{eff}}$	$+0.50 \pm 0.25^{+0.07}_{-0.04}$		$+0.55 \pm 0.22 \pm 0.04 \pm 0.11$
f_{even}	0	1	$0.89 \pm 0.08 \pm 0.06$
S	$+0.50 \pm 0.25^{+0.07}_{-0.04}$		$-0.42 \pm 0.17 \pm 0.03$
C	$0.00 \pm 0.23 \pm 0.05$		$+0.10 \pm 0.14 \pm 0.04$
Yield	114 ± 12	98 ± 18	452 ± 28

tem (4.6%). We also estimate a bias due to the modeling of the efficiency from MC events (2.5%). We find the total systematic error on $f_{\rm even}$ to be ± 0.06. This leads to a systematic error on $\sin 2\beta_{\rm eff}$ of ± 0.11.

Table II shows the measured CP parameters and yields from the final extended maximum-likelihood fits. Note that when fitting $\sin 2\beta_{\rm eff}$ for $K^+K^-K^0_S$, we constrain C_{KKK} to zero. All yields are consistent with our previously measured branching fractions [10,16]. Figure 1 shows the signal-enhanced distributions of $m_{\rm ES}$ for ϕK^0_S and $K^+K^-K^0_S$ events and of ΔE for ϕK^0_L events, together with the result from the final extended maximum-likelihood fits. Figure 2 shows the time-dependent asymmetry distributions. As a cross check, we also fit ϕK^0_S and

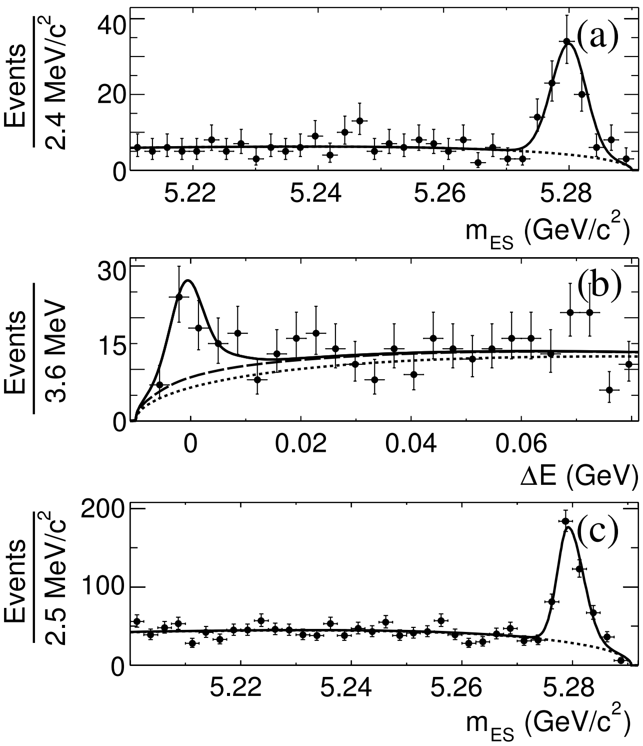

FIG. 1. Distributions of (a) $m_{\rm ES}$ for ϕK^0_S candidates, (b) ΔE for ϕK^0_L candidates, and (c) $m_{\rm ES}$ for $K^+K^-K^0_S$ candidates excluding ϕK^0_S, together with the results from the final extended maximum-likelihood fits after applying a requirement on the ratio of signal likelihood to signal-plus-background likelihood (computed without the displayed variable) to reduce the background. The requirement is chosen to roughly maximize $N_S^2/(N_S + N_C)$ where N_C is the total number of continuum events, and is applied only for the purpose of making these plots. The curves are projections from the likelihood fits for total yield (solid lines), continuum background (short dashed lines), and total background [long dashes in (b) only]. The efficiency of the likelihood-ratio cut is (a) 79% for signal and 5% for background, (b) 35% for signal, 16% for B-background, and 3% for continuum background, and (c) 77% for signal and 5% for background.

