Decay properties of new D-mesons

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Abstract. We consider radiative and pionic decays of the new D_s-mesons in the framework of a phenomenologically motivated approach. Present data on ratios of the two kinds of decays can be described without explicitly using a 4-quark component. Most probably, the isospin violation in decays of different D_s-mesons is not universal, and the binding potential should be different from Coulombic. New precise measurements may provide further clarification for the nature of the D_s excited states.

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1 Introduction

Recent discoveries of several new charmed meson states are among the most impressive recent events in the heavy flavour physics. These are, first of all, two narrow charmed-strange states, $D_{sJ}(2317)$ and $D_{sJ}(2460)$. The former one was initially observed by the BaBar group [1], and later confirmed by CLEO [2] and Belle [3,4]. Some evidence for the second state was also noted in ref. [1], but it was seen definitely only later, by CLEO [2] and Belle [3,4]. Further, it was reliably confirmed by BaBar as well [5]. To the present moment the two states have been seen both in B-decays and in the continuum annihilation $e^+e^- \to c\bar{c}$ [3]. So they are definitely established, though their properties, especially their quantum numbers, are not quite clear yet (for experimental minireviews on these states, see in [6,7]).

Two more states, non-strange charmed mesons, seem to be discovered by Belle [8] in final states $D^\pm\pi^\mp$ and $D^{*\pm}\pi^\mp$. They have been extracted from the coherent amplitude analysis of the Dalitz plots for $D\pi\pi$ and $D^*\pi\pi$. As a result, their quantum numbers are fixed (dominant S-waves), but their existence strongly needs confirmation. It is even more so, that these states have very large widths (some hundreds MeV), and overlap with kinematical reflections from other resonances. Evidence for the broad S-wave state in the $D\pi$-system has been recently presented also by the Wideband photoproduction experiment FOCUS [9]. However, the masses as given by the two collab-

orations differ by a couple of standard deviations, and the situation needs further clarification.

Unexpected properties of the new D_s-states have induced active theoretical discussions. Presumably, the mesons have spin-parity numbers 0^+ for $D_{sJ}(2317)$ and 1^+ for $D_{sJ}(2460)$ (these values, at least, do not contradict any experimental data). States with such quantum numbers have been, of course, predicted earlier, but they were expected to have higher masses and much higher widths [10, 11]. Therefore, various suggestions have appeared in the literature that the new states may have some nature different from the canonical $q\bar{q}$ states. The published ideas include DK-molecules [12], $D\pi$-atom [13], 4-quark states [14], and their combination with $q\bar{q}$ states [15].

In the framework of more "usual" approaches, the chiral perturbation theory was combined with HQET to include the new states into D_s spectroscopy as chiral partners of the well-known states $D_s(0^-)$ and $D_s^*(1^-)$ [16–18]. The previous calculations for masses were mainly based on the relativistic quark model with the potential consisting of two parts: Coulomb interaction at small distances (due to one-gluon exchange), and linear potential at large distances (for confinement) [19–21]. Now it was suggested that such method could be applied to masses of the new states as well, if one modified the confinement potential [22].

Decay properties of the new states have been also considered in various assumptions, e.g., HQET with chiral effective Lagrangian for light quarks [16,23], previous [24] and modified [22] potential pictures. However, all of them show disagreement with present experimental data, especially for the ratio of radiative and hadronic decays of the

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new mesons. This has led to the rather pessimistic conclusion that if the data are confirmed "the conventional D^*_{s0} and $D^{1/2}_{s1}$ states have yet to be discovered" [24].

In this paper we use another, essentially phenomenological way to estimate partial widths of the new D_s-states. We try to use as few dynamical assumptions as possible. Our approach is explained in sect. 2. Then it is applied to the new meson decays (sects. 3, 4). Our results are summarized and discussed in sect. 5.

In what follows we always assume that the states $D_{sJ}(2317)$ and $D_{sJ}(2460)$ have indeed the spin-parity 0^+ and 1^+, respectively. We will denote them as $D^*_{s0}(2317)$ and $D_{s1}(2460)$.

