Spectroscopy and Decay Properties Of Heavy Flavour Hadrons

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Spectroscopy of heavy flavour hadrons has attracted considerable interest in recent years due to many experimental facilities such as the BES at the Beijing Electron Positron Collider (BEPC), E835 at Fermilab, Belle, BaBar, DELPHI, CLEO, CDF, SELEX *etc.*, worldover. All these experiments are capable of observing new states, new production mechanisms, new decays and transitions. In near future, even larger data samples are expected from the BES-III upgraded experiment, while the B factories and the Fermilab Tevatron will continue to supply valuable data for few more years. Later on, the LHC experiments at CERN, Panda at GSI *etc.*, are capable of offering future opportunities and challenges in this field of heavy flavour physics.

The investigation of the properties of mesons composed of a heavy quark and antiquark ($c\bar{c}$, $b\bar{c}$, $b\bar{b}$) gives very important insight into heavy quark dynamics and to the understanding of the constituent quark masses. The theoretical predictions of the heavy flavour $c\bar{c}$, $b\bar{c}$ and $b\bar{b}$ mesons have rich spectroscopy with many narrow states of charmonium lying under the threshold of open charm production and of botomonium lying under the threshold of $B-B$ production [1, 2]. On the other hand, baryons are not only the interesting systems to study the quark dynamics and their properties but are also interesting from the point of view of simple systems to study three body problems. There exist many approaches *vis a vis* QCD sum rules, Potential models, Lattice QCD, the Bethe-Salpeter method *etc.*, that provide the low lying baryon spectra with one or two heavy flavour quarks. Unlike in the case of mesons, for baryons, the magnetic moments become an additional property that can be predicted using different approaches. Though many of these theoretical attempts successfully predict the masses, there is no consensus among the theoretical predictions of the properties like spin-parity, the form factors, magnetic moments *etc.* All these reasons together make the study of heavy flavour baryon spectroscopy extremely important and interesting [3–7]. Many of the recently observed new states are within the heavy flavour sector with one or more heavy flavor content and some are very different from the theoretical expectations. This has prompted us to look for several aspects of the constituent quark model with one or more heavy flavour content and to invoke different model descriptions of the basic quark-quark interaction potential.

We make an attempt to study the spectroscopic properties like mass spectra, radial wave functions, mean square radii and the average relative velocities of the confined quarks of the $Q\bar{Q}$ and $Q\bar{q}/q\bar{Q}$ systems ($Q \ \epsilon \ b, c$ and $q \ \epsilon \ u, d, s$) based on a phenomenological coulomb plus power potential (CPP$_\nu$). We study the properties of the meson systems upto few excited states seeking numerical solution of the Schrödinger equation containing the CPP$_\nu$ potential with different choices of the potential power index ν. The spin hyperfine, spin-orbit and tensor components of the one gluon exchange interaction are employed to compute the spectroscopy of the few lower nS and other $\ell \neq 0$ orbital excited states. The numerically obtained radial solutions at different choices of ν are important parameters for the study of decay

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properties of these mesons [2]. We present detailed account of decay constants $f_{P/V}$, the E1 - M1 transitions of the $Q\bar{Q}$ systems, the di-gamma, di-lepton decays of $c\bar{c}$ and $b\bar{b}$ mesons and the weak decays of B_c ($c\bar{b}$) meson. We observed the nature of the interquark potential and their parameters that provide us the spectroscopic properties as well as the decay properties of the $Q\bar{Q}$ system with the potential index between 0.7 and 1.1. The present study also provide us the importance of the quark mass parameters and the state dependence on the potential strength for the study of the spectral properties. The present study is also an attempt to show the importance of radiative corrections as well as the finite radial $Q - \bar{Q}$ separation for the decay widths of the heavy flavour quarkonia.

The heavy-light flavour mesons are of particular interest as their decay provides rich information regarding the interplay between the weak and strong interactions. Due to QCD asymptotic freedom and the large masses and momenta released by heavy flavor quarks, electroweak and strong interactions are closely inter liked. The weak decay width predictions of the mesons play a crucial role in the precision determination of the CKM matrix elements. Our results for the leptonic decay and the semileptonic decay are presented by employing the relevant spectroscopic parameters. We also present the decay constant of heavy-light mesons with and without QCD corrections which is then employed for the study of the mixing parameters of charge neutral $B - \bar{B}$ and $B_s - \bar{B}_s$ mesons. The importance of the binding energy effect considered through the effective mass for the constituent quarks ($m^{eff}_{Q/q}$) are being observed in many of their decay properties studied in this thesis.

We study the three-body problem of the single (qqQ), double (qQQ) and triple (QQQ) heavy flavour baryons using a hypercentral model. The confinement potential is assumed in the hypercentral co-ordinates of the coulomb plus power potential (CPP$_\nu$) form. For the low-lying baryon resonance states with one or more heavy quarks, we consider the variational scheme with the hypercoulomb trial wave function. The spin hyperfine interactions with the radial part expressed in terms of the hyper co-ordinate x has been used with explicit mass dependence of the constituting quarks in the present study. The magnetic moments of heavy flavour baryons are computed based on the nonrelativistic quark model using the spin-flavour wave functions of the constituting quarks and their effective masses within the baryon. We repeat our computations by varying the confinement potential power index ν from 0.5 to 2.0 [3–7].

In this thesis work, we have been able to do a comprehensive study of heavy flavour hadrons.

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