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Does x(2.8 GeV) Favour Charm or Color?

by

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Abstract

The possibilities of the newly discovered particle with mass 2.8 GeV belonging to the charm scheme or to the color scheme are discussed. It is pointed out that crucial tests for this problem are measurements of the decay of x(2.8) into $2\pi^+2\pi^-$ (or 4 pseudoscalar mesons) and the ratio $\Gamma(X(2.8) \to V\gamma)/\Gamma(X(2.8) \to 2\gamma)$.

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Recently some new particles which are not vector mesons have been discovered in the e^+e^- colliding beam experiments. The most striking one is the particle with mass 2.8 GeV, which has been found in the analyses of $\psi(3.1) \rightarrow 3\gamma$ at DESY /1/. In the charm scheme /2/ it is generally classified as a $c\bar{c}$-pseudoscalar state (η_c) having isospin I = o, G-partiy G = + 1. On the other hand, in the color scheme /3/ the x(2.8) can be an isoscalar with G = + 1 or an isovector with G = - 1. Because the x(2.8) is the lightest particle discovered, we assign to it the states (π,π) for I = 1, or (η,π) for I = o in the broken color scheme /4/ with the obvious $(SU(3), SU(3)_{color})$ notation. In this note we discuss how one can decide between these possibilities.

The best check of G-parity is the decay $x(2.8) \rightarrow 2\pi^+2\pi^-$. Because the decays of x'(3.4) and x''(3.52) into $2\pi^+2\pi^-$ have been seen in the decay $\psi(3.1) \rightarrow \gamma + (2\pi^+2\pi^-)$, we expect that the decay $x(2.8) \rightarrow 2\pi^+2\pi^-$ can be observed in the decay $\psi(3.1) \rightarrow \gamma + 2\pi^+2\pi^-$. If it is seen, we can exclude the possibility that x(2.8) is (π,π).

Now we discuss a possibility to distinguish between the charm and color model with help of the decay ratio $\Gamma(X(2.8) \rightarrow V\gamma)/\Gamma(X(2.8) \rightarrow Z\gamma)$ for $V = (\rho, \omega \ \phi)$. From the vector meson dominance assumption /5/ according to the graphs in Fig. 1, we estimate in the charm model: for diagram (a),

$$R(V\gamma/Z\gamma) \simeq \epsilon^2 \frac{f^2_{\psi(3.1)}}{4\pi} \alpha^{-1}, \qquad (1a)$$

where ϵ is a mixing parameter for η_1 (singlet state) and η_8 (octet state), and for diagram (b),

$$R(V\gamma/Z\gamma) \simeq \frac{\Gamma(\psi(3.1) \to V \to \text{hadrons})}{\Gamma(\psi(3.1) \longrightarrow \ell^+\ell^-)} \times \alpha$$

$$< \frac{\Gamma(\psi(3.1) \to \text{hadrons})}{\Gamma(\psi(3.1) \to \ell^+\ell^-)} \times \alpha \simeq 14\alpha \tag{1b}$$

and for diagram (c),

$$R(V\gamma/Z\gamma) \simeq \alpha^3/\alpha^2 = \alpha \,. \tag{1c}$$

In the diagram of the color model shown in Fog. 2 $(\rho, \omega\ \phi)$ contribute and we get

$$R(V\gamma/Z\gamma) \simeq \frac{f_V^2}{4\pi} \alpha^{-1} \,, \tag{2}$$

where $f_\rho^2/4\pi \simeq 2$ and $\alpha^{-1} \simeq 137$. In the charm model /6/ the diagram (a) dominates and the mixing parameter is given by $\epsilon^2 \simeq g^{-4}$, where $g \simeq 4 \sim 5$. In that case $R(V\gamma/Z\gamma)$ is a crucial test to decide between the two models, because the expectation in the two models differs by 2 ~ 3 order of magnitudes. In particular, if x(2.8) is (π, π) , the decay $x(2.8) \to \rho^0\gamma$ must be (200 ~ 300) times larger than the decay $x(2.8) \to Z\gamma$; this might be observed in the reaction $\psi(3.1) \longrightarrow \gamma + X(2.8) \longrightarrow \gamma + (\gamma + \pi^+\pi^-)$. In the case that x(2.8) is (η, π) , it decays into $\omega\gamma$ and $\phi\gamma$, for which one should also look in the cascade decay of $\psi(3.1) \to Z\gamma K^+K^-$ via $\phi\gamma$. Even if (η, π) is an ideally mixed state, we can expect that the decays $\psi(3.1) \to \gamma + X(2.8)$ $\to Z\gamma + \pi^+\pi^-$

via $\omega\gamma$ is (30~40) times larger than the decay $\psi(3.1) \rightarrow \gamma + X(2.8) \rightarrow 3\gamma$, while in the charm model this factor is expected to be (2~5).