2 Mass dependence of matrix elements

To explain our approach, let us discuss the problem in terms of 2-body configurations with an efficient potential. Then decay amplitudes are expressible through some overlap integrals between initial and final wave functions.

For the pure Coulomb potential, having no specific mass-dimensional parameter, the overlap integrals could be written as a power of the reduced mass $\mu = m_1 m_2/(m_1 + m_2)$ multiplied by a universal dimensionless factor (independent of the constituent masses). The same would be true, in particular, for mass differences of radial excitations having the same flavour quantum numbers. Those mass differences would be proportional to the corresponding reduced masses.

Experimental data, however, do not support such expectations. Let us take, for instance, vector and tensor mesons with different flavour content. They are well established and well studied for all known flavours (excluding beauty mesons), they nicely correspond to expectations for the quark-antiquark system. Both states have the same internal spin structure (the total spin of constituents is $S = 1$), and differ only in the internal orbital momentum ($L = 0$, 1 for the vector and tensor states, respectively). Moreover, tensor and vector non-strange isosinglet mesons have nearly the same $SU(3)_F$ violating mixing angles, leading to nearly ideal separation of the strange and non-strange components. It is reasonable, therefore, to compare tensor-vector mass differences for mesons of various flavours.

For the mesons with light (u, d, s) quarks we have the differences [25]

$$M_{a_2} - M_\rho = (547 \pm 1)\ \text{MeV}, \tag{1}$$
$$M_{K^*_2} - M_{K^*} = (534 \pm 2)\ \text{MeV}, \tag{2}$$
$$M_{f_2} - M_\omega = (493 \pm 1)\ \text{MeV}, \tag{3}$$
$$M_{f'_2} - M_\phi = (505 \pm 5)\ \text{MeV}, \tag{4}$$

which are nearly the same. Note that the change $(u, d) \rightarrow s$, though essentially shifts the particle masses, produces only very small effect ($\sim 2.5\%$) on $T - V$ mass differences.

For mesons with heavy quarks the differences are [25]

$$M_{D^{*0}_2} - M_{D^{*0}} = (452 \pm 2)\ \text{MeV}, \tag{5}$$
$$M_{D^{*\pm}_2} - M_{D^{*\pm}} = (449 \pm 4)\ \text{MeV}, \tag{6}$$
$$M_{D^{*\pm}_{s2}} - M_{D^{*\pm}_s} = (460 \pm 2)\ \text{MeV}, \tag{7}$$
$$M_{\chi_{c2}} - M_{J/\psi} = (459.31 \pm 0.14)\ \text{MeV}, \tag{8}$$
$$M_{\chi_{b2}(1P)} - M_{\Upsilon(1S)} = (452.3 \pm 0.6)\ \text{MeV}. \tag{9}$$

Again, the change of the mass difference under substitution $(u, d) \rightarrow s$ is only $\sim 2.5\%$. With this accuracy the $T - V$ mass differences are the same for all mesons containing at least one heavy quark, c or b, being lower (!) than those for light-quark mesons[1]. It is interesting to note that in the sequence of hidden-flavour quarkonia $[f_2, \omega] \rightarrow [f'_2, \phi] \rightarrow [\chi_{c2}, J/\psi] \rightarrow [\chi_{b2}(1P), \Upsilon(1S)]$, which corresponds to the quark sequence $u/d \rightarrow s \rightarrow c \rightarrow b$ with monotonously growing constituent masses, the $T - V$ mass difference slightly increases at the first step, and then monotonously decreases. Such behaviour does not correspond to Coulomb regularities, even for the most compact, b-quark systems.

The discussed $T - V$ mass differences are free from the constituent "rest mass" contributions, and are expressed only through diagonal matrix elements of some operators (corresponding to the kinetic and potential energy). As we see, such matrix elements, for changing quark contents, vary not more than $\sim 20\%$, i.e., they reveal only low dependence on the quark masses.

