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Color-allowed bottom baryon to s-wave and p-wave charmed baryon non-leptonic decays

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We study color allowed bottom baryon to s-wave and p-wave charmed baryon non-leptonic decays. The charmed baryons include spin-1/2 and spin-3/2 states. Explicitly, we consider $\Lambda_b \to \Lambda_c^{(*,**)} M^-$, $\Xi_b \to \Xi_c^{(**)} M^-$ and $\Omega_b \to \Omega_c^{(*,**)} M^-$ decays with $M = \pi, K, \rho, K^*, a_1, D, D_s, D^*, D_s^*, \Lambda_c^{(*,**)} = \Lambda_c, \Lambda_c(2595), \Lambda_c(2625), \Lambda_c(2765), \Lambda_c($ $\Xi_c^{(**)} = \Xi_c, \Xi_c(2790), \Xi_c(2815)$ and $\Omega_c^{(*,**)} = \Omega_c, \Omega_c(2770), \Omega_c(3050), \Omega_c(3090), \Omega_c(3120)$. There are six types of transitions, namely, (i) $calB_b(\mathbf{3}_{\rm f}, 1/2^+)$ to $calB_c(\mathbf{3}_{\rm f}, 1/2^+)$, (ii) $calB_b(\mathbf{6}_{\rm f}, 1/2^+)$ to $calB_c(\mathbf{6}_{\rm f}, 1/2^+)$, (iii) $calB_b(\mathbf{6}_{\rm f}, 1/2^+)$ to $calB_c(\mathbf{6}_{\rm f}, 3/2^+)$, (iv) $calB_b(\mathbf{6}_{\rm f}, 1/2^+)$ to $calB_c(\mathbf{6}_{\rm f}, 3/2^-)$, (v) $calB_b(\mathbf{3}_{\rm f}, 1/2^+)$ to $calB_c(\mathbf{3}_{\rm f}, 1/2^-)$, and (vi) $calB_b(\bar{\mathbf{3}}_f, 1/2^+)$ to $calB_c(\bar{\mathbf{3}}_f, 3/2^-)$ transitions. Types (i) to (iii) involve spin 1/2 and 3/2 s-wave charmed baryons, while types (iv) to (vi) involve spin 1/2 and 3/2 p-wave charmed baryons. The light diquarks are spectating in these transitions. The transition form factors are calculated in the light-front quark model approach. All of the form factors in the $1/2 \to 1/2$ and $1/2 \to 3/2$ transitions are extracted, and they are found to reasonably satisfy the relations obtained in the heavy quark limit, as we are using heavy but finite m_b and m_c. Using na\"{i}ve factorization, decay rates and up-down asymmetries of the above modes are predicted and can be checked experimentally. The study on these decay modes may shed light on the quantum numbers of $\Lambda_c(2765)$, $\Lambda_c(2940)$, $\Omega_c(3050)$, $\Omega_c(3090)$ and $\Omega_c(3120)$.

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