# Fragmentation fraction $f_{\Omega_b}$ and the $\Omega_b \to \Omega J/\psi$ decay in the light-front formalism

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# Abstract

One has measured  $f_{\Omega_b}\mathcal{B}(\Omega_b^-\to\Omega^-J/\Psi)$  at the level of  $10^{-6}$ , where the fragmentation faction  $f_{\Omega_b}$  is to evaluate the *b*-quark to  $\Omega_b^-$  production rate. Using the  $\Omega_b\to\Omega$  transition form factors calculated in the light-front quark model, we predict  $\mathcal{B}(\Omega_b^-\to\Omega^-J/\Psi)=(5.3^{+3.3+3.8}_{-2.1-2.7})\times 10^{-4}$ . In particular, we extract  $f_{\Omega_b}=(0.54^{+0.34+0.39+0.21}_{-0.22-0.28-0.15})\times 10^{-2}$ , demonstrating that the *b* to  $\Omega_b$  productions are much more difficult than the *b* to  $\Lambda_b(\Xi_b)$  ones. Since  $f_{\Omega_b}$  has not been determined experimentally,  $f_{\Omega_b}$  added to theoretical branching fractions can be compared to future measurements of the  $\Omega_b$  decays.

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#### I. INTRODUCTION

The anti-triplet b-baryons  $(\Lambda_b, \Xi_b^0, \Xi_b^-)$  and  $\Omega_b^-$  all decay weakly [1], where  $\Omega_b$  belongs to the sextet b-baryon states. Interestingly, only  $\Omega_b$  is allowed to have a direct transition to  $\mathbf{B}^*$  in the weak interaction, where  $\mathbf{B}^*$  stands for a spin-3/2 decuplet baryon. This is due to the fact that  $\Omega_b$  and  $\mathbf{B}^*$  both have totally symmetric quark orderings. By contrast, the anti-triplet baryon  $\mathbf{B}_b$  consisting of  $(q_1q_2 - q_2q_1)b$  mismatches  $\mathbf{B}^*$  with  $(q_1q_2 + q_2q_1)q_3$  in the  $\mathbf{B}_b$  to  $\mathbf{B}^*$  transition. Clearly, the  $\Omega_b$  decay into  $\mathbf{B}^*$  worths an investigation.

One has barely measured the  $\Omega_b$  decays. Moreover, the fragmentation fraction  $f_{\mathbf{B}_b(\Omega_b)}$  that evaluates the *b*-quark to  $\mathbf{B}_b(\Omega_b)$  production rate has not been determined yet. Consequently, the charmful  $\Omega_b$  decay channel  $\Omega_b^- \to \Omega^- J/\Psi$  can only be partially measured. In addition to  $\Lambda_b \to \Lambda J/\psi$  and  $\Xi_b^- \to \Xi^- J/\psi$ , the partial branching fractions are given by [1]

$$f_{\Omega_b} \mathcal{B}(\Omega_b^- \to \Omega^- J/\Psi) = (2.9^{+1.1}_{-0.8}) \times 10^{-6} ,$$

$$f_{\Lambda_b} \mathcal{B}(\Lambda_b \to \Lambda J/\psi) = (5.8 \pm 0.8) \times 10^{-5} ,$$

$$f_{\Xi_b} \mathcal{B}(\Xi_b^- \to \Xi^- J/\psi) = (1.02^{+0.26}_{-0.21}) \times 10^{-5} ,$$
(1)

where  $f_{\Xi_b} = f_{\Xi_b^{-(0)}}$ . Some theoretical attempts have been given to extract  $f_{\mathbf{B}_b(\Omega_b)}$  [2–4]. Using the calculations of  $\mathcal{B}(\Lambda_b \to \Lambda J/\psi)$  and  $\mathcal{B}(\Xi_b^- \to \Xi^- J/\psi)$  [2, 3], one extracts  $f_{\Lambda_b}$  and  $f_{\Xi_b}$  as some certain numbers. Without a careful study of  $\Omega_b^- \to \Omega^- J/\Psi$  [2, 3], it is roughly estimated that  $f_{\Omega_b} < 0.108$ . Therefore, it can be an important task to explore the charmful  $\Omega_b^- \to \Omega^- J/\Psi$  decay.

