

TABLE II: Features of the decay modes of  $D_{sJ}(3040)$  and of its spin partner at leading order in  $\frac{1}{m_c}$  expansion for the four proposed assignments.

decay modes	$\tilde{D}'_{s1} (n=2, J_{s\ell}^P = 1_{1/2}^+)$	$\tilde{D}_{s1} (n=2, J_{s\ell}^P = 1_{3/2}^+)$	$D_{s2} (n=1, J_{s\ell}^P = 2_{3/2}^-)$	$D_{s2}' (n=1, J_{s\ell}^P = 2_{5/2}^-)$
$D^*K, D_s^*\eta$	$s$ - wave	$d$ - wave	$p$ - wave	$f$ - wave
$R_1$	0.34	0.20	0.245	0.143
$D_0^*K, D_{s0}^*\eta, D_1'K$	$p$ - wave	$p$ - wave	$d$ - wave	$d$ - wave
$D_1K$	$p$ - wave	$p$ - wave	-	$d$ - wave
$D_2^*K$	$p$ - wave	$p$ - wave	$s$ - wave	$d$ - wave
$DK^*, D_s\phi$	$s$ - wave $\Gamma \simeq 140$ MeV	$s$ - wave $\Gamma \simeq 20$ MeV	$p$ - wave negligible	$p$ - wave negligible
spin partner				
	$\tilde{D}_{s0}^* (n=2, J_{s\ell}^P = 0_{1/2}^+)$	$\tilde{D}_{s2}^* (n=2, J_{s\ell}^P = 2_{3/2}^+)$	$D_{s1}^* (n=1, J_{s\ell}^P = 1_{3/2}^-)$	$D_{s3} (n=1, J_{s\ell}^P = 3_{5/2}^-)$
$DK, D_s\eta$	$s$ - wave	$d$ - wave	$p$ - wave	$f$ - wave
$D^*K, D_s^*\eta$	-	$d$ - wave	$p$ - wave	$f$ - wave
$D_0^*K, D_{s0}^*\eta$	-	-	$d$ - wave	-
$D_1'K$	$p$ - wave	$p$ - wave	$d$ - wave	$d$ - wave
$D_1K$	$p$ - wave	$p$ - wave	$s$ - wave	$d$ - wave
$D_2^*K$	-	$p$ - wave	-	$d$ - wave

- If  $D_{sJ}(3040)$  is  $\tilde{D}'_{s1}$  ( $s_\ell^P = \frac{1}{2}^+, J^P = 1^+, n=2$ ), its spin partner is  $\tilde{D}_{s0}^*$ , a  $J^P = 0^+$  state, the first radial excitation of  $D_{sJ}(2317)$ . This state can decay to  $DK$  and  $D_s\eta$  in  $s$ -wave;  $p$ -wave decays to  $D_1'K$  and  $D_1K$  are also allowed.
- If  $D_{sJ}(3040)$  is  $\tilde{D}_{s1}$  ( $s_\ell^P = \frac{3}{2}^+, J^P = 1^+, n=2$ ), its spin partner is  $\tilde{D}_{s2}^*$  with  $J^P = 2^+$ . It is allowed to decay to  $DK, D_s\eta, D^*K, D_s^*\eta, DK^*$  and  $D_s\phi$  in  $d$ -wave, and to  $D_1'K, D_1K$  and  $D_2^*K$  in  $p$ -wave.
- If  $D_{sJ}(3040)$  is  $D_{s2}$  ( $s_\ell^P = \frac{3}{2}^-, J^P = 2^-, n=1$ ), its spin partner is the vector meson  $D_{s1}^*$  with  $J^P = 1^-$ . It can decay to  $DK, D_s\eta, D^*K, D_s^*\eta, DK^*$  and  $D_s\phi$  in  $p$ -wave, to  $D_0^*K, D_{s0}^*\eta$  and  $D_1'K$  in  $d$ - wave and to  $D_1K$  in  $s$ - wave. The decay to  $D_2^*K$  is allowed at  $\mathcal{O}(\frac{1}{m_c})$  in  $d$ - wave.
- If  $D_{sJ}(3040)$  is  $D_{s2}'$  ( $s_\ell^P = \frac{5}{2}^-, J^P = 2^-, n=1$ ), its spin partner is  $D_{s3}$  with  $J^P = 3^-$ , decaying to  $DK, D_s\eta, D^*K$  and  $D_s^*\eta, DK^*, D_s\phi$  in  $f$ - wave, and to  $D_1'K, D_1K$  and  $D_2^*K$  in  $d$ - wave.

Since  $D_{sJ}(3040)$  has a broad width, we expect that also its spin partner shares the same feature. Considering the previous list, we can argue that  $\tilde{D}_{s0}^*$  is broad due to its  $s$ -wave decays into  $DK$  and  $D_s\eta$ . Also  $D_{s1}^*$  has allowed  $s$ -wave decays, but only to  $D_1K$  which is suppressed by phase space effects.

The identification of  $D_{sJ}(3040)$  with  $\tilde{D}'_{s1}$  is supported in Refs.[17, 18] on the basis of the  $c\bar{s}$  mass spectrum [17] or of the decay widths computed in the  $^3P_0$  model

[18]. In the second case, the identification with  $\tilde{D}'_{s1}$  and  $\tilde{D}_{s1}$  is discussed: the full widths of these two states are computed and compared to the experimental measurement of  $\Gamma(D_{sJ}(3040))$ , concluding that for  $\tilde{D}'_{s1}$  the experimental width can be reproduced, with the predic-

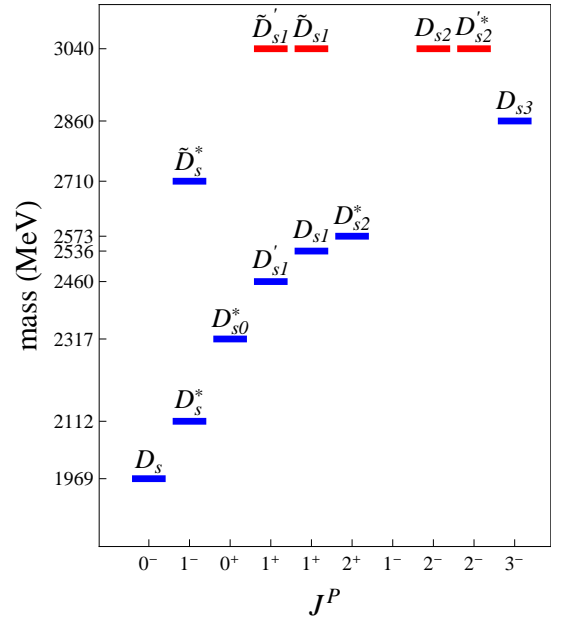


FIG. 1: Spectrum of the  $c\bar{s}$  system. All observed  $D_{sJ}$  states, with mass indicated on the  $y$  axis, are assigned to a level with  $J^P$  and proper name. The four assignments discussed for  $D_{sJ}(3040)$  are shown in correspondence to the mass value  $M = 3040$  MeV.