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E1 and M1 radiative transitions of heavy quarkonia

Content :

Heavy quarkonia states (b\bar{b} and c\bar{c}) below the open flavor threshold have enough life time before decaying so that their excitation level can be changed by emission of a photon or soft gluons turning into light hadrons. Radiative transitions in heavy quarkonia have been subject of recent interest as the CLEO-c experiment has measured the E1 and M1 transitions using combination of inclusive and exclusive techniques and reconciling with theoretical calculations of lattice QCD and effective field theory techniques [1,2,3].

Although M1 transition rates are typically rather weaker than E1 rates, they are nonetheless interesting because they may allow access to spin-singlet states that are very difficult to produce otherwise. It is also interesting that the known M1 rates show serious disagreement between theory and experiment when it comes to potential models. This is in part due to the fact that M1 transitions between different spatial multiplets, such as are nonzero only due to small relativistic corrections to a vanishing lowest-order M1 matrix element [4].

The photon energies depend on the model in most cases as we have assumed theoretical masses for unknown states. For the low-energy favored M1 transitions, the photon energies are found to be nearly the same as the mass splittings. The wide variation in predicted hyperfine splittings leads to considerable uncertainty in predicted rates for these transitions. For the higher-energy hindered M1 transitions in bottomonia, the expected photon energies are not so sensitive to hyperfine splittings.

We compute the E1 and M1 transitions for heavy quarkonia in various potential models and compare our results with available experimental data and other theoretical results with various factors like relativistic corrections, recoil factor, phase space factor etc [3,5,6].

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Primary authors : Dr. PANDYA, Jignesh N (The M S University of Baroda)

Co-authors : Dr. RAI, Ajay Kumar (SVNIT) ; Prof. P C, Vinodkumar (Sardar Patel University, Vallabh Vidyanagar)

Presenter : Dr. PANDYA, Jignesh N (The M S University of Baroda)

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