See Fig. 1,  $\Omega_b^- \to \Omega^- J/\Psi$  is depicted to proceed through the  $\Omega_b^- \to \Omega^-$  transition, while  $J/\Psi$  is produced from the internal W-boson emission. To calculate the branching fraction, the information of the  $\Omega_b \to \Omega$  transition is required. On the other hand, the light-front quark model has provided its calculation on the  $\Omega_c \to \Omega$  transition form factors, such that one interprets the relative branching fractions of  $\Omega_c^0 \to \Omega^- \rho^+$  and  $\Omega_c^0 \to \Omega^- \ell^+ \bar{\nu}_\ell$  to that of  $\Omega^-\pi^+$  [5]. Therefore, we propose to calculate the  $\Omega_b^- \to \Omega^-$  transition form factors in the light-front formalism, as applied to the  $\Omega_c$  decays as well as the other heavy hadron decays [6–24]. We will be able to predict  $\mathcal{B}(\Omega_b^- \to \Omega^- J/\Psi)$ , and extract  $f_{\Omega_b}$ . Besides, we will compare the branching fractions of  $\Omega_b^- \to \Omega^- J/\Psi$ ,  $\Lambda_b \to \Lambda J/\psi$  and  $\Xi_b^- \to \Xi^- J/\psi$ , and their fragmentation fractions.

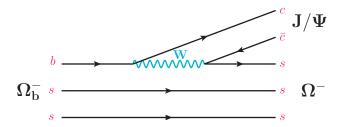


FIG. 1. Feynman diagram for  $\Omega_b^- \to \Omega^- J/\Psi$ .

### II. FORMALISM

According to Fig. 1, the amplitude of  $\Omega_b^- \to \Omega^- J/\Psi$  combines the matrix elements of the  $\Omega_b^- \to \Omega^-$  transition and  $J/\Psi$  production, written as [2, 3]

$$\mathcal{M}(\Omega_b^- \to \Omega^- J/\Psi) = \frac{G_F}{\sqrt{2}} V_{cb} V_{cs}^* a_2 \langle J/\psi | \bar{c} \gamma^\mu (1 - \gamma_5) c | 0 \rangle \langle \Omega^- | \bar{s} \gamma_\mu (1 - \gamma_5) b | \Omega_b^- \rangle , \qquad (2)$$

where  $G_F$  is the Fermi constant, and  $V_{cb(s)}^{(*)}$  the Cabibbo-Kobayashi-Maskawa (CKM) matrix element. The factorization derives that  $a_2 = c_2^{eff} + c_1^{eff}/N_c$ , where  $c_{1,2}^{eff}$  are the effective Wilson coefficients, and  $N_c$  the color number [25, 26]. For the  $J/\Psi$  production, the matrix elements read [27]

$$\langle J/\psi|\bar{c}\gamma^{\mu}(1-\gamma_5)c|0\rangle = m_{J/\psi}f_{J/\psi}\varepsilon_{\mu}^*, \qquad (3)$$

where  $m_{J/\psi}$ ,  $f_{J/\psi}$  and  $\varepsilon_{\mu}^*$  are the mass, decay constant and polarization four-vector, respectively. The matrix elements of the  $\Omega_b^-(bss) \to \Omega^-(sss)$  transition are parameterized as [21, 28]

$$\langle T^{\mu} \rangle \equiv \langle \Omega(sss) | \bar{s} \gamma^{\mu} (1 - \gamma_5) b | \Omega_b(bss) \rangle$$

$$= \bar{u}_{\alpha} \left[ \frac{P^{\alpha}}{M} \left( \gamma^{\mu} F_1^V + \frac{P^{\mu}}{M} F_2^V + \frac{P'^{\mu}}{M'} F_3^V \right) + g^{\alpha \mu} F_4^V \right] \gamma_5 u$$

$$- \bar{u}_{\alpha} \left[ \frac{P^{\alpha}}{M} \left( \gamma^{\mu} F_1^A + \frac{P^{\mu}}{M} F_2^A + \frac{P'^{\mu}}{M'} F_3^A \right) + g^{\alpha \mu} F_4^A \right] u , \tag{4}$$

where  $M^{(\prime)}$  and  $P^{(\prime)}$  represent the mass and momentum of  $\Omega_b(\Omega)$ , respectively, and  $F_i^{V,A}$  (i=1,2,...,4) are the form factors. By substituting the matrix elements of Eqs. (3, 4) for those of Eq. (2), we derive the amplitude in the helicity basis [28],

