International Journal of Modern Physics A

DALITZ PLOT ANALYSES OF CHARMLESS B DECAYS

ZHITANG YU *

Physics Department, University of Wisconsin, Madison
Madison, CA 53705, United States of America

Received (01 November 2004)
Revised (Day Month Year)

We present preliminary results of maximum-likelihood Dalitz plot analyses performed by the *BABAR* Collaboration of the charmless hadronic decays $B^0 \to K^+\pi^-\pi^0$, $B^+ \to K^+\pi^-\pi^+$, and $B^+ \to \pi^+\pi^-\pi^+$. We report inclusive decay rates, as well as fractions and phases for intermediate resonant decays. We also report CP-violating charge asymmetries for intermediate resonant decays of neutral B mesons.

Keywords: B meson; Dalitz plot; amplitude analysis; charmless; CP violation; decay rate.

1. Introduction

Charmless three-body B decays significantly broaden the understanding of B meson decay mechanisms and provide additional possibilities for direct CP violation searches. The B-meson decay to the three-body final state can proceed via intermediate resonances. These resonant states can interfere with each other and with the nonresonant three-body decay. The three-body state is unique in the search for weak phases as it is possible to determine the strong phase variation for overlapping resonances. A full Dalitz-plot analysis is necessary to correctly model this interference and to extract branching fractions (BF).

Observations of the B decays to the $K^+\pi^-\pi^0$, $K^+\pi^-\pi^+$, and $\pi^+\pi^-\pi^+$ three-body final states have been reported by the CLEO, Belle, and *BABAR* collaborations in the quasi-two-body approximation[1,2]. Belle also reported a preliminary Dalitz plot analysis of the decay $B^+ \to K^+\pi^-\pi^+$ [3]. In this report, we present Dalitz plot amplitude analyses, using a Maximum Likelihood (ML) approach. Charge conjugation is always implied throughout this paper. Details can be found in Ref. 4.

The data were collected with the *BABAR* detector [5] at the SLAC PEP-II asymmetric-energy e^+e^- storage ring. The sample consists of 213 million $B\overline{B}$ pairs, corresponding to an integrated luminosity of 193.2 fb^{-1} collected at the $\Upsilon(4S)$ resonance("on-resonance"), and an integrated luminosity of 16 fb^{-1} collected about

*On Behalf of the *BABAR* Collaboration

40 MeV below the $\Upsilon(4S)$ ("off-resonance"). A subset of the on-resonance data that corresponds to 165.9 fb^{-1} is used for the analysis of the charged B decays.

2. Analysis Method

For each signal B candidate, we apply particle identification for the charged tracks. The π^0 candidate must satisfy $0.11 < m(\gamma\gamma) < 0.16\,\text{GeV}/c^2$. Two kinematic variables, ΔE and m_{ES}[4], further suppress random combinations. Continuum $e^+e^- \to q\bar{q}$ ($q = u, d, s, c$) events are the dominant background, and are suppressed by imposing requirements on topological event shape variables calculated in the $\Upsilon(4S)$ rest frame[4]. Simulated events are used to study the background from other B decays (B-background). For charged B decays, we veto signal B candidates that have J/Ψ, $\psi(2\text{S})$, or D^0. The overall selection efficiencies are around 16% for $B^0 \to K^+\pi^-\pi^0$, 13% for $B^+ \to K^+\pi^-\pi^+$ and $\pi^+\pi^-\pi^+$, respectively.

The amplitude of the B to three-body decay is the coherent sum of one uniform nonresonant (NR) term, and of several resonant amplitudes. Each resonant amplitude is written as a product of a Blatt-Weisskopf factor[6], a spin-dependent kinematic function, and a dynamic function describing the resonance. The dynamic function is usually a relativistic Breit-Wigner form factor, with parameters fixed to world averages[7] and varied for systematic studies. We use the Gounaris-Sakurai parameterization[8] for $\rho(770)$, the LASS parameterization [9] for $K_0^*(1430)$, and a Flatté lineshape [10] for $f_0(980)$. The magnitudes and the phases are free parameters. For charged B meson decay, we assume no CP violation.

For the $B^0 \to K^+\pi^-\pi^0$ analysis, we use m_{ES}, ΔE, and the Dalitz plot to determine the yields and the amplitudes in one unbinned ML fit. For the charged B analyses, we do two unbinned ML fits. First, we use m_{ES} to determine the signal fraction, B-background being fixed to expectation. Second, we fit the Dalitz plane to determine the amplitudes, using the events in the signal box region.

