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PUZZLES IN HADRONIC CHARMONIUM DECAYS

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ABSTRACT

Recent results of experimental studies of hadronic decays of charmonium states using the BES (Beijing Spectrometer) detector are reported. A number of puzzling features are observed.

1 ψ' Decays

Both J/ψ and ψ' decays are expected to proceed via $\psi \to ggg$, with widths that are proportional to the square of the $c\bar{c}$ wave function at the origin [2]. This yields the expectation, that

$$\frac{Br(\psi' \to X_{had})}{Br(J/\psi \to X_{had})} = \frac{\alpha_s^3(M_{\psi'})Br(\psi' \to \mu^+\mu^-)}{\alpha_s^3(M(J/\psi))Br(J/\psi \to \mu^+\mu^-)} = 0.122 \pm 0.019.$$

BES has systematically studied ψ' decays to two-body meson and baryon final states. Some recent results of ψ' decays to VP, VT, AP and other final states are shown in tab.1. The corresponding J/ψ decays, from the PDG, are included for comparison. Outstanding features are:

- VP final states, such as $\rho\pi$ and $K^*\overline{K}$, are strongly suppressed with respect to the 12% expectations. This was first observed at Mark II [1].
- Decays to vector plus tensor final states, such as ωf_2, $a_2\rho$, $K^*\overline{K}_2^*$, and $\phi f_2'$, are also suppressed.

Table 1: Preliminary measurements of ψ' decays to VP, VT, AP and other final states.

Channel	$\mathcal{B}(\psi' \to X)$ (BES) (10^{-4})	$\mathcal{B}(J/\psi \to X)$ (PDG) (10^{-3})	$\mathcal{S}$ $(= \frac{0.12\mathcal{B}_{J/\psi}}{\mathcal{B}_{\psi'}})$
$\rho\pi$	< 0.29	12.8 ± 1.0	> 53
$K^+\overline{K}^*(892)^- + c.c.$	< 0.23	5.0 ± 0.4	> 26
$K^0\overline{K}^*(892)^0 + c.c.$	$1.30 \pm 0.34 \pm 0.16$	4.2 ± 0.4	3.9 ± 1.2
$\omega\pi^0$	$0.36 \pm 0.16 \pm 0.06$	0.42 ± 0.06	1.4 ± 0.7
$\omega\eta$	< 0.33	1.58 ± 0.16	> 6.0
$\gamma\eta$	$0.53 \pm 0.31 \pm 0.08$	0.86 ± 0.08	2.1 ± 1.3
$\gamma\eta'(958)$	$1.54 \pm 0.31 \pm 0.23$	4.31 ± 0.30	3.7 ± 1.0
$\omega f_2(1270)$	< 1.8	4.3 ± 0.6	> 2.8
$a_2(1320)\rho$	< 2.7	10.9 ± 2.2	> 5.2
$K^*(892)^0\bar{K}_2^*(1430)^0 + c.c.$	< 1.4	6.7 ± 2.6	> 5.7
$\phi f_2'(1525)$	< 0.47	0.8 ± 0.4	> 2.0
$b_1(1235)^+\pi^- + c.c.$	$5.3 \pm 0.8 \pm 0.8$	3.0 ± 0.5	0.7 ± 0.2
$K_1(1270)^+K^- + c.c.$	$8.4 \pm 1.9 \pm 1.7$	< 2.7 (BES)	< 0.40
$K_1(1400)^+K^- + c.c.$	< 2.7	$4.3 \pm 1.0 \pm 2.0$ (BES)	> 1.9
$\phi f_0(980)$	$0.77 \pm 0.24 \pm 0.15$	0.32 ± 0.09	0.5 ± 0.2
$K^*(892)^0\overline{K}^*(892)^0$	$0.45 \pm 0.25 \pm 0.07$	< 0.5	< 1.4
$K^+K^-K^+K^-$	$0.65 \pm 0.10 \pm 0.11$	0.7 ± 0.3	1.3 ± 0.6
$\phi\pi^+\pi^-$	$1.3 \pm 0.2 \pm 0.2$	0.80 ± 0.12	0.8 ± 0.2
$\omega\pi^+\pi^-$	$4.7 \pm 0.7 \pm 1.0$	7.2 ± 1.0	1.8 ± 0.4
$\Sigma^0\overline{\Sigma^0}$	$0.94 \pm 0.30 \pm 0.38$	1.0 ± 0.2	1.3 ± 0.5
$\Xi\overline{\Xi}$	$0.83 \pm 0.28 \pm 0.12$	0.9 ± 0.2	1.3 ± 0.6
$\Lambda\overline{\Lambda}$	$2.11 \pm 0.23 \pm 0.26$	1.35 ± 0.14	0.8 ± 0.2
$\Delta(1232)^{++}\overline{\Delta}(1232)^{--}$	$0.89 \pm 0.10 \pm 0.24$	1.10 ± 0.29	1.4 ± 0.5

- The decay rate of the isospin violating $\psi' \to \omega\pi^0$ final state, is as large as or even larger than the SU(3) allowed, isospin-conserving $\psi' \to \rho\pi$ decay. Large isospin violations are seen in $\psi' \to K^*\overline{K}$ decays.
- A flavor-SU(3) violation seen in $K_1\overline{K}$, has an opposite character for the J/ψ and the ψ'.

References

1. M.E.B. Franlkin et al., Phys. Rev. Lett. **51**, 963 (1983).
2. T. Appelquist and H.D. Politzer, Phys. Rev. Lett. **34**, 43 (1975); and A. De Rújula and S.L. Glashow, *ibid*, page 46.