Now let us consider the inprobable case that the mixing parameter ϵ in the charm model is much larger than g^{-2}. For example, if $\epsilon \simeq 0.15$, we have $R(V\gamma/2\gamma) \simeq 30$. In this case, however, we must expect a large decay width for $x(2.8) \rightarrow 2\pi^+2\pi^-$(via $\rho^\circ\rho^\circ$), $K\bar{K}2\pi$ (via $K^*\bar{K}^*$) and $2K2\bar{K}$ (via $\phi\phi$). Included simple phase space corrections,we obtain

$$\Gamma(X(2.8) \rightarrow 4\pi, K\bar{K}2\pi \text{ and } 2K2\bar{K}) \simeq 5 \sim 50 \text{ MeV} \qquad (3)$$

for $R \simeq 30$. On the other hand in the color scheme these decays break the color quantum number, and therefore their rate is about the same as the decay of ψ (3.1). They might be observed in the decay $\psi(3.1) \rightarrow \gamma +$ (4 pseudo-scalar mesons). We can also expect a large decay width for $\psi(3.1) \rightarrow \eta' + \gamma$ /7/.

In conclusion, we again enphasize, that we shall be able to decide the assignment of x(2.8), if the decay $x(2.8) \rightarrow 4$ pseudoscalar mesons and $R(V\gamma/2\gamma)$ are measured. A similar discussions can be applied to decays and $R(V\gamma/2\gamma)$ of x'(3.4) and x''(3.52) /7/.

Finally we mention that we can get the same conclusion for the ordinary color scheme replacing (π, π) and (η, π) by (π, γ_8) and (η, γ_8).

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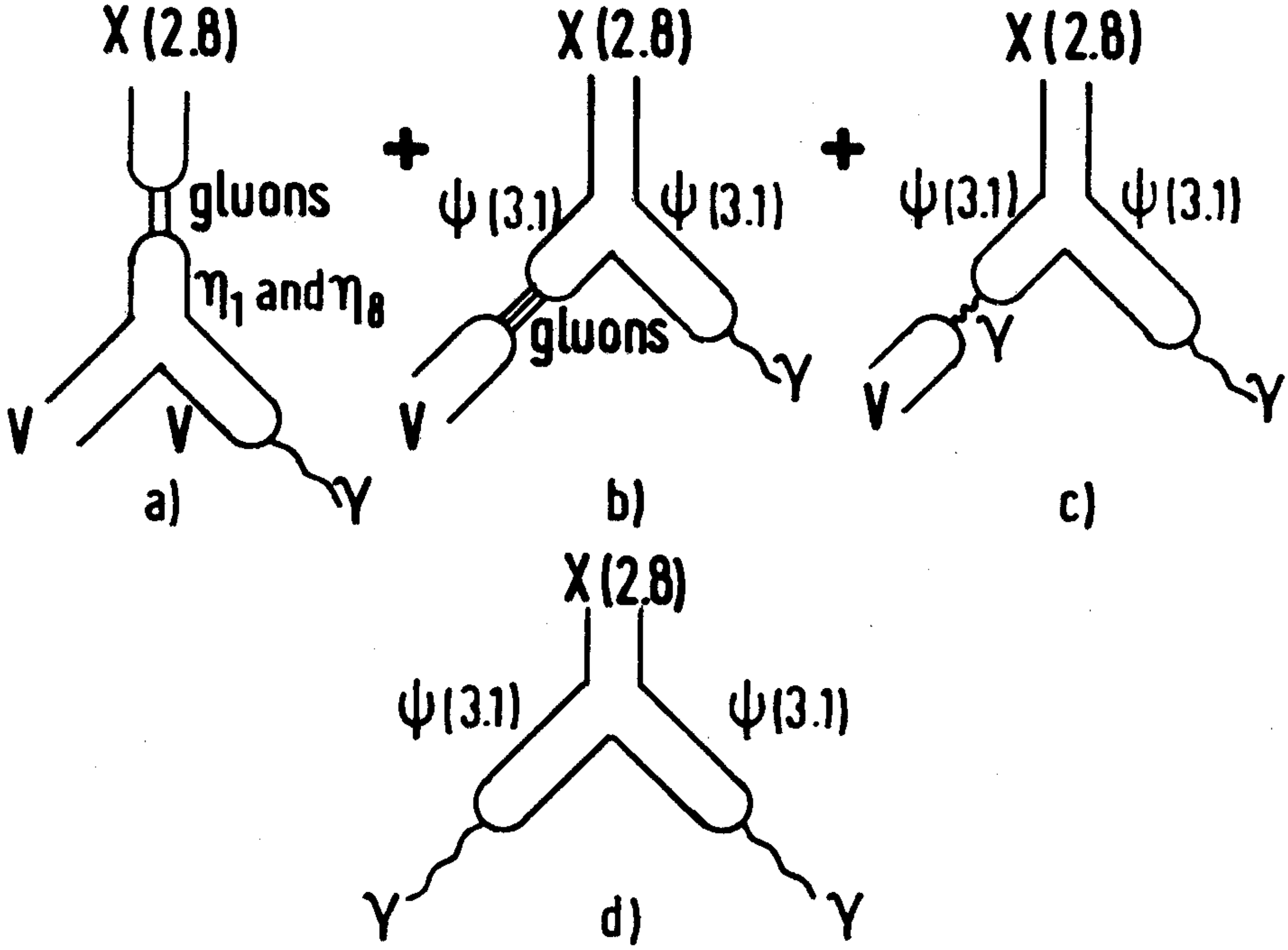
Figure Captions

