A GENERAL CONNECTION BETWEEN INCLUSIVE DECAYS RATES OF BOUND AND FREE HEAVY QUARKS

S.Ya. Kotkovsky[(a)], I.M. Narodetskii[(a)], S. Simula[(b)] and K.A. Ter-Martirosyan[(a)]

[(a)]Institute of Theoretical and Experimental Physics, Moscow, 117259 Russia

[(b)]Istituto Nazionale di Fisica Nucleare, Sezione Sanitá
Viale Regina Elena 299, I-00161 Roma (Italy)

Abstract

The relativistic constituent quark model, formulated on the light-front, is used to derive a new parton approximation for the inclusive semileptonic and nonleptonic decay widths of the B-meson. A simple connection between the decay rate of a free heavy-quark and the one of a heavy-quark bound in a meson or in a baryon is established. The main features of our approach are the treatment of the b-quark as an on-mass-shell particle and the inclusion of the effects arising from the b-quark transverse motion in the B-meson. In a way conceptually similar to the deep-inelastic scattering case, the B-meson inclusive width is expressed as the integral of the free b-quark partial width multiplied by a bound-state factor related to the b-quark distribution function in the B-meson. The non-perturbative meson structure is described through various quark-model wave functions, constructed via the Hamiltonian light-front formalism using as input both relativized and non-relativistic potential models. A link between spectroscopic quark models and the B-meson physics is obtained in this way. It is shown that the bound-state effects and the Fermi motion of the b-quark remarkably reduce the free-quark decay rate. Our predictions for the $B \to X_c \ell \nu_\ell$ and $B \to X_u \ell \nu_\ell$ decays are used for extracting the CKM parameters $|V_{cb}|$ and $|V_{ub}|$ from available inclusive data. After averaging over the various quark models adopted, we obtain $|V_{cb}| = (41.2 \pm 0.7_{exp} \pm 1.7_{th}) \cdot 10^{-3}$ and $|V_{ub}| = (3.53 \pm 0.44_{exp} \pm 0.14_{th}) \cdot 10^{-3}$, implying $|V_{ub}/V_{cb}| = 0.086 \pm 0.011_{exp} \pm 0.005_{th}$, in nice agreement with existing predictions. Finally, we discuss the applications of our parton formulae for calculation of B_d lifetime and the inclusive width $\Gamma(B \to X_s \gamma)$.

Keywords: bottom mesons, inclusive semileptonic decays, relativistic quark model.

E xclusive and inclusive weak decays of the B_c meson

A.Yu.Anisimov, I.M. Narodetskii and K.A.Ter–Martirosyan

Institute of Theoretical and Experimental Physics, Moscow, 117259 Russia

Abstract

We investigate the total decay rate of the (ground state) B_c meson within the framework of the relativistic constituent quark model, formulated on the light-front. T he exclusive semileptonic (SL) and nonleptonic (NL) beauty and charm decays of the B_c meson are described through vector and axial hadronic form factors, which are calculated in terms of of a constituent quark model LF wave functions. The laters are derived via the Hamiltonian light–front formalism using the update version of the ISGW model. The inclusive SL and NL partial rates are calculated within a convolution approach inspired by the partonic model and involving the same B_c wave fu nction used for evaluation of the exclusive modes. So far this approach has been applied only for the partial widths and B^0 lifetime [1], where it has been found that the overall picture is quantitatively satisfactory. The framework incorporates systematically 40 exclusive and 40 inclusive partial rates corresponding to the underlying $b \to c$ and $c \to s$ quark decays. Based on our approach and using $|V_{cb}| = 0.0386$, $|V_{sc}| = 0.974$ we find $\Gamma^{(b\to c)}(B_c^+) = 0.70 \pm 0.02\, ps^{-1}$, $\Gamma^{(c\to s)}(B_c^+) = 0.98\pm 0.05\, ps^{-1}$, where the theoretical uncertainty is dominated by the uncertainty in the choice of the threshold values at which the hadron continuum starts. For B_c lifetime we obtain $\tau_{B_c} = 0.60\pm 0.02\, ps$ in nice agreement with the result [2] obtained using a non–relativistic operator product expansion. We also predict decay rates for many specific weak transitions of B_c. In particular, for the branching fractions of the $B_c^+ \to J/\psi\mu^+\nu_\mu$ and $B_c^+ \to J/\psi\pi^+$ decays we obtain 1.65% and 0.1%, respectively. The resulting branching ratio for $B_c \to (J/\psi +$ light quarks or leptons) is 10.6%, while the total branching ratio $BR(B_c \to J/\psi + X)$ is found to be 13.1%.

References

[1] I.L.Grach, I.M.Narodetskii, S.Simula and K.A.Ter–Martirosyan, in *Hyperons, Charm and Beauty Hadrons*, Proc. of the 2nd International Confe rence on Hyperon, Charm and Beauty Hadrons, Montreal, August 1996, Eds. C.S.Kalman, M.Bozzo, J.Gascon and J.McKenna, North Holland, 1997, p. 89; Nucl. Phys. **B502** (1997) 227;

[2] M.Benecke and G.Buchalla, Phys. Rev. **D53** (1996) 4991

Keywords: B_c meson, exclusive and inclusive beauty and charm decays, relativistic quark model.