

Portraits of Charmoniumlike States

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The charm quark density-density correlation is calculated for 1S and 1P conventional charmonia and $J^{PC} = 1^{-+}, 0^{+-}$ charmoniumlike states from lattice QCD and are interpreted as spatial wave functions of these states with some approximations. The angular distributions of $c\bar{c}$ in conventional charmonia are found to be in accordance with the expectation of two-body systems, while that of the 1^{-+} state exhibits an S-wave feature. However, the $c\bar{c}$ radial distributions turn out to be strikingly different from the non-relativistic quark model and can be understood by the Dirac theory of two-body bound states. These results provide the first gauge invariant and model-independent three-dimensional portraits of charmonium(like) states.

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