DETERMINATION RESTITUTION COEFFICIENT OF BRANCHING FRACTION OF $D^0 Meson \to K^- \pi^+ decay$

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Abstract

We measure the restitution coefficient of branching fraction for $D^0 meson \to K^- \pi^+$ decay using the partial reconstruction of $\overline{B}^0 \to D^{*+} X \ell^- \overline{\nu}_\ell$ decays, for branching fraction we use the charge lepton and the soft pion from the $D^{*+} \to D^0 \pi^+$. We will compare the branching fraction in based on a data sample of 230 million $B\overline{B}$ pairs collected at $\gamma(4s)$ resonance with BABAR detector at PEP II asymmetric-energy B factory at SLAC with our theory result, after determination of branching fraction we use mass of soft pion and mass of lepton and energy soft pion and energy soft lepton for finding restitution of coefficient.

Keywords*: branching fraction, D*^{0}*-meson, BABAR detector, pion, lepton.*

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INTRODUCTION

The matter is built from two types of fundamental fermion, called quarks and lepton. Quarks carry fractional electric charge of $+\frac{3}{2}|e|$ and $-\frac{1}{3}|e|$. They occur in several variety or flavors distinguished by the assignment of internal quantum numbers and are labeled u, d, s, c, b, t.

Table 1

Quarks	Anti Quarks
$Q/\lvert e\rvert = +\frac{2}{3} u, c, \ldots$	$Q/\lvert e\rvert = -\frac{2}{3} \bar{u}, \bar{c}, \ldots$
$Q/\lvert e\rvert = -\frac{1}{3} d, s, b$	$Q/\lvert e\rvert = +\frac{1}{3} \bar{d}, \bar{s}, \bar{b}$

u = "up"quarks
d = "down"quarks } $m_u \cong m_d \cong 350\, MeV/c^2$
s = "srange"quarks (s=-1)
$m_s \cong 550\, MeV/c^2$
c = "charmed"quarks (c=+1)
$m_c \cong 1800\, MeV/c^2$
b = "bottom"quarks (B=-1)
$m_b \cong 4500\, MeV/c^2$
t = "top" quarks (T=+1)
$m_t > 20.000\, Mev/c^2$

If only two types of quarks combination occur is successfully accounted for in the theory of inter quarks forces (QCD) lepton carry integral charge, 0 or $\pm\lvert e\rvert$ and three types of each are known.

Table II

Lepton		Anti Lepton	
$Q/\lvert e\rvert = -1$	e^-, μ^-, τ^-	$Q/\lvert e\rvert = +1$	e^+, μ^+, τ^+
$Q/\lvert e\rvert = 0$	ν_e, ν_μ, ν_τ	$Q/\lvert e\rvert = 0$	$\bar{\nu}_e, \bar{\nu}_\mu, \bar{\nu}_\tau$
$m_e = 0.511\, MeV/c^2$			
$m_\mu = 105.6\, MeV/c^2$			
$m_\tau = 1870\, MeV/c^2$			

The charge leptons have electromagnetic and weak interaction. The decay $D^0 \rightarrow K^-\pi^+$ is used as a normalizing mode in many measurements of D and B-meson decay branching fraction. For find the D and B-meson properties, we are going to a good value of $B(D^0 \rightarrow K^-\pi^+)$, and a precise value of fundamental parameter of the standard model; such as three generation the mixing matrix which can be parameterized by a product of three rotation matrix R and a phase insertion matrix D.

$$V = R_2(-\theta_2)R_1(-\theta_1)D(\delta-\pi)R_2(\theta_3)$$

This construction leads to Kobayashi Maskawa (MK) for m.

$$V = \begin{pmatrix} (1-)(S_{12})(S_{13}e^{-i\delta'}) \\ (-S_{12})(1-)(S_{23}) \\ (-S_{13}e^{i\delta'})(-S_{23})(1-) \end{pmatrix}$$

The KM-parameter are not predicted by the standard model for decay $D^0 \to K^- \pi^+$,
The parameter of decay will be placed to the matrix element of V and are labeled by quarks accord to the Kobayashi-Maskawa matrix element $|V_{cb}|$.

