International Journal of Modern Physics A

Study of $B^- \to D_2^*(2460)^0\pi^-$ and $B^- \to D_1(2420)^0\pi^-$ Decays

Vance O. Eschenburg

Department of Physics and Astronomy, University of Mississippi – Oxford University, Mississippi 38677 United States of America

Representing the BABAR Collaboration

Received 19 November 2004

We report on a study of B mesons decaying into one of the narrow P-wave charm resonances, $D_2^*(2460)^0$ and $D_1(2420)^0$. Our preliminary results are based on 89 million $B\overline{B}$ pairs collected with the BABAR detector at the PEP-II asymmetric B Factory. Our study will be useful in the investigation of the properties of Heavy Quark Effective Theory.

1. Introduction

The notation D_J (D^{**}) refers to orbitally excited D mesons, consisting of a charm quark and an up or down anti-quark with an orbital angular momentum of $L = 1$ (P-wave). Measurement of the properties of these particles tests theories such as Heavy Quark Effective Theory (HQET)[1]. HQET predicts two sets of doublets[2] (Fig. 1), one with $j = \frac{3}{2}$ (j being the sum of the spin of the lighter quark and the

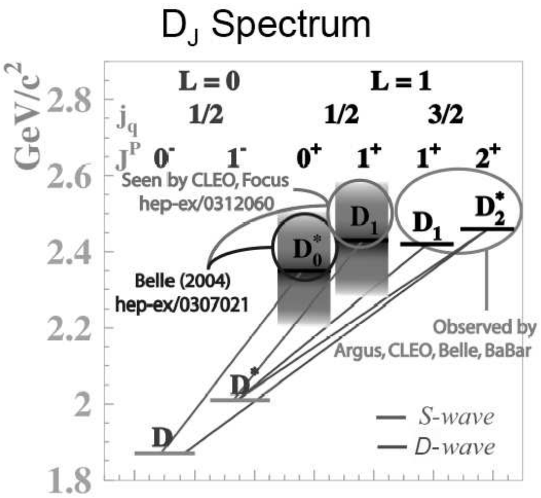

Fig. 1. Spectroscopy of the D_J mesons.

Table 1. Properties of D_J^0 mesons. Mass and width measurements from Ref. 3 and 4.

State	$D_0^*(j=\frac{1}{2})^0$	$D_1(2420)^0$	$D_1(j=\frac{1}{2})^0$	$D_2^*(2460)^0$
J^P	0^+	1^+	1^+	2^+
Mass (MeV/c^2)	$2308 \pm 17 \pm 15 \pm 28$	2422.2 ± 1.8	$2427 \pm 26 \pm 20 \pm 15$	2458.9 ± 2.0
Width (MeV)	$276 \pm 21 \pm 18 \pm 60$	$18.9^{+4.6}_{-3.5}$	$384^{+107}_{-75} \pm 24 \pm 70$	23 ± 5
Decays	$D\pi$	$D^*\pi$	$D^*\pi$	$D\pi$, $D^*\pi$

orbital angular momentum) and another with $j = \frac{1}{2}$. The four neutral D_J mesons are $D_0^*(j=\frac{1}{2})^0$, $D_1(2420)^0$, $D_1(j=\frac{1}{2})^0$, and $D_2^*(2460)^0$ (Table 1). The two D_J with $j=\frac{1}{2}$ are broad resonances (with a width of a few hundred MeV) while the other two states are narrow resonances (width $20-30\,\mathrm{MeV}$)[3,4].

Of special interest is the ratio of the two branching fractions of the narrow states: $R \equiv \frac{\mathcal{B}(B^- \to D_2^*(2460)^0\pi^-)}{\mathcal{B}(B^- \to D_1(2420)^0\pi^-)}$. The CLEO Collaboration measured this ratio[5] to be 1.8 ± 0.8 while the Belle Collaboration's value[3] is 0.77 ± 0.15. One theoretical study[6] uses HQET to calculate this value's range to be $0.0 < R < 1.5$. Another prediction[7] narrows this value down to $R \approx 0.35$.

2. Analysis Method

The data, 89 million $B\overline{B}$ pairs at the $\Upsilon(4S)$ resonance, were collected by the *BABAR* detector[8] using the PEP-II asymmetric-energy B Factory[9] at the Stanford Linear Accelerator Center. The B^- mesons are reconstructed via the final state $D^{*+}\pi^-\pi^-$ or $D^+\pi^-\pi^-$ for studying the properties of the D_J resonances. D^{*+} candidates are reconstructed with a D^0 and a π^+. D^0 candidates are reconstructed as $D^0 \to K^-\pi^+, K^-\pi^+\pi^0, K^-\pi^+\pi^-\pi^+, K_S^0\pi^+\pi^-$, and the D^+ candidates as $D^+ \to K^-\pi^+\pi^+, K_S^0\pi^+$. Monte Carlo events are used for the optimization of selection criteria and estimation of the reconstruction efficiency. Tight particle identification requirements ensure that clean kaons and pions are used in the reconstruction of the B mesons.

