A short overview on decays of heavy flavored mesons

ABSTRACT

Due to non-abelian and non-perturbative complicacies inherent in QCD, various phenomenological models have been proposed to describe dynamics of hadronic structure. The model adopted in the present investigation is a relativistic independent quark (RIQ) model. The dynamics of constituent particles inside the hadron-core is described by the effective quark Lagrangian density $\mathcal{L}_0^q$ with a confining interaction potential in equally mixed scalar-vector harmonic form as:

$$U(r) = \frac{1}{2}(1+\gamma^0)V(r)$$

where, $V(r) = ar^2 + V_0$ and (a, V_0) are potential parameters. The potential taken in the form provides a phenomenological representation of the confining interaction expected to be generated by non-perturbative multigluon mechanisms. A decay physically occur between the momentum eigen-states of participating hadrons. Therefore, in an exact field theoretic description of the decay processes, hadron state should be represented by an appropriate momentum wave packets reflecting the respective quark-antiquark momentum distribution between the constituents. It is possible to obtain the momentum probability amplitude by suitable momentum space projection of corresponding quark/antiquark orbitals available in this model. Then using the effective momentum profile function one can represent a meson as a momentum wave packet. Such an approach has yielded successful description of various decays of heavy flavored mesons. With this phenomenological picture we have attempted description of electromagnetic and weak decays of B_c mesons in their ground and radially excited states. The outcome of our investigation are as follows:

1. Magnetic dipole transitions of B_c and B_c^* mesons:

We first studied $B_c \to B_c^*\gamma$ and $B_c^* \to B_c\gamma$ transitions in their ground and radially excited states. The transition form factors representing the decay amplitudes is studied over the kinematic range of q^2. It is found that the form factor shows its analytical continuation from the spacelike ($q^2 < 0$) region to physical timelike ($0 \leq q^2 \leq q^2_{max}$) region.Our predicted decay rate is compatible with the predictions based on Bethe-Salpeter approach, relativistic, and also QCD sum rule approach.

2. Electromagnetic transition of $b\bar{c}$ bound system:

Here, we undertook $B_c \to B_c^* e^+ e^-$ and $B_c^* \to B_c e^+ e^-$ transitions with an off shell photon leptonizing to lepton pairs were studied. Our decay rates and form factors estimation for these transitions are again found compatible with other model predictions.

3. Semileptonic B_c decays to S-wave charmonium states:

We then studied the semileptonic decays of B_c meson and investigated the behavior of radial quark momentum distribution amplitude function. This leads to the contribution of weak form factors to the decay rates in the decreasing order of magnitude.The form factors are studied in the physical kinematic range. Like all other model predictions, our predicted BR are obtained in the hierarchy: BR($B_c^+ \to \eta_c/\psi(3S)$) $<$ BR($B_c^+ \to \eta_c/\psi(2S)$) $<$ BR($B_c^+ \to \eta_c/\psi(1S)$). The longitudinal ($\Gamma_L$) and transverse ($\Gamma_T$) polarization are also predicted in the entire q^2 region.

4. Lepton mass effects in Semileptonic B decays:

Here we discuss the decays: $B_c \to \eta_c(J/\psi) l\nu_l$ and $B_c \to D(D^*) l\nu_l$ in non-vanishing lepton mass limit. We adopted helicity spin formalism and calculated invariant form factors representing decay amplitudes from the overlapping integrals of meson wave functions derivable in the RIQ model. We first study the q^2- dependence of form factors in the accessible kinematic range of q^2 in e and τ mode separately. Similar studies on helicity amplitudes, q^2 spectra for different helicity contributions, and total q^2 spectra for each decay process are carried out separately. We predict the decay rates branching fractions, forward-backward asymmetry, and the asymmetry parameter in reasonable agreement with other model predictions. We also predicted the flavor puzzle $R_{J/\psi}$ R_D and R_{D^*} observable. Our results are comparable to other standard model(SM) predictions which highlight the inadequacy of new physics (NP) description in our model.

This gives me enough motivation to carry forward my future research in pinning down NP scales in studying various B and K meson decays.