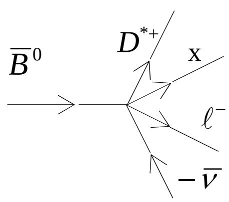
1. We present here a result of theory based on partial reconstruction of the decay $\overline{B}^0 \to D^{*+} X \ell^- \overline{\nu}_\ell$.
2. This partial reconstruction method was introduced later to measure $B^0\overline{B}^0$ mixing.
3. to determine several B-meson properties, and
4. We will calculate the $\overline{B}^0$ meson life time and branching fraction of $\gamma \to B^0\overline{B}^0$ and for an improved determination of $\overline{B}^0$ life time and $B^0\overline{B}^0$ oscillation frequency.

ANALYSIS TECHNIQUE

The decay $D^0 \to K^- \pi^+$ are reconstructed by decay mode $\overline{B}^0 \to D^{*+} X \ell^- \overline{\nu}_\ell$,
Daughter from the decay $D^{*+} \to D^0 \pi_s^{\ +}$, $\pi^+ \to \mu^+ \nu_\mu$, $B^0 \to \rho^0 \gamma$, and $B^0 \to \omega\gamma$, and searching for the lepton charge ($\ell = e$ and μ) and the low momentum pion (soft pion), $\pi_s^{\ +}$.
Using the conservation of momentum and energy, neutrinos are undetected in this reaction.
The neutrino invariant mass squared is given by:

$$M^2 \equiv \left(E_{Beam} - E_{D^*} - E_\ell\right)^2 - \left(P_{D^*} + P_\ell\right)^2$$

Consider $\overline{B}^0 \to D^{*+} X \ell^- \overline{\nu}_\ell$ is semi leptonic decay transition, according the Feynman diagram:



We show that the D^{*+} four-momentum can be computed by approximating its direction.
And a consequence of the limited phase space that available in D^{*+} decay, the soft pion is emitted at rest in the D^{*+} rest frame and D^0-meson is emitted at rest in the D^{*+} rest frame too. We parameterize its momentum as a linear function of the soft pion momentum.

According to spectator approximation the life time for D^0-meson is $4.3 \pm 0.2x10^{-3} s$, D^0-meson contains $c\bar{u}$ quarks. The lepton momentum must be in the range $1.4 < P_{\ell^-} < 2.3 \, GeV/c$ and the soft pion candidate must be $55 < P_{\pi_s^+} < 190 \, MeV/c$ in the e^+e^- centre of mass frame.

According to CP violation, comparison between $B^0 \to \rho^0\gamma$ and $\overline{B}^0 \to \rho^0\gamma$ in amplitudes for an initial decay into a state $\rho^0\gamma$ after time t gives

$$A\left(B^0 \to \rho^0\gamma; t\right) = \frac{\alpha\left(\rho^0\gamma\right)}{2}\left[e^{-i\mu_1 t} + e^{-i\mu_2 t}\right] + \frac{\eta\overline{\alpha}\left(\rho^0\gamma\right)}{2}\left[e^{-i\mu_1 t} - e^{-i\mu_2 t}\right]$$

$$A\left(\overline{B}^0 \to \rho^0\gamma; t\right) = \frac{\overline{\alpha}\left(\rho^0\gamma\right)}{2}\left[e^{-i\mu_1 t} + e^{-i\mu_2 t}\right] + \frac{\alpha\left(\rho^0\gamma\right)}{2\eta}\left[e^{-i\mu_1 t} - e^{-i\mu_2 t}\right],$$

where $\alpha\left(\rho^0\gamma\right)$, $\overline{\alpha}\left(\rho^0\gamma\right)$ are matrix element for $B^0 \to \rho^0\gamma$, $\overline{B}^0 \to \rho^0\gamma$ and $\mu_J = m_J - \frac{1}{2} i\Gamma_J$, the final state:

$$B_d{}^0\left(\overline{B}_d{}^0\right) \to \Psi K^{\pm}\pi^{\mp}$$

is flavor tagging decay and have no C_P violating asymmetry. We consider $D^0 \to K^-\pi^+$ using $c \to s$ method. Total charm decay width is:

$$\Gamma\left(D^0 \to K^-\pi^+\right) \cong \frac{SG_F{}^2 m_c{}^5}{192\pi^3} I\left(\frac{\left(m_{\pi^+} m_{K^-}\right)^2}{m_{D^0}{}^2}\right)$$

D^0-meson life time:

$$\tau_{D^0} \cong \frac{\tau_\mu}{5}\left(\frac{m_\mu}{m_c}\right)^5 \Bigg/ I\left(\frac{\left(m_{\pi^+} m_{K^-}\right)^2}{m_{D^0}{}^2}\right)$$