Decay amplitudes are also expressed through some matrix elements, though non-diagonal ones, and of different operators. Nevertheless, we will assume that the emerging matrix elements also have low dependence on the quark masses. As a first approximation, we will neglect such dependence.

3 Decays of D$_{s0}$(2317)

Let us begin with the consideration of $D^*_{s0}(2317)$. Its only observed decay mode is

$$D^{*\pm}_{s0}(2317) \rightarrow D^\pm_s\, \pi^0, \tag{10}$$

having the final momentum about 320 MeV/c. If the initial meson corresponds to the $c\bar{s}$ system, then this decay violates isospin, and should have some suppression. It is well known that there are at least two possible sources for such violation, electromagnetic interactions and/or mass difference of d- and u-quarks. Examples of the isospin violation for light-quark hadrons (without explicit photon

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[1] Recall that T- and V-mesons differ only in the internal orbital momentum. Mass difference for such systems bound by the Coulomb potential should grow with the increase of constituent mass(es). In contrast, V- and P-mesons differ only in spin orientation, and their mass differences should decrease with increasing constituent masses, independently of the binding potential, due to the decrease of (chromo)magnetic moments. This latter expectation exactly agrees with measurements.

radiation or absorption) demonstrate numerical smallness of order 10^{-2}–$10^{-3} \sim \mathcal{O}(\alpha)$ (the rare exclusion, rather intensive decay $\omega \to \pi^+\pi^-$, only confirms this empirical rule, since contains enhancement due to the small $\rho\omega$ mass difference). This does not allow to separate strong and electromagnetic violations of the isospin.

The situation for heavy-quark hadrons seems to be different. The best studied example is the isospin-forbidden decay $\psi(2S) \to J/\psi\,\pi^0$ with branching ratio [25]

$$B_{\pi^0} = (9.6 \pm 2.1) \cdot 10^{-4}$$

and final momentum $p_{\pi^0} = 527$ MeV/c. It can be compared with the similar, but isospin-allowed decay $\psi(2S) \to J/\psi\,\eta$ having branching ratio [25]

$$B_\eta = (3.17 \pm 0.21) \cdot 10^{-2}$$

and the final momentum $p_\eta = 200$ MeV/c. Both decays produce p-wave final states. So, the suppression factor in the isospin-violating amplitude is

$$\epsilon = \left[\frac{B_{\pi^0}}{B_\eta} \left(\frac{p_\eta}{p_{\pi^0}} \right)^3 \right]^{1/2} = (4.07 \pm 0.47) \cdot 10^{-2} \,. \quad (11)$$

Such a value looks too large for the electromagnetic mechanism. It might be enhanced by $(\eta\,\pi^0)$-mixing, in similarity (though weaker) with $(\rho^0\,\omega)$-mixing which enhances the isospin-violating decay $\omega \to \pi^+\pi^-$. If so, the same parameter ϵ should work in all decays which produce π^0 with violation of isospin. Alternatively, its large value in compact charmonium mesons could give evidence for the direct effect of the mass difference $m_d - m_u$, being determined, say, by the ratio $(m_d - m_u)/\Lambda_{\mathrm{QCD}}$. In any case, we will try to assume that this parameter is universally applicable to isospin violation in decays of both charmonium and D_s-mesons.

Now we can compare decay (10) with the similar, but isospin-conserving decay

$$D_0^{*\pm} \to D^\pm\,\pi^0 \,, \quad (12)$$

where $D_0^{*\pm}$ are charmed–non-strange mesons with $J^P = 0^+$. Their isotopic partner, D_0^{*0}, was found by Belle [8] to have the mass and total width

$$M_0^* = (2308 \pm 37)\ \mathrm{MeV}\,, \quad \Gamma_0^* = (276 \pm 66)\ \mathrm{MeV}\,. \quad (13)$$

With reasonable accuracy, we can assume for $D_0^{*\pm}$ the same values of the mass and total width. Further, we suggest that the large total width is completely due to the decay mode $D_0^* \to D\pi$ which should be strongly dominant. For the particular charged channel (12) we then obtain the final momentum of about 378 MeV/c and the partial width

$$\Gamma(D_0^{*\pm} \to D^\pm\,\pi^0) \approx (1/3)\Gamma_0^* = (92 \pm 22)\ \mathrm{MeV}\,. \quad (14)$$

The rest $(2/3)\Gamma_0^*$ comes, according to isotopic relations, from the mode $D_0^{*\pm} \to D^0\,\pi^\pm$.

