

P-wave molecular resonance: $G(3900)$

The BESIII Collaboration recently performed a precise measurement of the $e^+e^- \rightarrow D\bar{D}$ Born cross sections, and confirmed the $G(3900)$ structure reported by BaBar and Belle with high significance. We identify the $G(3900)$ as the first P-wave $D\bar{D}^*/\bar{D}D^*$ 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 $T_{cc}(3875)$. 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, thanks to the centrifugal barrier, it is easier to form resonances in P-wave than in S-wave. 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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