$$\mathcal{M} = c_W \sum_{\lambda_{\Omega}, \lambda_J} (H^V_{\lambda_{\Omega} \lambda_J} - H^A_{\lambda_{\Omega} \lambda_J}), \qquad (5)$$

where  $c_W \equiv (G_F/\sqrt{2})V_{cb}V_{cs}^* a_2 m_{J/\psi} f_{J/\psi}$ , and  $\lambda_{\Omega} = (\pm 3/2, \pm 1/2)$  and  $\lambda_J = (0, \pm 1)$  denote the helicity states of  $\Omega$  and  $J/\Psi$ , respectively. Due to the helicity conservation,  $\lambda_{\Omega_b} = \lambda_{\Omega} - \lambda_J$  should be respected, where  $\lambda_{\Omega_b} = \pm 1/2$ . Subsequently, we obtain [28]

$$\begin{split} H_{\frac{1}{2}0}^{V(A)} &= \sqrt{\frac{2}{3}\frac{Q_{\mp}^2}{q^2}} \left[ F_1^{V(A)} \left( \frac{Q_{\pm}^2 M_{\mp}}{2MM'} \right) \mp \left( F_2^{V(A)} + F_3^{V(A)} \frac{M}{M'} \right) \left( \frac{|\vec{P}'|^2}{M'} \right) \mp F_4^{V(A)} \vec{M}'_{-} \right] \,, \\ H_{\frac{1}{2}1}^{V(A)} &= -\sqrt{\frac{Q_{\mp}^2}{3}} \left[ F_1^{V(A)} \left( \frac{Q_{\pm}^2}{MM'} \right) - F_4^{V(A)} \right] \,, \\ H_{\frac{3}{3}1}^{V(A)} &= \mp \sqrt{Q_{\mp}^2} \, F_4^{V(A)} \,, \end{split} \tag{6}$$

and  $H_{-\lambda_{\Omega}-\lambda_{J}}^{V(A)} = \mp H_{\lambda_{\Omega}\lambda_{f}}^{V(A)}$ , with  $M_{\pm} = M \pm M'$ ,  $Q_{\pm}^{2} = M_{\pm}^{2} - q^{2}$ ,  $\bar{M}_{\pm}^{(\prime)} = (M_{+}M_{-} \pm q^{2})/(2M^{(\prime)})$  and  $|\vec{P}'| = \sqrt{Q_{+}^{2}Q_{-}^{2}}/(2M)$ .

In the light-front quark model, we can calculate the form factors. To start with, we consider the baryon as a bound state that consists of three quarks  $q_1$ ,  $q_2$  and  $q_3$ , where  $q_{2,3}$  are combined as a diquark, denoted by  $q_{[2,3]}$ . Explicitly, the baryon bound state can be written as [9]

$$|\mathbf{B}(P, S, S_z)\rangle = \int \{d^3 p_1\} \{d^3 p_2\} \times 2(2\pi)^3 \delta^3(\tilde{P} - \tilde{p}_1 - \tilde{p}_2) \sum_{\lambda_1, \lambda_2} \Psi^{SS_z}(\tilde{p}_1, \tilde{p}_2, \lambda_1, \lambda_2) | q_1(p_1, \lambda_1) q_{[2,3]}(p_2, \lambda_2) \rangle,$$
(7)

where  $p_i$  and  $\lambda_i$  stand for the momentum and helicity state, respectively, and  $\Psi^{SS_z}(\tilde{p}_1, \tilde{p}_2, \lambda_1, \lambda_2)$  is the momentum-space wave function. In the light-front frame, one defines  $P = (P^-, P^+, P_\perp)$  with  $P^{\pm} = P^0 \pm P^3$  and  $P_{\perp} = (P^1, P^2)$ , and  $p_i = (p_i^-, p_i^+, p_{i\perp})$  with  $p_i^{\pm} = p_i^0 \pm p_i^3$  and  $p_{i\perp} = (p_i^1, p_i^2)$ , together with  $\tilde{P} = (P^+, P_\perp)$  and  $\tilde{p}_i = (p_i^+, p_{i\perp})$ , which result in  $P^+P^- = M^2 + P_\perp^2$  and  $p_i^+p_i^- = m_i^2 + p_{i\perp}^2$  with  $(m_1, m_2) = (m_{q_1}, m_{q_2} + m_{q_3})$ . Moreover, P and  $p_i$  are related as  $P^+ = p_1^+ + p_2^+$  and  $P_\perp = p_{1\perp} + p_{2\perp}$ , where

