

The identification of the new state $Y(3872)$ as the P-wave $D\bar{D}^* / \bar{D}D^*$ resonance

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The BESIII Collaboration recently observed a new charmonium-like vector state $Y(3872)$ in $e^+e^- \rightarrow D\bar{D}^*$, which should be the first P-wave $D\bar{D}^*$ molecular resonance. The experimental and theoretical identification of the P-wave dimeson state holds paramount importance in enhancing our comprehension of the non-perturbative QCD and few-body physics. Its existence is firmly established in a unified meson-exchange model which simultaneously depicts the features of the $\chi_{c1}(3872)$, $Z_c(3900)$ and $T_{cc}(3875)$. This scenario can be directly examined in the $e^+e^- \rightarrow D\bar{D}^* / \bar{D}D^*$ cross section to see whether a resonance exists at the threshold. The credibility of the investigations is also ensured by the fact that the P-wave interaction dominantly arises from the well-known long-range pion exchange. Additionally, the existence of the P-wave resonance only depends on the interaction strength and is less sensitive to the potential shapes. We extensively calculate all systems up to P-wave with various quantum numbers and predict a dense population of the $D\bar{D}^* / \bar{D}D^*$ and DD^* states, where the S-wave $D\bar{D}^* / \bar{D}D^*$ state with $I^G(J^{PC})=0^-(1^+{+-})$, P-wave $D\bar{D}^* / \bar{D}D^*$ state with $I^G(J^{PC})=0^+(0^+{--})$, and P-wave DD^* state with $I(J^P)=0(0^+)$ are more likely to be observed in experiments.

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