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## Quark model explanation of Upsilon(10860)

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The explanation of the large  $e^+e^- \rightarrow \pi^+\pi^-\Upsilon(nS)$  ( $n = 1, 2, 3$ ) widths at  $\sqrt{s} = 10.866 \pm 0.002$  GeV near the  $\Upsilon(10860)$  peak [1], about two orders of magnitude larger than those for  $\Upsilon(nS) \rightarrow \pi^+\pi^-\Upsilon(1S)$  ( $n = 2, 3, 4$ ), has been in recent years a theoretical challenge (see for example [2]) despite the quite natural (according to its mass) assignment of  $\Upsilon(10860)$  to the standard  $\Upsilon(5S)$  quark model state. Moreover, the experimental production rates of  $\Upsilon(10860) \rightarrow \pi^+\pi^-h_b(np)$  ( $n = 1, 2$ ) and  $\Upsilon(10860) \rightarrow \pi^+\pi^-\Upsilon(nS)$  are of the same order of magnitude whereas the calculated  $\Upsilon(5S) \rightarrow \pi^+\pi^-h_b(np)$  rates are suppressed against  $\Upsilon(5S) \rightarrow \pi^+\pi^-\Upsilon(nS)$  ones by Heavy Quark Spin Symmetry.

We show that a good quantitative description of the  $\Upsilon(10860)$  mass, its  $e^+e^-$  leptonic width and its  $\pi^+\pi^-\Upsilon(nS)$  production rates, as well as a qualitative understanding of its  $\pi^+\pi^-h_b(np)$  production rates can be obtained under the assumption that  $\Upsilon(10860)$  is a mixture of the conventional  $\Upsilon(5S)$  quark model state with a small proportion of the lowest  $1^{--}$  hybrid state [3].

[1] M. Tanabashi et al. (Particle Data Group (PDG)), Phys. Rev. D98, 030001 (2018).

[2] L. Olsen, T. Skwarnicki, and D. Zieminska, Rev.Mod.Phys.90,015003 (2018).

[3] R. Bruschini and P. Gonzalez, Pys. Lett. B791,409 (2019).

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