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Hadronic B Decays at *BABAR*

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Abstract. The large integrated luminosity collected by the *BABAR* detector at the SLAC PEP-II e^+e^- B-Factory offers an excellent opportunity for the study of hadronic B-meson decays. A selection of recent results reported by *BABAR* is presented: a full amplitude analysis of B decays to the vector-vector final states ϕK^*, branching fraction measurements and study of decay dynamics in B decays to proton-antiproton pairs and a light hadron, and branching fraction measurements of B decays to the charmonium states η_c and h_c and K or K^* meson.

1. Introduction

The B-Factory experiments offer an excellent opportunity for hadronic B-decay studies. In fact they accumulated huge data samples, more than 470 fb^{-1} in the case of *BABAR*. A selection of recent hadronic B-decay results by *BABAR* is presented here. More results focussed on measurements of the Cabibbo-Kobayashi-Maskawa (CKM) matrix parameters and searches for physics beyond the Standard Model were presented in other talks at this Conference.

2. Amplitude Analysis of $B \to \phi K^*$ Decays

The B decays to a two-vector final state like $\phi K^*(890)$ are characterized by three complex helicity amplitudes A_λ, with $\lambda = 0$, $+1$ and -1. For later convenience, we can also define $A_\pm = (A_{||} \pm A_\perp)/\sqrt{2}$. In the Standard Model, the decay $B \to \phi K^*$ is a flavour-changing neutral current transition dominated by a $b \to s\bar{s}s$ penguin diagram. Owing to the V-A structure of the weak interaction, helicity conservation and spin flip suppression in penguin decays, one expects a hierarchy between the decay amplitudes of the three helicity states, namely $|A_0|^2 >> |A_+|^2 >> |A_-|^2$ [1].

Using a data sample of 384 million $B\overline{B}$ pairs, *BABAR* performed a full amplitude analysis of the $B^+ \to \phi K^{*+}(890)$ decay [6]. Charged conjugated modes are implied throughout. Analyzing the angular distributions of the decay, twelve non-trivial independent parameters are measured in an unbinned maximum likelihood fit. In the fit, different B^+ and B^- amplitudes are also allowed to account for potential CP violation in the process. In contrast with the expectations, the fraction of longitudinal polarization, $f_L = |A_0|^2/\Sigma_\lambda|A_\lambda|^2$, is not found to be dominant: $0.49 \pm 0.05 \pm 0.03$. The fraction of transverse polarization, $f_\perp = |A_\perp|^2/\Sigma_\lambda|A_\lambda|^2$, is found to be $0.21 \pm 0.05 \pm 0.03$. The phases of the amplitudes, defined as $\phi_{||} = Arg(A_{||}/A_0)$ and $\phi_\perp = Arg(A_{||}/A_0)$, can only be determined up to a two-fold ambiguity if no other information is used. In fact, two solutions would be equally plausible: one (I) with $\phi_\perp \sim \phi_{||} - \pi$ and $A_\perp \sim -A_{||}$ and consequently $|A_+|^2 << |A_-|^2$, the other (II) with $\phi_\perp \sim \phi_{||}$, $A_\perp \sim A_{||}$ and $|A_+|^2 >> |A_-|^2$. The ambiguity can be solved by using the dependence on the $K\pi$ invariant

mass of the interference between the 1^- and the 0^+ $K\pi$ components. Indeed about 57 events for B decays to $\phi(K\pi)$ with the $K\pi$ pair in S wave are found by the fit. If the interference between the P wave $K^*(890)$ and S wave $K\pi$ is taken into account, only solution II is acceptable. This implies that $|A_+|^2 >> |A_-|^2$ and that the amplitudes for the 0 and + helicity states are comparable. The phases $\phi_{||}$ and $\phi_\perp$ are found to be $\pi - 0.67 \pm 0.20 \pm 0.07$ and $\pi - 0.45 \pm 0.20 \pm 0.03$, respectively. No sign of CP violation is observed.

BABAR also studied neutral B decays to ϕK^{*0}, including K^* states above the $K^*(890)$ [7]. Similarly to the charged $K^*(890)$ case, also in the neutral mode the fraction of longitudinal polarization is found to be not dominant, in contrast with expectations: $f_L = 0.51 \pm 0.04 \pm 0.02$. On the contrary, for the vector-tensor final state $\phi K_2^*(1430)$, the fraction of longitudinal polarization is found to be larger, $0.85^{+0.06}_{-0.07} \pm 0.04$.

In summary, an unexpected excess of the A_+ amplitude is observed for B decays to $\phi K^*(890)$, confirming previous results by *BABAR* and Belle on B decays to ϕK^* and ρK^* [2]. Various hypotheses have been proposed to explain the excess of A_+. Some of these comprise new mechanisms previously unaccounted for within the Standard Model, such as annihilation penguin [3] or electroweak penguin, or QCD rescattering [4]. Other hypotheses call for mechanisms beyond the Standard Model [5], such as scalar interaction or supersymmetry interaction.