$$p_1^+ = (1 - x)P^+, \ p_2^+ = xP^+,$$
  
$$p_{1\perp} = (1 - x)P_{\perp} - k_{\perp}, \ p_{2\perp} = xP_{\perp} + k_{\perp},$$
 (8)

with  $k_{\perp}$  from  $\vec{k} = (k_{\perp}, k_z)$  the relative momentum. By means of  $e_i \equiv \sqrt{m_i^2 + \vec{k}^2}$  the energy of the (di)quark and  $M_0 \equiv e_1 + e_2$ , the above parameters can be rewritten as

$$(x, 1 - x) = (e_2 - k_z, e_1 + k_z)/(e_1 + e_2), \ k_z = \frac{xM_0}{2} - \frac{m_2^2 + k_\perp^2}{2xM_0}.$$
 (9)

In addition, we obtain  $M_0^2 = (m_1^2 + k_\perp^2)/(1-x) + (m_2^2 + k_\perp^2)/x$ . We also get  $(\bar{P}_\mu \gamma^\mu - M_0)u(\bar{P}, S_z) = 0$  with  $\bar{P} \equiv p_1 + p_2$ , where  $p_{1,2}$  describe the internal motions of the internal

quarks. Under the Melosh transformation [7], we derive  $\Psi^{SS_z}$  as [19–22]

$$\Psi^{SS_z}(\tilde{p}_1, \tilde{p}_2, \lambda_1, \lambda_2) = \sqrt{\frac{C}{2(p_1 \cdot \bar{P} + m_1 M_0)}} \, \bar{u}(p_1, \lambda_1) \Gamma u(\bar{P}, S_z) \phi(x, k_\perp) \,, \tag{10}$$

where  $\Gamma = \Gamma_S(\Gamma_A^{(\alpha)})$  represents the vertex function for the scalar (axial-vector) quantity of the diquark, given by [19–22]

$$\Gamma_S = 1,$$

$$\Gamma_A = -\frac{1}{\sqrt{3}} \gamma_5 \phi^*(p_2, \lambda_2), \ \Gamma_A^{\alpha} = \epsilon^{*\alpha}(p_2, \lambda_2). \tag{11}$$

Moreover, the parameter C for  $(\Gamma_{S(A)}, \Gamma_A^{\alpha})$  is given by

$$C = \left(\frac{3(m_1 M_0 + p_1 \cdot \bar{P})}{3m_1 M_0 + p_1 \cdot \bar{P} + 2(p_1 \cdot p_2)(p_2 \cdot \bar{P})/m_2^2}, \frac{3m_2^2 M_0^2}{2m_2^2 M_0^2 + (p_2 \cdot \bar{P})^2}\right). \tag{12}$$

In Eq. (10),  $\phi(x, k_{\perp})$  is the wave function that illustrates the momentum distribution of the constituent quark-diquark states. Here, we present  $\phi(x, k_{\perp})$  in the Gaussian form [5, 6, 19–23]:

$$\phi(x, k_{\perp}) = 4 \left(\frac{\pi}{\beta^2}\right)^{3/4} \sqrt{\frac{e_1 e_2}{x(1-x)M_0}} \exp\left(\frac{-\vec{k}^2}{2\beta^2}\right) , \qquad (13)$$

with  $\beta \equiv \beta_{b[ss]}(\beta_{s[ss]})$  to shape the momentum distribution of the b-[ss] (s-[ss]) system in the  $\Omega_b$  ( $\Omega$ ) bound state.

Using the bound states of  $|\Omega_b(P, S, S_z)\rangle$  and  $|\Omega(P, S', S'_z)\rangle$  in Eq. (7) and the above identities, we derive the matrix elements of the  $\Omega_b \to \Omega$  transition in the light-front frame, given by [21]

$$\langle \bar{T}^{\mu} \rangle \equiv \langle \Omega(P', S' = 3/2, S'_z) | \bar{s} \gamma^{\mu} (1 - \gamma_5) b | \Omega_b(P, S = 1/2, S_z) \rangle$$

