Open Charm Contributions to the E1 Transitions of $\psi(3686)$ and $\psi(3770) \to \gamma\chi_{cJ}$

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In this proceeding, we present our recent study of the open charm effects in the E1 transitions of $\psi(3686)$ and $\psi(3770) \to \gamma\chi_{cJ}$ in a non-relativistic effective field theory(NREFT) in which several systematical effects are included. We find that these open charm contributions play an essential role in understanding the large discrepancies between the non-relativistic leading order calculations and the experimental data.

KEYWORDS: E1 transition, hadronic loops, NREFT

1. Introduction

Following the discovery of a vast number of candidates for QCD exotics in experiment, such as $Z_c(3900)$ and $Z_c(4020/4025)$ at BESIII [1–4] and $Z_c(4430)$ at Belle [5] and LHCb [6], we are now in a good position for improving our knowledge about the charmonium spectroscopy. While it indicates strong correlations between these states and the proximal open charm thresholds, i.e. $D^*\bar{D} + c.c.$ for $X(3872)$ and $Z_c(3900)$, $D^*\bar{D}^*$ for $Z_c(4020/4025)$, there should be other cases in which open charm thresholds play important roles in some of those low-lying states.

In this work, we focus on the open charm effects on the E1 transition of $\psi(3686)$ and $\psi(3770)$ (denoted by ψ' and ψ'', respectively, for simplicity as follows) to $\gamma\chi_{cJ}$ in a non-relativistic effective field theory (NREFT) since they are both close to the mass threshold of $D\bar{D}$. Within various EM transitions in this region, E1 transitions are better measured in comparison with the magnetic dipole transitions which are suppressed by a factor of p_Q/M_Q with p_Q and M_Q denoting the momentum and mass of the heavy quark, respectively. Many theoretical studies have been done in the non-relativistic quark model. Among them the Cornell potential model [7] has made a great success in describing the charmonium spectrum. Also relativistic corrections to quark potentials were included in Refs. [8, 9]. In Ref. [10] and references therein a detailed review of different approaches for the charmonium EM transitions can be found.

For the E1 transition of ψ' and $\psi'' \to \gamma\chi_{cJ}$ the intermediate meson loop effects can bring important corrections to the leading tree-level diagrams and can be compared to corrections introduced by the spin-dependent forces as relativistic corrections in the potential quark model [7]. The leading tree-level diagram is introduced by a contact interaction that obeys the HQSS and will mimic the leading order results from the non-relativistic quark model calculations. Then, three kinds of subleading