Both decays (10) and (12) have S-wave final states; each of their widths should be a product of the final momentum by the square of some matrix element. We can assume that those matrix elements differ only by the suppression factor ϵ of eq. (11). Then, accounting for this suppression and for the increased final momentum, 378 MeV/c in decay (12) *vs.* 320 MeV/c in decay (10), we estimate, at last,

$$\Gamma(D_{s0}^{*\pm} \to D_s^\pm\,\pi^0) = (129 \pm 43)\ \mathrm{keV}\,. \quad (15)$$

On the other hand, according to FOCUS [9], the enhancements near the mass 2300 MeV are consistent with kinematical effects of feed-downs from different resonant states, while the true scalar states D_0^{*0} and $D_0^{*\pm}$ have [9]

$$M_0^* = (2407 \pm 41)\ \mathrm{MeV}\,, \quad \Gamma_0^* = (240 \pm 81)\ \mathrm{MeV}\,, \quad (16)$$

$$M_\pm^* = (2403 \pm 38)\ \mathrm{MeV}\,, \quad \Gamma_\pm^* = (283 \pm 42)\ \mathrm{MeV}\,. \quad (17)$$

At such parameters decay (12) has the final momentum of 459 MeV and leads to the estimate

$$\Gamma(D_{s0}^{*\pm} \to D_s^\pm\,\pi^0) = (109 \pm 16)\ \mathrm{keV}\,. \quad (18)$$

It is somewhat lower but consistent with the Belle-based estimate (15).

Let us compare now the pion decay (10) with radiative decays of $D_{sJ}^\pm(2317)$. None of such radiative decays has been observed yet. If the $D_{sJ}^\pm(2317)$ indeed has $J^P = 0^+$, then its decay to D_s, with $J^P = 0^-$, is strictly forbidden (as any radiative 0-0 transition). Possible is the decay

$$D_{s0}^{*\pm}(2317) \to D_s^{*\pm}\,\gamma \,. \quad (19)$$

Its absence in experiment is one of strange properties of $D_{sJ}(2317)$. This decay should exist, if the interpretation of $D_{sJ}(2317)$ as D_{s0}^* is correct. To estimate its expected probability, we compare it to the similar decay

$$\chi_{c0} \to J/\psi\,\gamma \,. \quad (20)$$

Both decays should correspond to $E1$ transitions. Their partial widths may be written as

$$\Gamma(0^+ \to 1^- + \gamma) = |\langle \mathbf{d} \rangle|^2\, p_\gamma^3 \,. \quad (21)$$

Here $\langle \mathbf{d} \rangle$ may be interpreted as the transition matrix element of the operator of the electric dipole moment, p_γ is the momentum of the produced photon. In its turn, the dipole moment element may be written as

$$\langle \mathbf{d} \rangle = \langle \Delta e \rangle \cdot \langle \mathbf{r} \rangle \,, \quad (22)$$

where $\langle \Delta e \rangle$ is the weighted charge difference of constituents in the 2-body $(q\bar{q})$ system. For the charmonium $(c\bar{c})$ it is

$$\langle \Delta e \rangle_{c\bar{c}} = (e_c - e_{\bar{c}})/2 = 2/3 \,.$$

For the D_s-system $(c\bar{s})$, with unequal quark masses, we take the non-relativistic expression

$$\langle \Delta e \rangle_{c\bar{s}} = (m_c e_{\bar{s}} - m_s e_c)/(m_c + m_s) \,.$$