$$= \int \{ d^3 p_2 \} \hat{C}^{-1/2} \phi'(x', k'_{\perp}) \phi(x, k_{\perp})$$

$$\times \sum_{\lambda_2} \bar{u}_{\alpha}(\bar{P}', S'_z) \left[ \bar{\Gamma}_A^{\prime \alpha} (p'_1 + m'_1) \gamma^{\mu} (1 - \gamma_5) (p'_1 + m_1) \Gamma_A \right] u(\bar{P}, S_z) , \qquad (14)$$

where  $m_1^{(\prime)} = m_{b(s)}$ ,  $\bar{\Gamma} = \gamma^0 \Gamma^{\dagger} \gamma^0$  and  $\hat{C} = 4p_1^+ p_1^{\prime +} (p_1 \cdot \bar{P} + m_1 M_0) (p_1^{\prime} \cdot \bar{P}^{\prime} + m_1^{\prime} M_0^{\prime})$ .

To determine  $F_i^{V,A}$ , the identities  $J_{(5)}^{\mu} \equiv \bar{u}\Gamma^{\mu\beta}(\gamma_5)u_{\beta}$  and  $\bar{J}_{(5)}^{\mu} \equiv \bar{u}\bar{\Gamma}^{\mu\beta}(\gamma_5)u_{\beta}$  can be useful, where  $\Gamma^{\mu\beta} = (\gamma^{\mu}P^{\beta}, P'^{\mu}P^{\beta}, P^{\mu}P^{\beta}, g^{\mu\beta})$  and  $\bar{\Gamma}^{\mu\beta} = (\gamma^{\mu}\bar{P}^{\beta}, \bar{P}'^{\mu}\bar{P}^{\beta}, \bar{P}^{\mu}\bar{P}^{\beta}, g^{\mu\beta})$ . We can hence perform the following calculations [5, 21],

$$J_{5} \cdot \langle T \rangle = Tr \left\{ u_{\beta} \bar{u}_{\alpha} \left[ \frac{P^{\alpha}}{M} \left( \gamma^{\mu} F_{1}^{V} + \frac{P^{\mu}}{M} F_{2}^{V} + \frac{P'^{\mu}}{M'} F_{3}^{V} \right) + g^{\alpha \mu} F_{4}^{V} \right] \gamma_{5} \bar{u} \Gamma_{\mu}^{\beta} \gamma_{5} \right\},$$

$$\bar{J}_{5} \cdot \langle \bar{T} \rangle = \int \{ d^{3} p_{2} \} \hat{C}^{-1/2} \phi'(x', k'_{\perp}) \phi(x, k_{\perp})$$

$$\times \sum_{\lambda_{2}} Tr \left\{ u_{\beta} \bar{u}_{\alpha} \left[ \bar{\Gamma}_{A}^{\prime \alpha} (p'_{1} + m'_{1}) \gamma^{\mu} (p'_{1} + m_{1}) \Gamma_{A} \right] u \bar{\Gamma}_{\mu}^{\beta} \gamma_{5} \right\}. \tag{15}$$

By connecting  $J_5 \cdot \langle T \rangle$  to  $\bar{J}_5 \cdot \langle \bar{T} \rangle$ , that is,  $J_5 \cdot \langle T \rangle = \bar{J}_5 \cdot \langle \bar{T} \rangle$ ,  $F_i^V$  in  $J_5 \cdot \langle T \rangle$  can be extracted with  $\bar{J}_5 \cdot \langle \bar{T} \rangle$  in the light-front quark model, as the other extractions of the  $\mathbf{B}_{b(c)} \to \mathbf{B}^{(*)}$  transition form factors [5, 6, 19–23]. Similarly,  $J \cdot \langle T \rangle = \bar{J} \cdot \langle \bar{T} \rangle$  enables us to get  $F_i^A$ . We will present our results in the next section.

#### III. NUMERICAL ANALYSIS

For the numerical analysis, the CKM matrix elements and the mass (decay constant) of the  $J/\Psi$  meson state are given by [1]

$$(V_{cb}, V_{cs}) = (A\lambda^2, 1 - \lambda^2/2),$$
  
 $(m_{J/\Psi}, f_{J/\Psi}) = (3.097, 0.418) \text{ GeV},$  (16)

with  $\lambda=0.2265$  and A=0.790 in the Wolfenstein parameterization. The effective Wilson coefficients  $(c_1^{eff}, c_2^{eff}) = (1.168, -0.365)$  come from Refs. [25, 26]. In the generalized version of the factorization approach,  $N_c$  is taken as a floating number, in order that the non-factorizable effects from QCD corrections can be estimated. By adopting  $N_c=2.15\pm0.17$  in [2, 3], we obtain  $a_2=0.18^{+0.05}_{-0.04}$ , which has been used to interpret  $\mathcal{B}(\Lambda_b\to\Lambda J/\psi)$  and  $\mathcal{B}(\Xi_b^-\to\Xi^-J/\psi)$ .