3. Study of $B \to p\bar{p}h$ Decays

The study of B decays to final states of the form $p\bar{p}h$, where h indicates a light hadron, is interesting for the dynamical distribution of the three final state particles as well as for the possible presence of exotic intermediate states, such as the pentaquark candidate $\Theta^+(1540)$ in the pK_s^0 spectrum or the $f_J(2220)$ glueball candidate in the $p\bar{p}$ spectrum.

BABAR reported new results for $h = \pi^+, K_s^0, K^{*0}, K^{*+}$ [8], while results for $h = K^+$ were reported in [9]. The $B^+ \to p\bar{p}\pi^+$ decay proceeds mainly through an external and internal W emission tree process; the $B^0 \to p\bar{p}K^{0(*)}$ decay is dominated by a virtual loop penguin $b \to sg$ process; finally the decays $B^+ \to p\bar{p}K^{+(*)}$ receive contributions from both the penguin and the doubly CKM suppressed external W emission tree process [10]. Since different mechanisms contribute, carrying in general different weak and strong phases, direct CP violation can occur in these processes [11]. Several experiments reported an enhancement at low $p\bar{p}$ masses in baryonic B and J/ψ decays [12]. This can be due to a short range correlation between p and $\bar{p}$ in a fragmentation chain, or to the decay of a resonance: the two scenarios can be distinguished by studying the distribution of events in the Dalitz plot [13].

Using a sample of about 232 million $B\overline{B}$ pairs, *BABAR* measured the branching fractions for the $B \to p\bar{p}h$ modes to be $3.0 \pm 0.5 \pm 0.3$, $5.3 \pm 1.5 \pm 1.3$, $1.5 \pm 0.5 \pm 0.4$, $1.7 \pm 0.3 \pm 0.3$, for $h = K^0, K^{*+}, K^{*0}, \pi^+$, respectively, in units of 10^{-6}. The results agree with the measurements reported by Belle [14]. In the case of $B^0 \to p\bar{p}K^{*0}$, evidence of the decay is reported for the first time. It is interesting to compare the modes between one another, and with similar mesonic B decays. From isospin symmetry, one would expect the branching fraction for $B^0 \to p\bar{p}K^0$ to be comparable with that for $B^+ \to p\bar{p}K^+$, while it is found to be smaller by a factor about 2, in contrast with mesonic decays. This could possibly be explained by the absence of the tree diagram for $p\bar{p}K^0$, however if this diagram were important, it would be difficult to explain why $p\bar{p}\pi^+$ is so suppressed. The branching fractions for $B \to p\bar{p}K^*$ are found to be consistently larger than $B \to p\bar{p}K$. The branching fraction for $B^+ \to p\bar{p}K^{*+}$ is found to be larger than $B^0 \to p\bar{p}K^{*0}$, similarly to the mesonic case.

No evidence is reported for the pentaquark candidate $\Theta^+(1540)$ and the glueball candidate $f_J(2220)$, and stringent upper limits on the branching fractions $\mathcal{B}(B^0 \to \Theta^+(1540)\bar{p})$ and $\mathcal{B}(B \to f_J(2220)h) \times \mathcal{B}(f_J(2220) \to p\bar{p})$ are derived. In the $p\bar{p}$ spectrum, signals for the η_c and J/ψ charmonium states are observed. In particular, the first evidence for the $B^+ \to \eta_c K^{*+}$

decay is reported. In the pK^0_s and pK^{*0} spectra, the Λ^+_c baryon is observed. The branching fraction $\mathcal{B}(B^0 \to \Lambda^+_c \bar{p})$ is measured to be $(21.0^{+6.7\,+6.7\,+2.1\,+7.4}_{-5.5\,-6.2\,-1.7\,-4.3}) \times 10^{-6}$, consistent with the measurement reported by Belle [15].

In the $p\bar{p}K^0$ and $p\bar{p}\pi^+$ final states, the low $p\bar{p}$ mass enhancement is found to be prominent, while no statistically relevant excess is observed in the case of $p\bar{p}K^{*0,+}$. The distribution of events in the Dalitz plot is expected to be symmetric for a resonance [13]. In the $p\bar{p}\pi^+$ case, there is a marginal excess at high $p\pi$ masses for $p\pi^+$ with respect to $p\pi^-$. However the low statistics does not allow to derive a definite conclusion.

4. Branching Fraction Measurement for B Decays to $\eta_c K^*$ and $\eta_c K^{(*)}\gamma$

The study of B decays to singlet states of charmonium, such as η_c or h_c, is interesting because these are still more poorly known with respect to B decays to triplet states, such as J/ψ or χ_{c1}. In addition, the B decays to P wave states, such as h_c and the χ_{cJ} states, are foreseen in non-relativistic QCD [16] to occur with similar rates. B decays to χ_{c0} or χ_{c1} and a kaon have indeed been observed with similar branching fractions, of around 10^{-4}. However, no B decay to h_c has been observed yet: the Belle Collaboration reported an upper limit for B^+ decays to h_cK^+ of 3.8×10^{-5}, at the 90% C.L. [17].