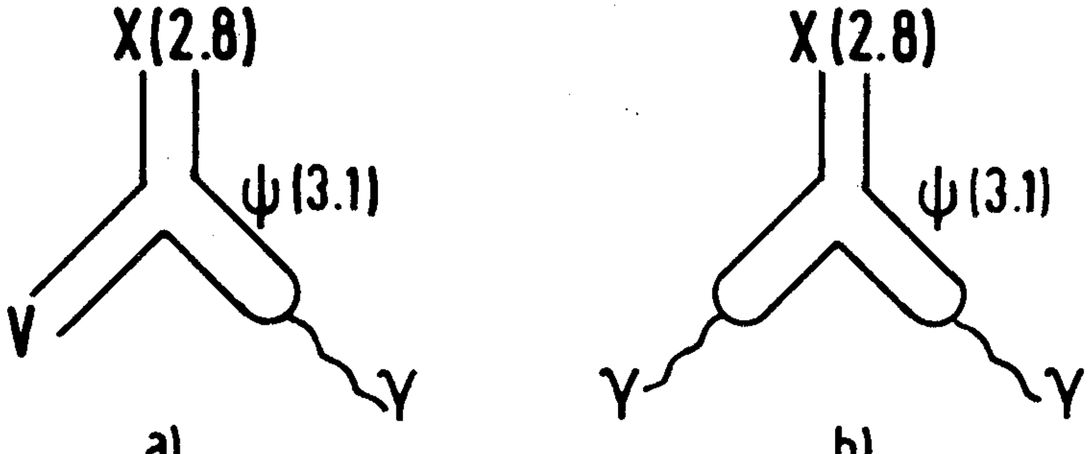
Fig. 1 Decay diagrams of x(2.8) in the charm model. Diagrams (a), (b) and (c) represent the decay x(2.8) $\rightarrow V\gamma$ and (d) represents the decay x(2.8) $\rightarrow 2\gamma$.

Fig. 2 Decay diagrams of x(2.8) in the color model. Diagrams (a) and (b) represent the decays x(2.8) $\rightarrow V\gamma$ and 2 γ , respectively.



X (2.8)
gluons
η1 and η8
V
V
γ
a)
+
X (2.8)
ψ (3.1)
ψ (3.1)
gluons
V
γ
b)
+
X (2.8)
ψ (3.1)
ψ (3.1)
γ
V
γ
c)
X (2.8)
ψ (3.1)
ψ (3.1)
γ
d)
γ

Fig.1



X (2.8)
ψ (3.1)
V
γ
a)
X (2.8)
ψ (3.1)
γ
γ
b)

Fig.2