In terms of  $J_5 \cdot \langle T \rangle = \bar{J}_5 \cdot \langle \bar{T} \rangle$  and  $J \cdot \langle T \rangle = \bar{J} \cdot \langle \bar{T} \rangle$  and the theoretical inputs in Eqs. (13, 14, 15), given by [23]

$$(m_b, \beta_{b[ss]}) = (5.00 \pm 0.20, 0.78 \pm 0.04) \text{ GeV},$$
  
 $(m_s, \beta_{s[ss]}) = (0.38, 0.48) \text{ GeV},$  (17)

we derive  $F_i^{V(A)}$  as the functions of  $q^2$ , depicted in Fig. 2. It is common that one parameterizes the form factors in the dipole expressions [16, 17, 24], which reproduce the momentum dependences derived in the quark model. Subsequently, the form factors can have simple forms to be used in the weak decays. In our case, we present [5, 6]

$$F(q^2) = \frac{F(0)}{1 - a\left(q^2/m_F^2\right) + b\left(q^4/m_F^4\right)},\tag{18}$$

with  $m_F$ , a, b and F(0) at  $q^2 = 0$  given in Table I, in order to describe the momentum behaviors of  $F_i^{V,A}$  in Fig. 2.

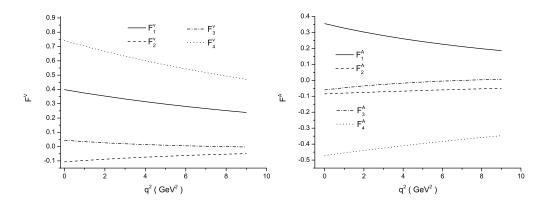


FIG. 2.  $F_i^{V(A)}$  versus  $q^2$  (i = 1, 2, 3, 4).

Thus, we calculate the branching fraction and fragmentation fraction as

$$\mathcal{B}(\Omega_b^- \to \Omega^- J/\Psi) = (5.3^{+3.3+3.8}_{-2.1-2.7}) \times 10^{-4} ,$$

$$f_{\Omega_b} = (0.54^{+0.34+0.39+0.21}_{-0.22-0.28-0.15}) \times 10^{-2} ,$$
(19)

where  $f_{\Omega_b}$  is extracted with  $\mathcal{B}(\Omega_b^- \to \Omega^- J/\Psi)$  and the data in Eq. (1). Moreover, the first and second uncertainties come from  $a_2$  and  $F_i^{V,A}$ , respectively, and the third one for  $f_{\Omega_b}$  is from the measurement.

## IV. DISCUSSIONS AND CONCLUSIONS

Because of the insufficient information on the  $\Omega_b \to \mathbf{B}^*$  transition, the  $\Omega_b$  decays have not been richly explored. In the light-front quark model, we calculate the  $\Omega_b \to \Omega$  transition form factors. We can hence predict  $\mathcal{B}(\Omega_b \to \Omega J/\Psi) = (5.3^{+3.3+3.8}_{-2.1-2.7}) \times 10^{-4}$ , which is compatible with those of the anti-triplet b-baryon decays  $\mathcal{B}(\Lambda_b \to \Lambda J/\Psi) = (3.3 \pm 2.0) \times 10^{-4}$  and

TABLE I. The  $\Omega_b \to \Omega$  transition form factors with (F(0), a, b) in Eq. (18), where  $m_F = 6.05$  GeV is from  $m_{\Omega_b}$ . The uncertainties come from  $m_b$  and  $\beta_{b[ss]}$  in Eq. (17).

