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E2-88-465 e

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SCALAR GLUONIUN CANDIDATES AND THE RADIATIVE J/ψ DECAYS

Submitted to "Czechoslovak Journal of Physics B"

1988

1. INTRODUCTION

The radiative decays $J/\psi \to \gamma$ + hadrons are good sources of gluons since in agreement with perturbative QCD [1] such decays proceed first through the process $J/\psi \to \gamma gg$ and then two gluons gg are converted into hadrons. Thus, radiative J/ψ decays are usually considered as favourable to search for bound states of gluons called gluonia or glueballs although this fortuitous circumstance does not guarantee that gluonia are actually produced. For instance, a rather large decay [2] $J/\psi \to \gamma + f_2(1270)$ is an example of production of a typical quarkonium $q\bar{q}$ bound state. This means that an exclusive decay of the type $J/\psi \to \gamma$ + a meson is a matter of detailed nonperturbative QCD dynamics and perturbative QCD predictions are not probably very reliable in this case.

In fact, a spin-parity analysis of the produced two-gluon system in the decay $J/\psi \to \gamma gg$ has been performed [3] and the strong enhancement has been found for $J^{PC} = 0^{++}$, 0^{-+} and 2^{++} final states in the gg system with the equality of decays into 0^{++} and 0^{-+} channels, i.e. with $BR(J/\psi \to \gamma + gg \text{ in } 0^{++}) = BR(J/\psi \to \gamma + gg \text{ in } 0^{-+})$. On the basis of this perturbative QCD result one may expect that, e.g., scalar gluonium $\sigma \sim gg$ with the mass $m_\sigma \geq 1$ GeV is produced in the radiative J/ψ decay at least as strongly as the pseudoscalar η' (or $\eta(1440)$), i.e. by comparison with $BR(J/\psi \to \gamma\eta') = 4.2\times10^{-3}$ (or $BR(J/\psi \to \gamma\eta(1440) \to \gamma K\bar{K}\pi) = 4.6\times10^{-3}$)[2] one estimates:

$$BR(J/\psi \to \gamma\sigma) \gtrsim 4\times10^{-3} \ . \tag{1}$$

However, in contrast with a clear observation of the produced pseudoscalars η' and $\eta(1440)$, no scalar mesons were observed in the radiative J/ψ decay and so perturbative QCD estimate (1) (see also [4]) is probably unacceptably large.

On the other hand, within nonperturbative, long-range QCD we are not as yet able to solve the problem of hadronic state formations and, in particular, we cannot answer the question what are the decay rates for exclusive decays of the type $J/\psi \to \gamma$ + a hadron. However, there is a possibility of saying something about these decays on the basis of the Euler - Heisenberg type of effective Lagrangians for the gluon-photon interactions. In fact, Lagrangians of that type have already been used [5,6] to describe the coupling between X (X = pseudoscalars η, η' or a scalar gluonium σ) and photons, and then to estimate the radiative decays $\sigma \to \gamma\gamma$ [6] as well as $J/\psi \to \gamma + X$ [5] assuming J/ψ vector meson dominance for one of the photons in the latter case. The pole approximation is generally a delicate problem (for a more detailed discussion, see [5]) but due to expected cancellation of the continuum contributions in the ratios like $\Gamma(J/\psi \to \gamma\eta')/\Gamma(J/\psi \to \gamma\eta)$, etc., we believe that such ratios are more accurate. Moreover, in the ratios the dependence on the mass m_c of the c - quark is conveniently cancelled, too. In this way one gets:

$$\frac{\Gamma(J/\psi \to \gamma\sigma)}{\Gamma(J/\psi \to \gamma\eta)} = \frac{9}{64}\left|\frac{\langle 0|\alpha_s G^a_{\mu\nu} G^{\mu\nu}_a|\sigma\rangle}{\langle 0|\alpha_s G^a_{\mu\nu}\tilde{G}^{\mu\nu}_a|\eta\rangle}\right|^2 \left(\frac{P_\sigma}{P_\eta}\right)^3 , \tag{2}$$

and

$$\frac{\Gamma(J/\psi \to \gamma\eta')}{\Gamma(J/\psi \to \gamma\eta)} = \left|\frac{\langle 0|\alpha_s G^a_{\mu\nu}\tilde{G}^{\mu\nu}_a|\eta'\rangle}{\langle 0|\alpha_s G^a_{\mu\nu}\tilde{G}^{\mu\nu}_a|\eta\rangle}\right|^2 \left(\frac{P_{\eta'}}{P_\eta}\right)^3 , \tag{3}$$

where

$$P_X = 1 - (m_X/m_{J/\psi})^2 , \quad \tilde{G}^a_{\mu\nu} = (1/2)\epsilon_{\mu\nu\alpha\beta}\, G^{a\alpha\beta} ,$$