3. Preliminary Results

Table 1 shows the preliminary results of the nominal fits to on-resonance data. For $B^0 \to K^+\pi^-\pi^0$, we also measure $\mathbf{BF}(B^0 \to \overline{D}^0\pi^0) = (3.3 \pm 0.2 \pm 0.4) \times 10^{-4}$. All nominal fits show very good agreement with data.

The systematics uncertainties due to tracking, particle identification, neutral reconstruction, and kinematic selection, are assigned by comparing control channels in simulation and data. The uncertainties in the parameterization of the discriminating variables and of the resonant dynamics ("model systematics") are obtained by varying the parameters within their uncertainties.

4. Summary

Due to lack of knowledge of the final state interactions in B decays, we have assumed uniform phase space for the nonresonant decay amplitude and parameterized

Table 1. Results of the nominal fits. ϕ is the phase for B^0 decay and $\overline{\phi}$ for $\overline{B}^0$ decay.

	$B^0 \to K^+\pi^-\pi^0$, total BF = $(34.9 \pm 2.1 \pm 3.9)\ \times 10^{-6}$		
Mode	Fraction (%)	Phase(ϕ / $\overline{\phi}$, degree)	A_{CP}
$K^*(892)^+\pi^-$	$10.4^{+2.1}_{-2.0} \pm 0.8$	138 ± 35 / 174 ± 42	$-0.25 \pm 0.17 \pm 0.02 \pm 0.02$
$\rho(770)^-K^+$	$24.6^{+3.6}_{-2.9} \pm 0.6$	0.0 (fixed) / 0.0 (fixed)	$0.13^{+0.14}_{-0.17} \pm 0.04 \pm 0.13$
$K_0^*(1430)^+\pi^-$	$32.2 \pm 3.8 \pm 9.4$	115 ± 34 / 149 ± 35	$-0.07 \pm 0.12 \pm 0.06 \pm 0.05$
$K_0^*(1430)^0\pi^0$	$22.5 \pm 4.0 \pm 7.2$	-12 ± 40 / 8 ± 42	$-0.34 \pm 0.15 \pm 0.07 \pm 0.08$
$K^*(892)^0\pi^0$	$5.8^{+1.7}_{-1.5} \pm 0.6$	-160 ± 41 / -144 ± 41	$-0.01^{+0.24}_{-0.22} \pm 0.07 \pm 0.11$
NR	$7.1^{+3.6}_{-2.9} \pm 0.1$	55 ± 28 / 79 ± 28	$-0.12^{+0.36}_{-0.37} \pm 0.20 \pm 0.07$
	$B^+ \to K^+\pi^-\pi^+$, total BF = $(61.4 \pm 2.4 \pm 4.5)\ \times 10^{-6}$		
Mode	Fraction (%)	Phase (degree)	
$K^*(892)^0\pi^+$	$11.4 \pm 2.0 \pm 1.5$	0.0 (fixed)	-
$K_0^*(1430)^0\pi^+$	$52.6 \pm 2.3 \pm 4.0$	$167 \pm 6 \pm 6$	-
$\rho(770)^0K^+$	$8.5 \pm 1.9 \pm 1.1$	$49 \pm 22 \pm 20$	-
$f_0(980)K^+$	$15.0 \pm 2.4 \pm 1.3$	$-32 \pm 18 \pm 23$	-
$\chi_{c0}K^+$	$1.45 \pm 0.27 \pm 0.23$	$9 \pm 19 \pm 12$	-
NR	$7.9 \pm 0.9 \pm 2.3$	$29 \pm 14 \pm 14$	-
	$B^+ \to \pi^+\pi^-\pi^+$, total BF = $(16.2 \pm 2.1 \pm 1.3)\ \times 10^{-6}$		
Mode	Fraction (%)	Phase (degree)	
$\rho(770)^0\pi^+$	$58.2 \pm 2.9 \pm 6.0$	0.0 (fixed)	-
$\rho(1450)^0\pi^+$	$13.6 \pm 2.8 \pm 2.0$	$34 \pm 22 \pm 10$	-
$f_0(980)\pi^+$	$2.0 \pm 1.3 \pm 2.8$	$140 \pm 35 \pm 11$	-
$f_2(1270)\pi^+$	$14.3 \pm 2.0 \pm 1.8$	$-154 \pm 20 \pm 10$	-
NR	$4.2 \pm 2.0 \pm 1.4$	$35 \pm 32 \pm 11$	-

the intermediate resonant amplitudes with knowledge obtained from non-B-meson experiments. The results are in agreement with those reported in Ref. 1, 2, and 3.

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