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ON TWO – PHOTON WIDTH OF δ– MESON

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Abstract

It is shown that a natural magnitude of the radiative width of the δ meson must be $\Gamma_{\delta\gamma\gamma} \approx 1$ KeV.

The reason for which the published experimental number for $\Gamma_{\delta\gamma\gamma}$ seems to be too low is presented.

The preliminary result of determination of the two-photon width of the scalar resonance δ (980) from the data on the process $e^+ e^- \rightarrow e^+ e^- \eta \pi^0$ is[1].

$$\Gamma_{\delta\gamma\gamma} \cdot BR(\delta \rightarrow \eta\pi) = (0.100 \pm 0.025 \pm 0.100)\ KeV \quad (1)$$

In a literature, one can find the estimates according to which $\Gamma_{\delta\gamma\gamma} \approx 5$ KeV[2,3] if the δ meson is a bound quark-antiquark system, and $\Gamma_{\delta\gamma\gamma} \approx 0.27$ KeV[3] if the δ is a four-quark system $\bar{q}^2 q^2$. On a base of these estimates, the result (1) was interpreted as one testifying a four-quark nature of the δ meson[4]. In our opinion such a conclusion is not seem to be perfectly grounded.

Firstly, a quantitative evaluation in the framework of the $\bar{q}q$ scheme, based on using of an effective chiral Lagrangian gives the result[5]

$$\Gamma_{\delta\gamma\gamma}(m_\delta) = \frac{m_\delta}{\pi}\left(\frac{\alpha m_\delta}{12\pi F_\pi}\right)^2 \approx 1.3\ KeV \quad (2)$$

As to the estimate $\Gamma_{\delta\gamma\gamma} \approx 0.27$ in $\bar{q}^2 q^2$ scheme, it has been obtained without of computing any definite diagrams and it can be easily increased up to the value 1-2 KeV.

Really, evaluating the contribution of the diagrams of Fig.1 in $\Gamma_{\delta\gamma\gamma}$, we shall get (in approximation $m_\delta = 2 m_K$)

$$\Gamma^{(K\bar{K})}_{\delta\gamma\gamma} = \frac{\alpha^2(\pi^2/4-1)^2}{16\pi^2 m_\delta} \cdot \frac{g^2_{\delta K\bar{K}}}{4\pi} \qquad (3)$$

Substituting the values $g^2_{\delta K\bar{K}}/4\pi$ = 2.3 GeV^2 or $g^2_{\delta K\bar{K}}/4\pi$ = 3 GeV^2 used in the $\bar{q}^2 q^2$ scheme/8/, one gets $\Gamma^{(K\bar{K})}_{\delta\gamma\gamma}$ = 1.7 KeV or $\Gamma^{(K\bar{K})}_{\delta\gamma\gamma}$ = 2.2 KeV respectively.

In the $\bar{q}q$ scheme, where $g^2_{\delta K\bar{K}}/4\pi$ = 0.82 GeV^2, we should get $\Gamma^{(K\bar{K})}_{\delta\gamma\gamma}$ = 0.61 KeV.

Of course, a calculation of a loop diagram with one definite physical intermediate state does not permit yet to fix an exact value of amplitude, but such calculation determines a scale of natural values of the amplitude under consideration. We see that a scale of values of the amplitude $\delta\to\gamma\gamma$ is the same in $\bar{q}^2 q^2$ and $\bar{q}q$ schemes, and, consequently, the result (1) is too small to be explained in these schemes.

Let's show now that the data/1/ are compatible with the values of $\Gamma_{\delta\gamma\gamma}$ considerable larger than the value (1).

The result (1) was obtained under assumption that the total width of the δ meson is small : Γ_δ = 54 MeV/9/. But in both schemes ($\bar{q}q$ and $\bar{q}^2 q^2$) a natural value of Γ_δ approximately is by six time more, and this fact does not contradict (see Ref./6-8, 10/) to observation of a narrow peak in the process $K^- p \to \Sigma^+(1385)\eta\pi^-$.

If the δ resonance is wide ($\Gamma_\delta \sim 300$ MeV), it must be described (see Ref./6-8, 10/) by formulae

$$\sigma_{\gamma\gamma\to\eta\pi}(W) = 8\pi\,\Gamma_{\delta\gamma\gamma}(W)\,\Gamma_{\delta\eta\pi}(W)\cdot \left|W^2 - m_\delta^2 + i m_\delta \Gamma_\delta(W)\right|^{-2} \qquad (4)$$

where

$$\Gamma_\delta \cong \Gamma_{\delta\eta\pi^0} + \Gamma_{\delta K\bar{K}}$$

and $\Gamma_{\delta\gamma\gamma}(W) = (W/m_\delta)^3\,\Gamma_{\delta\gamma\gamma}(m_\delta)$,

$$\Gamma_{\delta\eta\pi^0} = \frac{g^2_{\delta\eta\pi^0}}{16\pi W}\left[1 - \frac{2(m_\eta^2+m_\pi^2)}{W^2} + \frac{(m_\eta^2-m_\pi^2)^2}{W^4}\right]^{\frac{1}{2}},$$

$$\Gamma_{\delta K\bar{K}}(W) = \frac{g^2_{\delta K\bar{K}}}{16\pi W}\begin{cases}\sqrt{1-4m_K^2/W^2}, & W \geq 2m_K\\ i\sqrt{4m_K^2/W^2-1}\left(1-\frac{2}{\pi}\operatorname{arctg}\sqrt{4m_K^2/W^2-1}\right), & W \leq 2m_K\end{cases}$$

Then, it is possible to get a value of $\Gamma_{\delta\gamma\gamma}$ larger than the value (1).

