Comparison of J/ψ and $\psi(2S)$ Radiative Decays – I

State	J/ψ	$\psi(2S)$
$\gamma\pi^0$	$(3.49 \pm 0.3) \times 10^{-5}$	$(1.6 \pm 0.4) \times 10^{-6}$
$\gamma\eta$	$(1.104 \pm 0.034) \times 10^{-3}$	$(1.4 \pm 0.5) \times 10^{-6}$
$\gamma\eta'$	$(5.15 \pm 0.16) \times 10^{-3}$	$(1.23 \pm 0.06) \times 10^{-4}$
γ light$q\bar{q}$	$\sim 1\%$	$\sim 10^{-3}$

$$\mathcal{B}\left(J/\psi \to \gamma\pi^0\right) \ll \mathcal{B}((J/\psi \to \gamma\eta) \simeq \mathcal{B}((J/\psi \to \gamma\eta')$$

$$\mathcal{B}\left(\psi(2S) \to \gamma\pi^0\right) \simeq \mathcal{B}\left(\psi(2S) \to \gamma\eta\right) \ll \mathcal{B}\left(\psi(2S) \to \gamma\eta'\right)$$

Do we understand this hierarchy?

J.-M. Gérard, A. Martini, Phys. Lett. B730, 264 (2014)

provide some ideas that might also shed light on the $\rho\pi$ puzzle

Comparison of J/ψ and $\psi(2S)$ Radiative Decays – II

State	J/ψ	$\psi(2S)$
γ light $q\bar{q}$	$\sim 1\%$	$\sim 10^{-3}$
γgg	$(8.8 \pm 1.1)\%$	$(1.03 \pm 0.29)\%$
$\gamma\eta_c(1S)$ $\gamma\eta_c(2S)$	(2-3)% –	$(3.4 \pm 0.5) \times 10^{-3}$ $(7 \pm 5) \times 10^{-4}$
$\gamma\chi_{cJ}$	–	$\sim 29\%$

1. The total observed $\mathcal{B}(J/\psi(\psi(2S)) \to \gamma$ light $q\bar{q})$ is about 10% of expected from γgg, where are the remaining 90%?
2. The lineshape problem in magnetic dipole decays, relativistic corrections
3. Why are $\mathcal{B}(\psi(2S) \to \chi_{cJ}\gamma)$ about equal: $(9.99 \pm 0.27)\%$, $(9.55 \pm 0.31)\%$, $(9.11 \pm 0.31)\%$ for $J = 0,\ 1,\ 2$?

Nature of $X(3872)$ and X_b and Radiative Decays

M. Karliner and J.L.Rosner, arXiv:1410.7729, consider $X(3872)$ and X_b, for $X(3872)$ as a mixture of the $\chi_{c1}(2P)$ and a $D^0\bar{D}^{*0}$+c.c. molecule, they predict 1.11, while other predictions range from 1.24 to 6.36

LHCb, R. Aaij et al., Nucl. Phys. B886,635 (2014):
$\frac{\mathcal{B}(X(3872)\to\psi(2S)\gamma)}{\mathcal{B}(X(3872)\to J/\psi\gamma)} = 2.46 \pm 0.64 \pm 0.29$

If the isoscalar X_b, the bottomonium analogue of the $X(3872)$, is a mixture of a $B^0\bar{B}^{*0}$ molecule with the $\chi_{b1}(3P)$, it decays into $\Upsilon(1S)\omega$, $\chi_{b1}\pi\pi$ and $\Upsilon(3S)\gamma$, the latter dominates over $\Upsilon(1S,2S)\gamma$ with mass spectra deviating from the pure Breit-Wigner