Archives

Ref.TH.2305-CERN

CORRIGENDUM

HADRONIC WIDTHS IN CHARMONIUM

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Please replace page 11 with the revised text overleaf. Only the last eight lines are changed. The estimated radiative width of the transition, $\chi(3454) \to \gamma_2\psi(3095)$, was too large by a factor of 5. The $^1D_2$ assignment therefore has its own difficulties.

Ref.TH.2305-CERN
22 April 1977

Another and more intelligent way of proceeding is to observe that if the $\chi(3454)$ is the partner of the $\psi'(3684)$ we expect their spatial wave functions to be similar and so the first transition, $\psi' \to \gamma_1\chi$, to be an allowed M1 transition, with a radial overlap integral of roughly unity. The estimated rate is 18 keV, only a factor of two larger than the upper bound of 11 keV. But the second transition is another story. Since the ψ' and η' are radial excitations, their spatial wave functions are largely orthogonal to the ground state wave function of the $\psi(3095)$. The transition, $\chi \to \gamma_2\psi$, is thus an unfavoured M1 with a very small overlap integral. The unobserved transition, $\psi' \to \gamma X(2.83)$, is a similarly unfavoured transition. In fact, from the upper limit[3,8] of 1.1% for $\psi' \to \gamma X(2.83)$, corresponding to a width of less than 2.5 keV, one can expect the width for $\chi \to$ $\to \gamma_2\psi$ to be no more than $3 \times 2.5 = 7.5$ keV [14]. Then we conclude $\Gamma_t < 7.5/0.16 \simeq$ $\simeq 50$ keV.

Other ways of estimating or setting a bound on Γ_{γ_2} lead to numbers nearer the 50 keV figure for Γ_t than the over-simple 760 keV. Thus there appears to be a fairly serious discrepancy (by an order of magnitude or more) between QCD predictions and "experiment" *if* the $\chi(3454)$ is identified with the η_c'.

An alternative identification of $\chi(3454)$ as the $^1D_2$-state ($J^{PC} = 2^{-+}$) has been suggested[15]. This at first seems unpalatable, but in view of the apparently large "hyperfine" splitting between the X(2.83) and $\psi(3095)$ cannot be excluded. The triplet d-states are expected just above the ψ'; the singlet d-state *could* be depressed to 3454 MeV. The radiative transitions through the $^1D_2$-state are both unfavoured M1's, involving spin-flip and an overlap of s- and d-state radial wave functions, if the ψ and ψ' are assumed to be purely $^3S_1$-states. The expected transition rate for $\psi' \to \gamma_1\chi$ is so small as to be inconsistent with the observed branching ratio of $B_1B_2 = (0.8 \pm 0.4) \times 10^{-2}$. This $^1D_2$ interpretation can only hope to make sense if there is an admixture of $^3D_1$ in the ψ and ψ'. This is quite plausible on general grounds, QCD having in it a tensor force contribution to the binding potential. With the simple quark model estimate[5] for allowed M1 transitions, one finds $\Gamma_{\gamma_1} \simeq 18\ \varepsilon_D'$ keV, $\Gamma_{\gamma_2} \simeq 38\ \varepsilon_D$ keV, where ε_D and ε_D' are the intensity fractions of d-states present in the ψ and ψ'. The upper limit of $\Gamma_{\gamma_1} < 11$ keV sets the bound, $\varepsilon_D' < 0.6$. The lower limit, $B_2 > 0.16 \pm 0.08$, implies $\Gamma_t < \left(240^{+240}_{-80}\right)\varepsilon_D$ keV. The percentage of d-state in the ψ is probably quite small ($\varepsilon_D \lesssim 0.01$), leading to an estimated total width of a few keV or less. The expected width of the $^1D_2$ state is small, but unlikely to be that tiny[16]. Thus the $^1D_2$ hypothesis, while not completely excluded, has its own difficulties. Besides, such an assignment means that the η_c' is still to be discovered! One problem has been replaced by another.