The Fig.2 demonstrates an attempt to describe the data[1] in terms of two resonance cross sections, first of which was calculated using the formulae (3) and (4) with $\Gamma_{\delta\gamma\gamma}(m_\delta) = 0.5$ KeV and $g_{\delta\eta\pi^0} = -4.8$ GeV, $g_{\delta K\bar{K}} = -3.2$ GeV[7]. The part of cross section connected with A_2 meson was computed using the standard formula for narrow resonance with $\Gamma_{A_2\gamma\gamma} = 0.6$ KeV and with other parameters from Ref.[9]. We have used a slightly less value of $\Gamma_{A_2\gamma\gamma}$ as compared to conventional mean value, because some part of events from area of A_2 meson must be treated as belonging to right branch of δ resonance $m_{\eta\pi^0}$ distribution if δ resonance is wide.

Thus, as it is seen from Fig.2 the data[1] do not contradict to $\Gamma_{\delta\gamma\gamma} = 0.5$ KeV. If one will take into account that the systematic mistake in determination of $\Gamma_{\delta\gamma\gamma}$ in Ref.[1]

is estimated to be 100 %, one can not exclude until now that the real value of $\Gamma_{\delta\gamma\gamma}$ could be close to $\Gamma_{\delta\gamma\gamma}(m_\delta) \approx 1$ KeV - a value predicted by the $\bar{q}q$ scheme of the δ meson.

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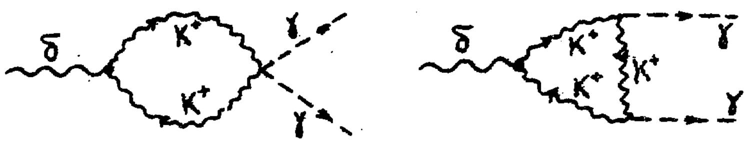

Fig. 1

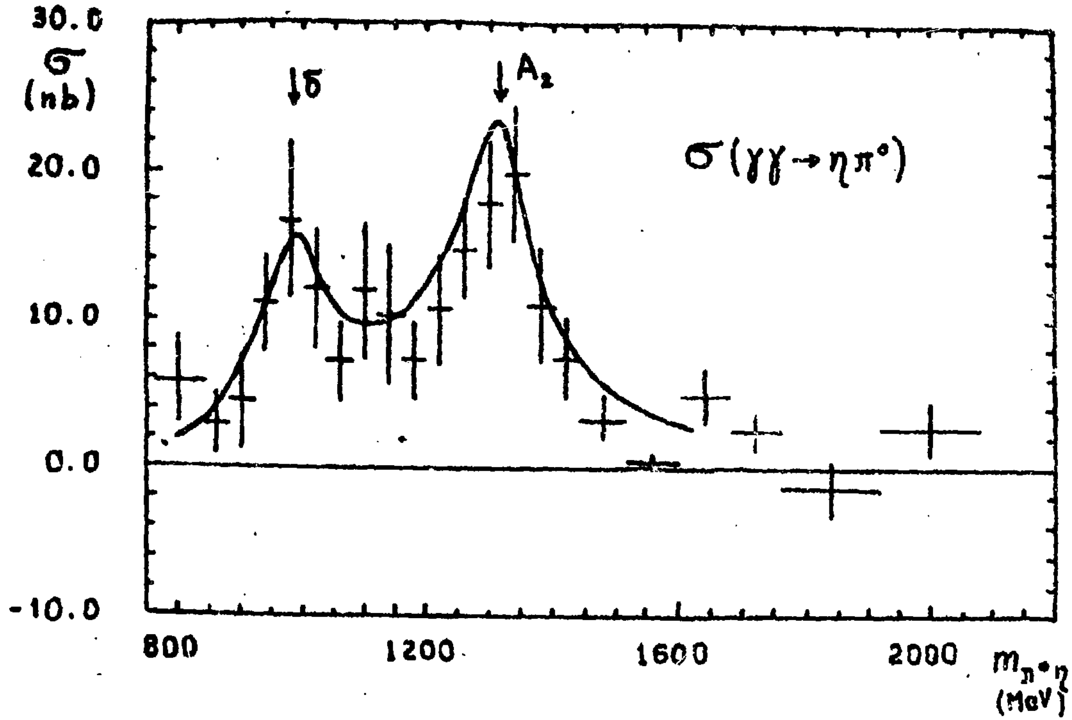

Fig. 2

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