On a sample of about 384 million $B\overline{B}$ pairs, *BABAR* reported new measurements of the branching fractions for B decays to η_cK^{*0}, h_cK^+ and h_cK^{*0} [18]. The η_c meson is reconstructed in the $K^0_sK^+\pi^-$ and $K^+K^-\pi^0$ decay modes, and the h_c in its decay to $\eta_c\gamma$, which is expected to comprise about half of the total decay width of h_c. A clear signal is observed for $B^0 \to \eta_cK^{*0}$ and its branching fraction is measured to be $(6.1 \pm 0.8 \pm 1.1) \times 10^{-4}$, reducing the uncertainty with respect to the previous world average by a factor about 2. No h_c signal is seen and 90% C.L. upper limits are reported for the branching fraction products $\mathcal{B}(B^+ \to h_cK^+) \times \mathcal{B}(h_c \to \eta_c\gamma)$ and $\mathcal{B}(B^0 \to h_cK^{*0}) \times \mathcal{B}(h_c \to \eta_c\gamma)$ of 5.2×10^{-5} and 2.41×10^{-4}, respectively, confirming h_c suppression in B decays.

References

[1] Ali A *et al.* 1979 *Z. Phys.* C **1** 269; Chen H *et al.* 2002 *Phys. Rev.* D **66** 054013; Suzuki M 2002 *Phys. Rev.* D **66** 054018
[2] *BABAR* Collaboration, Aubert B *et al.* 2004 *Phys. Rev. Lett.* **93** 231804; Belle Collaboration, Chen K F *et al.* 2005 *Phys. Rev. Lett.* **94** 221804; Belle Collaboration, Zhang J *et al.* 2005 *Phys. Rev. Lett.* **95** 141801; *BABAR* Collaboration, Aubert B *et al.* 2006 *Phys. Rev. Lett.* **97** 201801
[3] Kagan A L 2004 *Phys. Lett.* B **601** 151; Li H N and Mishima S 2005 *Phys. Rev.* D **71** 054025
[4] Bauer C W *et al.* 2004 *Phys. Rev.* D **70** 054015; Colangelo P *et al* 2004 *Phys. Lett.* B **597** 291
[5] Grossman Y 2004 *Int. J. Mod. Phys.* A **19** 907; Chen C H and Geng C Q 2005 *Phys. Rev.* D **71** 115004; Baek S 2005 *Phys. Rev.* D **72** 094008
[6] *BABAR* Collaboration, Aubert B *et al.* 2007 *Preprint* arXiv:0705.0398 [hep-ex] to appear in *Phys. Rev. Lett.*
[7] *BABAR* Collaboration, Aubert B *et al.* 2007 *Phys. Rev. Lett.* **98** 051801; *BABAR* Collaboration, Aubert B *et al.* 2007 *Phys. Rev.* D **76** 051103
[8] *BABAR* Collaboration, Aubert B *et al.* 2007 *Preprint* arXiv:0707.1648 [hep-ex] to appear in *Phys. Rev.* D
[9] *BABAR* Collaboration, Aubert B *et al.* 2005 *Phys. Rev.* D **72** 051101
[10] Cheng H Y and Yang K C 2002 *Phys. Rev.* D **66** 014020
[11] Geng C Q, Hsiao Y K and Ng J N 2007 *Phys. Rev. Lett.* **98** 011801; Geng C Q, Hsiao Y K and Ng J N 2007 *Phys. Rev.* D **75** 094013
[12] Belle Collaboration, Wang M Z *et al.* 2003 *Phys. Rev. Lett.* **90** 201802; CLEO Collaboration, Anderson S *et al.* 2001 *Phys. Rev. Lett.* **86** 2732; BES Collaboration, Bai J Z *et al.* 2003 *Phys. Rev. Lett.* **91**, 022001
[13] Rosner J L 2003 *Phys. Rev.* D **68** 014004
[14] Belle Collaboration, Wang M Z *et al.* 2004 *Phys. Rev. Lett.* **92** 131801; Belle Collaboration, Wang M Z *et al.* 2005 *Phys. Lett.* B **617** 141; Belle Collaboration, Wei J T *et al* 2007 *Preprint* arXiv:0706.4167 [hep-ex]
[15] Belle Collaboration, Gabyshev N *et al.* 2003 *Phys. Rev. Lett.* **90** 121802
[16] Bodwin G T, Braaten E and Lepage G P 1995 *Phys. Rev.* D **51** 1125
[17] Belle Collaboration, Fang F *et al.* 2006 Phys. Rev. D **74** 012007
[18] *BABAR* Collaboration, Aubert B *et al.* 2007 *Preprint* arXiv:0707.2843 [hep-ex]