The inclusive branching fractions of $B^- \to D^+\pi^-\pi^-$ and $B^- \to D^{*+}\pi^-\pi^-$ are extracted from fits to $\Delta E = E_B^* - E_{\mathrm{beam}}^*$. E_{beam}^* is the center-of-mass (CM) energy of the e^+/e^- beam. E_B^* is the CM energy of the B^- candidate. The signal is described by a Gaussian and the background by a linear function.

For the measurement of the exclusive branching fractions of the narrow resonances, the mass distributions $m(D^{*+}\pi)$ and $m(D^+\pi)$ are fitted (Fig. 2). The signal is described by Breit-Wigner functions convolved with Gaussians that take the detector resolution into account. The broad resonances and the background from non-resonant $B \to D^{(*)}\pi\pi$ are represented by relativistic Breit-Wigner functions. The shape of the combinatorial background is obtained from events with ΔE outside the signal region. Additional details of this analysis may be found in Ref. 10.

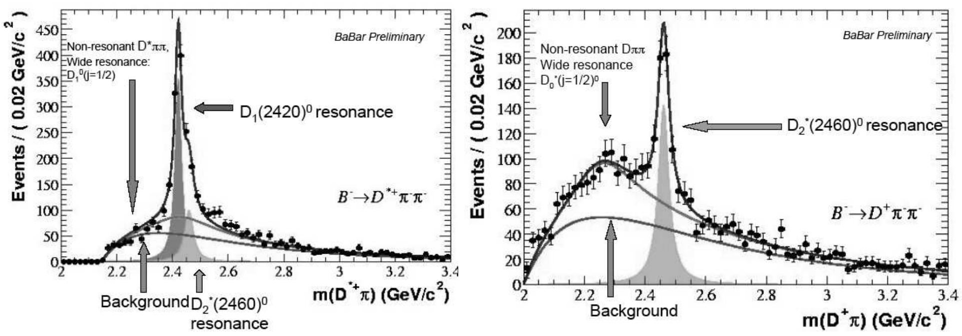

Fig. 2. *Left:* Distribution of $m(D^*\pi)$ with the narrow resonances $D_1(2420)^0$ and $D_2^*(2460)^0$. *Right:* Distribution of $m(D\pi)$ with narrow resonance $D_2^*(2460)^0$. *Both:* The lower background line represents combinatorial background, while the upper background line also contains the wide resonant states and non-resonant $B^- \to D^{(*)+}\pi^-\pi^-$ events.

3. Results and Acknowledgment

All results are preliminary. Table 2 lists the results for the inclusive and exclusive branching fractions. Our measurements of the branching fractions and of the branching ratio $R = 0.80 \pm 0.07\,(\text{stat.}) \pm 0.16\,(\text{syst.})$ agree with the results[3] of the Belle Collaboration.

The author thanks the *BABAR* Collaboration, the SLAC accelerator group and all contributing computing organizations. He was supported by U.S. Dept. of Energy grant DE-FG05-91ER40622.

Table 2. Preliminary branching fractions.

Mode	Branching Fraction ($\times 10^{-3}$)
$B^- \to D^{*+}\pi^-\pi^-$	$1.22 \pm 0.05 \pm 0.18$
$B^- \to D^+\pi^-\pi^-$	$0.87 \pm 0.04 \pm 0.13$
$(B^- \to D_2^*(2460)^0\pi^-) \times (D_2^*(2460)^0 \to D^+\pi^-)$	$0.29 \pm 0.02 \pm 0.05$
$(B^- \to D_1(2420)^0\pi^-) \times (D_1(2420)^0 \to D^{*+}\pi^-)$	$0.59 \pm 0.03 \pm 0.11$
$(B^- \to D_2^*(2460)^0\pi^-) \times (D_2^*(2460)^0 \to D^{*+}\pi^-)$	$0.18 \pm 0.03 \pm 0.05$

References

1. M. Neubert, *Phys. Reports* **245**, 259 (1994).
2. S. Godfrey and R. Kokoski, *Phys. Rev.* **D43**, 1679 (1991).
3. Belle Collaboration, K. Abe *et al.*, *Phys. Rev.* **D69**, 112002 (2004).
4. Particle Data Group, S. Eidelman *et al., Phys. Lett.* **B592**, 1 (2004).
5. CLEO Collaboration, S. Anderson *et al., Nucl. Phys.* **A663**, 647 (2000).
6. A. K. Leibovich, Z. Legeti, I. W. Stewart and M. B. Wise, *Phys. Rev.* **D57**, 308 (1997).
7. M. Neubert, *Phys. Lett.* **B418**, 173 (1998).
8. *BABAR* Collaboration, B. Aubert *et al., Nucl. Instrum. Meth.* **A479**, 1 (2002).
9. P. Oddone, eConf C870126, 423; C. Albajar *et al.*, *Phys. Lett.* **B186**, 247 (1987).
10. *BABAR* Collaboration, B. Aubert *et al.*, hep-ex/0308026.