Using the naive estimation $m_c \approx 3m_s$, we obtain $\langle \Delta e \rangle_{c\bar{s}} \approx \langle \Delta e \rangle_{c\bar{c}}/8$. Fitting experimental meson spectra to some detailed potential calculations gives $m_c \approx 4m_s$ (see, e.g., ref. [24]); then $\langle \Delta e \rangle_{c\bar{s}} \approx \langle \Delta e \rangle_{c\bar{c}}/5$. So we can safely take

$$\langle \Delta e \rangle_{c\bar{s}} \leq \frac{1}{5} \langle \Delta e \rangle_{c\bar{c}}. \tag{23}$$

The matrix element $\langle \mathbf{r} \rangle$ could also be different for the systems $c\bar{c}$ and $c\bar{s}$ (in the pure Coulomb case the difference would be determined by the factor $(m_c/m_s + 1)/2$, which can be ~ 2 for realistic constituent masses). However, even the ground state of charmonium is not sufficiently compact to be concentrated in the pure Coulomb area. As a result, this matrix element should change much less. For simplicity, as in other cases, we take it independent of the constituent masses, and apply relation (23) directly to matrix elements of the dipole moment.

The partial width of decay (20) is known experimentally to be [25]

$$\Gamma(\chi_{c0} \to J/\psi\,\gamma) = 119 \pm 19 \text{ keV}. \tag{24}$$

Its final photon momentum is 303 Mev/c, vs. about 200 MeV/c in decay (19). Accounting for suppression (23) and for the p^3 behaviour of eq. (21) with the smaller final momentum, we can now estimate the expected partial width of decay (19)

$$\Gamma(D_{s0}^* \to D_s^*\,\gamma) \leq 1.4 \text{ keV}. \tag{25}$$

The treatment of eq. (23) as equality with the "naive" coefficient 1/8 instead of the "safe" one 1/5 would give the value

$$\Gamma(D_{s0}^* \to D_s^*\,\gamma) \approx 0.55 \text{ keV}. \tag{26}$$

Thus, we expect the ratio $\Gamma(D_{s0}^* \to D_s^*\,\gamma)/\Gamma(D_{s0}^* \to D_s\,\pi^0)$ to be not higher than $\sim 1.5\%$. The present experimental boundary of CLEO [6]

$$\frac{\text{Br}(D_{sJ}^*(2317) \to D_s^*\,\gamma)}{\text{Br}(D_{sJ}^*(2317) \to D_s\,\pi^0)} < 6\% \tag{27}$$

completely agrees with our expectation.

4 Decays of $D_{s1}(2460)$

Here we begin with considering the radiative decay

$$D_{s1}(2460) \to D_s\,\gamma, \tag{28}$$

which was definitely observed by Belle [4]. The D_s-meson has $J^P = 0^-$, and for $D_{s1}(2460)$ we assume $J^P = 1^+$. Then the radiative decay (28) corresponds to the $E1$ transition, and can be estimated in essentially the same way as done in the preceding section for the radiative decay of D_{s0}^*.

Charmonium analog of D_s is η_c with $J^{PC} = 0^{-+}$. The state $D_{s1}(2460)$ has two possible analogs, h_c with $J^{PC} = 1^{+-}$, and χ_{c1} with $J^{PC} = 1^{++}$. Decay $\chi_{c1} \to \eta_c\,\gamma$ is forbidden by C-parity, and thus, analogous to decay (28)

could be only the radiative decay $h_c \to \eta_c\,\gamma$. However, the state h_c itself is badly known (see listings in tables in [25]), and its radiative decay has never been observed. Instead, we again can use decay (20), but with an essential note. Contrary to decays (19) and (20), which are $0^+ \to 1^-$ transitions, decay (28) corresponds to the transition $1^+ \to 0^-$. This leads to the radiative width

$$\Gamma(1^+ \to 0^- + \gamma) = \frac{1}{3} |\langle \mathbf{d} \rangle|^2\, p_\gamma^3, \tag{29}$$

which should be compared with expression (21). The new factor 1/3 appears due to averaging over spin-1 states of the initial system, instead of summing over them for the final system in expression (21). Taking the other factors to be the same as before, and accounting for the larger final momentum in decay (28), of about 440 MeV/c, we obtain the upper boundary

$$\Gamma(D_{s1} \to D_s\,\gamma) \leq 5 \text{ keV}. \tag{30}$$

It would give

$$\Gamma(D_{s1} \to D_s\,\gamma) \approx 2 \text{ keV} \tag{31}$$

at the "naive" treatment of eq. (23) as an equality with the coefficient 1/8, instead of 1/5.