Semi leptonic branching fraction:

$$B\left(D^0 \to K^-\pi^+\right) = \frac{\Gamma\left(D^0 \to K^-\pi^+\right)}{\Gamma\left(D^0 \to K^-\pi^+\pi^0\right)}$$

We consider as signal all even where $D^{*+}\ell^-$ correlated production result in peak near zero in M^2. Several processes contribute to the signal:

a. $\overline{B}^0 \to D^{*+} X \ell^- \overline{\nu}_\ell$ decay (primary).

b. $\overline{B}^0 \to \overline{D}^{*+} n(\pi) \ell^- \overline{\nu}_\ell$ where the $\overline{D}^{*+} n(\pi)$ may or not originate from an exited charm state $\overline{D}^{**}$.

c. $\overline{B}^0 \to D^{*+}\overline{D}\left(\tau^-\right), \overline{D}\left(\tau^-\right) \to \ell^- X$ (cascade) and,

d. $\overline{B}^0 \to D^{*+} h^-$ (peak), where the hadron $\left(h = \pi, K\right)$ is erroneously identified as lepton.

According to Romulus Godang paper, the branching fraction as:

$$B\left(D^0 \to K^-\pi^+\right) = \frac{N^{D^{*+}\to D^0\pi_s^+}}{N^{D^0\to K^-K^+} \Big/ N^{D^0\to\pi^-\pi^+}} \left(\frac{1}{\varepsilon\left(K^-\pi^+\right)\beta}\right) = \left(4.025 \pm 0.038 \pm 0.098\right)\%$$

COEFFICIENT OF RESTITUTION $D^0 \to K^-\pi^+$

The coefficient of restitution or COR of a particle is a fractional value representing the ratio of velocities. COR can be used as a value which determine the elastic colliding. COR is given by :

$$C_R = \frac{V_{2f} - V_{1f}}{V_1 - V_2},$$

where V_{1f} and V_{2f} is the scalar final velocity of the first object and the second object after impact respectively, V_1 and V_2 are the scalar initial of the first object before impact respectively. According to our result that soft pion π^+ must satisfy $60 < \rho_{\pi_s^+} < 190 \, MeV/c$, and mass of soft pion $\pi_s^+ \cong 139.567 MeV$ soft pion π_s^+ is a product particle in D^0-meson decay.

Considering $D^{x+} \to D^0\pi_s^+$ we can get the result that velocity value has range $\frac{0.43}{c} < V_{\pi_s^+} < \frac{1.36}{c}$.

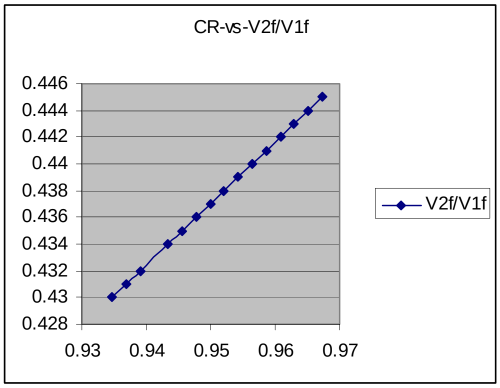
According to R. Godang paper result that if combine each D^0 candidate with π_s^+ and get the mass interval in range $142.4 < \Delta m < 149.9 \, MeV/c^2$, and of data from high energy physics D.H Parkins that momentum D^0 is $860 \, MeV/c$, and velocity of D^0- meson is $\frac{0.46}{c} m/s$. The scalar find velocity of the first object after impact is zero and the scalar initial velocity of the second object before impact is zero.

The CR formula becomes:

$$C_R = \frac{V_{2f}}{V_1}$$

In this case, we only use two particles between D^0-meson and π^+ pion.

Graph $C_R - vs - \frac{V_{2f}}{V_1}$.



The graph showed that coefficient of restitution will increase if the velocity of the soft pion increases too.

CONCLUSIONS

- We have calculation of the coefficient restitution of branching fraction of $D^0 \rightarrow K^-\pi^+$ with value $= (4.025 \pm 0.038 \pm 0.098)\%$
- The graph represent that $D^0 \rightarrow K^-\pi^+$ decay have an inelastic scattering for the certain value and if the velocity of soft pion increase more until 0.46 /c up $D^0 \rightarrow K^-\pi^+$ have elastic scattering.

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