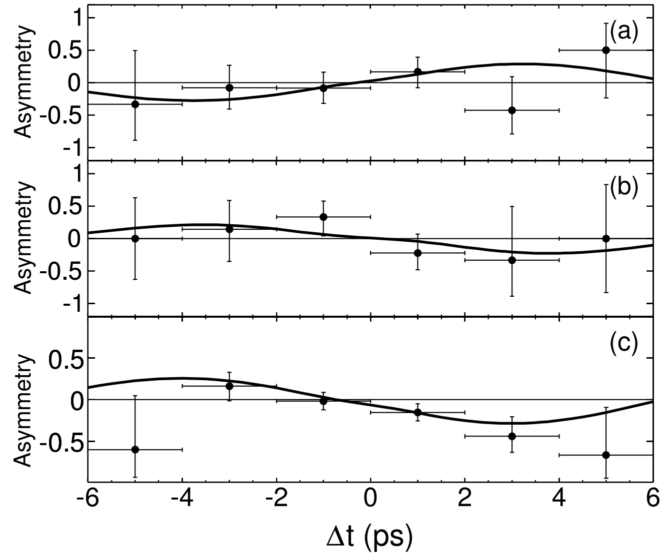

FIG. 2. The time-dependent asymmetry distributions for (a) ϕK^0_S, (b) ϕK^0_L, and (c) $K^+K^-K^0_S$ with no ϕK^0_S decays. The asymmetry is defined as $A_{B^0/\overline{B}^0} = (N_{B^0} - N_{\overline{B}^0})/(N_{B^0} + N_{\overline{B}^0})$, where N_{B^0} ($N_{\overline{B}^0}$) is the number of $B_{\rm tag}$ mesons identified as a B^0 ($\overline{B}^0$) for a given measured value of Δt. The signal-to-background ratio is enhanced with a cut on the likelihood ratio as in Fig. 1.

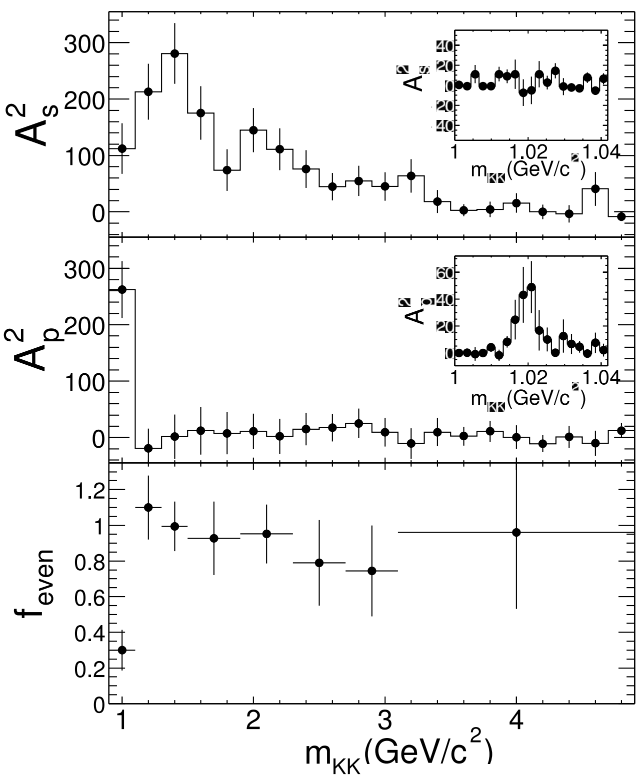

FIG. 3. Distributions of S- and P-wave intensities and CP even fraction as a function of K^+K^- invariant mass. Notice that the first bin integrates a wider mass range than the ϕ resonance occupies. Insets show S- and P-wave intensities in the ϕ mass region.

ϕK_L^0 separately. Our fit to only ϕK_S^0 events gives $S = 0.29 \pm 0.31$ and $C = -0.07 \pm 0.27$. Our fit to only ϕK_L^0 events gives $S = 1.05 \pm 0.51$ and $C = 0.31 \pm 0.49$.

For the $K^+K^-K_S^0$ final state including the ϕ mass region, the distributions of the S- and P-wave intensities, and the CP-even fraction, as a function of K^+K^- invariant mass, are shown in Fig. 3. The total fraction of CP-even events with the ϕ mass region excluded is given in Table II. We successfully verified our value of $f_{\rm even}$ with a different method [17] that uses the event rates in $B^+ \to K^+K_S^0K_S^0$ and the isospin-related channel $B^0 \to K^+K^-K_S^0$.

To summarize, in a sample of 227×10^6 $B\overline{B}$ meson pairs, we measure the CP content and CP parameters in B^0-meson decays into ϕK^0, and into $K^+K^-K_S^0$ with the ϕ mass region excluded. We determine the fraction of CP-even and CP-odd contributions with an angular analysis. In $B^0 \to \phi K^0$, our values for $\sin 2\beta_{\rm eff}$ and $C_{\phi K}$ are in good agreement with our previously published values [8], and the small S-wave contamination is treated as a systematic uncertainty. In $B^0 \to K^+K^-K_S^0$, the K^+K^- system is observed to be dominated by S wave; this, along with the measured value of $\sin 2\beta_{\rm eff}$, is consistent with previous measurements based on isospin symmetry [9,10]. Both of our $\sin 2\beta_{\rm eff}$ values are consistent to within 1 standard deviation with the value of $\sin 2\beta$ measured in $B^0 \to c\bar{c}s$ decays [6].

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