Pionic decay

$$D_{s1}(2460) \to D_s^*\,\pi^0, \tag{32}$$

with $p_\pi = 425$ MeV/c, violates isospin symmetry. Its theoretical consideration may appear ambiguous since there are two possible pion transitions $1^+ \to 1^-$, through S- or D-wave. Of course, they can be discriminated experimentally, but this has not been done yet for $D_{s1}(2460)$.

In the charmed–non-strange sector there are two 1^+-states [8,9,25] with nearby masses. One of them is relatively narrow, another is much wider. Those are D_1 with

$$M_{D_1} = (2421.4 \pm 1.7) \text{ MeV}, \quad \Gamma_{D_1} = (23.7 \pm 4.8) \text{ MeV} \tag{33}$$

and D_1' with

$$M_{D_1'} = (2427 \pm 36) \text{ MeV}, \quad \Gamma_{D_1'} = (384 \pm 120) \text{ MeV}. \tag{34}$$

We use here the two masses and widths from the simultaneous coherent analysis of the $D^*\pi$-system [8]. PDG tables [25] contain only a narrower state, its parameters being consistent with values (33). On the other hand, analysis of the FOCUS Collaboration [9] reveals only a wider state, whose mass and width are consistent with (34).

Further, according to ref. [8], D_1 decays mainly through D-wave, and D_1' through S-wave (the latter agrees with data in [9]), thus explaining the large difference of the widths. The mutual admixtures are about 10% in the wave functions [8], and as a first step we neglect the mixing.

Here we need to make an assumption about the partial-wave properties of decay (32). If it goes (mainly) in the S-wave, we should compare it to the S-wave decay $D_1' \to D^*\,\pi^0$, with the final momentum of 482 MeV/c. This can

be done in exactly the same way as for decays (10) and (12), and leads to

$$\Gamma^{(S)}(D_{s1}(2460) \to D_s^* \pi^0) = (187 \pm 73)\ \text{keV}. \qquad (35)$$

But if decay (32) is the D-wave one, it should be compared to the D-wave decay $D_1 \to D^* \pi^0$, having the final momentum 477 MeV/c. The width for such decays may be written as product of the 5th power of the final momentum by the square of a matrix element. As before, we relate the matrix elements for isospin-violating (D_{s1}) and isospin-conserving (D_1) decays by the suppression parameter ϵ and then account for the p^5-behaviour of the partial width. Thus we obtain

$$\Gamma^{(D)}(D_{s1}(2460) \to D_s^* \pi^0) = (7.4 \pm 2.3)\ \text{keV}. \qquad (36)$$

To discriminate between these two possibilities, we can use the experimental fact of observing decay (28) with relative intensity [3,4]

$$\frac{\Gamma(D_{s1}(2460) \to D_s \gamma)}{\Gamma(D_{s1}(2460) \to D_s^* \pi^0)} \sim 0.5. \qquad (37)$$

The comparison of values (30), (35) and (36) shows that our estimate for the S-wave case leads to strong disagreement with the ratio (37), while it is quite compatible with the D-wave case.

5 Discussion and conclusion

Let us summarize our assumptions and their implications.

1) First of all, we have assumed that overlap integrals in decay amplitudes are nearly independent of the constituent-quark masses. This assumption would be incorrect if the binding potential were Coulombic. But a realistic potential should be more complicated, thus making our assumption admissible. In any case, it is inspired by the phenomenology of measured meson mass differences.

2) Another assumption may be less clearly motivated. It is the universal character of the suppression factor ϵ, as given by eq. (11), for isospin-violating amplitudes in decays of mesons containing at least one heavy quark. We will discuss this point below in more detail.