	F(0)	a	b		F(0)	a	b
$F_1^V$	$0.371^{+0.045}_{-0.042}$	-2.22	2.37	$F_1^A$	$0.329^{+0.121}_{-0.110}$	-1.93	2.73
$F_2^V$	$-0.104^{+0.022}_{-0.025}$	-3.19	4.69	$F_2^A$	$-0.081^{+0.022}_{-0.020}$	-3.31	4.36
$F_3^V$	$0.040^{+0.042}_{-0.035}$	4.11	11.38	$F_3^A$	$-0.064^{+0.130}_{-0.140}$	-3.16	0.77
$F_4^V$	$0.692^{+0.054}_{-0.051}$	-2.05	1.91	$F_4^A$	$-0.416^{+0.092}_{-0.082}$	-1.89	0.99

 $\mathcal{B}(\Xi_b^- \to \Xi^- J/\Psi) = (5.1 \pm 3.2) \times 10^{-4} [2, 3]$ . On the other hand,  $\mathcal{B}(\Omega_b \to \Omega J/\Psi) = 8.1 \times 10^{-4}$  is given by the authors of Ref. [28]. In addition, the total decay width  $\Gamma(\Omega_b \to \Omega J/\Psi) = 3.15a_2^2 \times 10^{10} \text{ s}^{-1}$  [29] leads to  $\mathcal{B}(\Omega_b \to \Omega J/\Psi) = 16.7 \times 10^{-4}$ , where we have used  $a_2 = 0.18$  for the demonstration.

In the helicity basis, the branching fraction is given by

$$\mathcal{B} \propto (|\mathcal{H}_V|^2 + |\mathcal{H}_A|^2), \tag{20}$$

where  $|\mathcal{H}_{V(A)}|^2 \equiv |H_{\frac{3}{2}1}^{V(A)}|^2 + |H_{\frac{1}{2}1}^{V(A)}|^2 + |H_{\frac{1}{2}0}^{V(A)}|^2$ . It is found that  $(|\mathcal{H}_V|^2, |\mathcal{H}_A|^2)$  give (19.81)% of  $\mathcal{B}$ ; besides,  $(|H_{\frac{3}{2}1}^A|^2, |H_{\frac{1}{2}1}^A|^2, |H_{\frac{1}{2}0}^A|^2)/|\mathcal{H}_A|^2 = (54.0, 22.4, 23.6)\%$ , such that  $F_4^A$  gives the main contribution to  $\mathcal{B}(\Omega_b \to \Omega J/\Psi)$ .

In Eq. (19),  $f_{\Omega_b} = 0.54 \times 10^{-2}$  agrees with the previous upper limit of 0.108 [2]. By comparing our extraction to  $f_{\Lambda_b} = 0.175 \pm 0.106$  and  $f_{\Xi_b} = 0.019 \pm 0.013$  [2], it demonstrates that the b to  $\Omega_b$  productions are much more difficult than the b to  $\mathbf{B}_b$  ones. Since the fragmentation fraction has not been determined experimentally, the branching fractions of the  $\Omega_b$  decays should be partially measured with the factor  $f_{\Omega_b}$ . Therefore, our extraction for  $f_{\Omega_b}$  can be useful. With  $f_{\Omega_b}$  of Eq. (19) added to the branching fractions, one can compare his theoretical results to future measurements of the  $\Omega_b$  decays.

In summary, we have investigated the charmful  $\Omega_b$  decay channel  $\Omega_b^- \to \Omega^- J/\Psi$ . In the light-front quark model, we have studied the  $\Omega_b \to \Omega$  transition form factors  $(F_i^V, F_i^A)$  (i=1,2,...,4). We have hence predicted  $\mathcal{B}(\Omega_b^- \to \Omega^- J/\Psi) = (5.3^{+3.3+3.8}_{-2.1-2.7}) \times 10^{-4}$ , which is compatible with those of the  $\Lambda_b \to \Lambda J/\Psi$  and  $\Xi_b^- \to \Xi^- J/\Psi$  decays. In addition,  $F_4^A$  has been found to give the main contribution. Particularly, we have extracted  $f_{\Omega_b} = (0.54^{+0.34+0.39+0.21}_{-0.22-0.28-0.15}) \times 10^{-2}$  from the partial observation  $f_{\Omega_b}\mathcal{B}(\Omega_b^- \to \Omega^- J/\Psi) = (2.9^{+1.1}_{-0.8}) \times 10^{-6}$ . Since  $f_{\Omega_b}$  has not been determined experimentally, by adding  $f_{\Omega_b}$  to the branching fractions, one is allowed to compare his calculations to future observations of the  $\Omega_b$  decays.

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