All our estimates begin with decays of mesons which are usually considered as quark-antiquark systems (charmonium, excited D-mesons). Therefore, we never use, at least explicitly, the presence of 4-quark components.

With such assumptions we are able to describe the present data on the relation of photon and pion decays of the new D_s-mesons, but only if the decay (32), i.e. $D_{s1}(2460) \to D_s^* \pi^0$, goes (mainly) through the D-wave. In terms of the effective heavy-quark description, this would mean that $D_{s1}(2460)$ corresponds to the state with $j = 3/2$. Though the question can (and will) be solved by direct measurement of the angular distribution in the decay, today such prescription disagrees with familiar expectation of the theoretical community. Moreover, if it is correct, another assumed 1^+-state, $D_{sJ}(2535)$, should

have $j = 1/2$ and decay to $D^* K$ through the S-wave. In that case one could hardly understand its small width $\Gamma_{\text{tot}} < 2.3$ MeV [25].

If $D_{s1}(2460)$ corresponds to $j = 1/2$, our calculations can still be made consistent with data, if we weaken the above assumptions. As the easiest way to this goal we can drop out the universality of the suppression factor (11) for isospin violation. Indeed, if we accept estimates (26) and (31) for radiative decays, then the amplitude for the S-wave decay (32) should be suppressed by the factor $\sim \epsilon/7$, instead of $\sim \epsilon$, to satisfy the experimental relation (37). Such suppression ($\sim 6 \cdot 10^{-3}$) has rather familiar order of smallness and does not look too severe.

On the other side, to satisfy the boundary (27), the amplitude for decay (10), i.e. $D_{s0}^{*\pm}(2317) \to D_s^\pm \pi^0$, should not be suppressed more strongly than $\sim \epsilon/4$, which is $\sim 10^{-2}$. Thus, the isospin violation in decays (10) and (32) seems to be non-universal, and different from violation effects in decays of charmonium.

This might look strange, since all the cases should have universal contributions due to $(\eta \pi^0)$-mixing. Note, however, that for charmonium we compare decays to η and to π^0, while in estimating decays (10) and (32) we compare pionic decays of different systems, $c\bar{s}$ and $c\bar{d}$. Such ratios should not be necessarily the same.

Moreover, as shown in ref. [26], the universal mixing violation of isospin symmetry should be always accompanied by non-universal direct violation (compare the mixing vs. direct violation of CP-parity, say, in kaon decays). Due to the small mass difference, the $(\omega \rho^0)$-mixing strongly enhances violation, and makes the whole effect to be nearly universal. The enhancement due to $(\eta \pi^0)$-mixing is weaker, and non-universal contributions of direct violation may become more essential. Thus, non-universality of isospin violation in decays of different D_s-mesons is not amusing.

One may also try to weaken the first of our above assumptions. It is easy to see that some increase of the overlap integrals for D_s-mesons as compared with charmonium allows to reach better agreement between our estimates and experimental data. It could be done even with the universal suppression factor of isospin violation, but then the increase should be faster than for the Coulomb potential, in contradiction with data on mass differences. Therefore, the suppression, most probably, should be non-universal. We will not discuss here the structure of the admissible effective potential.

These two modifications of our assumptions provide interesting features. Estimates (26) and (31), appended by non-universal isospin violation, provide for the new D_s-mesons the total widths of less than ~ 10 keV. Universal isospin violation suppression, together with increasing overlap integrals, would give the total widths of ~ 100 keV. So, the two possibilities could be discriminated by special precise experiments.

As a conclusion, we can say that the present data on decay properties of new D_s-mesons may be described in terms of a quark-antiquark bound system with some non-Coulombic potential. The presence of an essential 4-quark

component is not required. A similar conclusion was derived earlier [22] on the basis of spectroscopy only. Our additional, and new, result is the probable non-universality of isospin violation in pionic decays of different D_s-states, even if it is related to $(\eta\pi^0)$-mixing. Important and clarifying new information could come from measurements of total widths for the new mesons, though this seems to be a very hard problem.

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