$G^a_{\mu\nu}$ being the gluon field strength tensor. The ratios (2) and (3) crucially depend on the matrix elements $\langle 0|\alpha_s G^a_{\mu\nu} G^{\mu\nu}_a|\sigma\rangle$ and $\langle 0|\alpha_s G^a_{\mu\nu}\tilde{G}^{\mu\nu}_a|\eta(\eta')\rangle$ that represent couplings of the states σ and $\eta(\eta')$ to gluonic currents $\alpha_s G^a_{\mu\nu} G^{\mu\nu}_a$ and $\alpha_s G^a_{\mu\nu}\tilde{G}^{\mu\nu}_a$, respectively. These couplings are given by long-range, nonperturbative dynamics and have been estimated as follows [4,5,6]

$$\langle 0|\alpha_s G^a_{\mu\nu}\tilde{G}^{\mu\nu}_a|\eta\rangle = \frac{4\pi}{\sqrt{3}} m^2_\eta f_\pi ,$$
$$\langle 0|\alpha_s G^a_{\mu\nu}\tilde{G}^{\mu\nu}_a|\eta'\rangle = \frac{4\pi}{\sqrt{6}} m^2_{\eta'} f_\pi , \tag{4}$$

and

$$\langle 0|\alpha_s G^a_{\mu\nu} G^{\mu\nu}_a|\sigma\rangle = \frac{8\pi}{3\sqrt{2}} m_\sigma \sqrt{G_0} , \tag{5}$$

where $f_\pi = 93$ MeV is the pion decay constant and $G_0 = \langle 0|(\alpha_s/\pi) G^a_{\mu\nu} G^{\mu\nu}_a|0\rangle$ is the gluon condensate. Since (3) and

(4) are in a reasonable agreement with experiment, we expect that (2), (4) and (5) would also be successful in the prediction of the decay width $\Gamma(J/\psi \to \gamma\sigma)$. Taking the ITEP[7] value of $G_0 = 0.012\ \mathrm{GeV}^4$ we obtain the branching ratio $BR(J/\psi \to \gamma\sigma)$ for production of the pure gluonium σ in the radiative J/ψ decay as follows

$$BR(J/\psi \to \gamma\sigma) = \begin{cases} 0.97 \times 10^{-3} \\ 1.37 \times 10^{-3} \end{cases} \quad \text{for} \quad m_\sigma = \begin{cases} 1\ \mathrm{GeV} \\ 1.59\ \mathrm{GeV}, \end{cases} \tag{6}$$

where we have used $BR(J/\psi \to \gamma\eta) = 0.86 \times 10^{-3}$ [2]. We note that (6) is a factor 4 smaller than (1). This is not surprising because a lot of nonperturbative physics is included into (2) - (5).

The estimates (6) still probably contradict the experiment if one assumes that the pure scalar gluonium σ is identified with either the narrow state $S_1(991)$[8] or the GAMS $f_0(1590)$ meson[9]. In fact, on the one hand, the existing upper limit[10] $BR(J/\psi \to \gamma f_0(975)) \times BR(f_0(975) \to \pi\pi) < 7 \cdot 10^{-5}$ (90% C.L.) also applies to $S_1(991)$ and contradicts (6). On the other hand, the lack of the decay $J/\psi \to \gamma\eta\eta'$ in the $f_2(1720)$ region provides the upper limit[11] $BR(J/\psi \to \gamma f_2(1720)) \times BR(f_2(1720) \to \eta\eta') < 2.1 \times 10^{-4}$. Applying this bound also for the state $f_0(1590)$ we presumably see disagreement with the value of $BR(J/\psi \to \gamma\sigma(1590)) \times BR(\sigma(1590) \to \eta\eta') = 4.8 \times 10^{-4}$ that we get when identifying the pure gluonium $\sigma(1590)$ with $f_0(1590)$[12] and combining (6) with the experimental result[13] $BR(f_0(1590) \to \eta\eta') = 0.35$. In other words, (6) is not probably in agreement with the following experimental upper bound (see also[14]):

$$BR(J/\psi \to \gamma f_0(1590)) < 6 \times 10^{-4}. \tag{7}$$

We conclude that these disagreements may be against the interpretation of both the states $S_1(991)$ and $f_0(1590)$ as pure nonmixed gluonia.

What concerns the GAMS $f_0(1590)$ state, still other alternative assignments for it have been suggested recently[15-17]. If $f_0(1590)$ is an octet component[16] of a hybrid nonet, then its production in the radiative J/ψ decay would be naturally suppressed but the problem remains to observe other members of this nonet. If, on the other hand, the meson $f_0(1590)$ is a flavour $SU(3)_f$ singlet scalar quarkonium $S_0 \sim (1/3)^{1/2}(u\bar{u} + d\bar{d} + s\bar{s})$[15] with strong coupling to gluons in order to explain its large $\eta\eta'$ and $\eta\eta$ decays, then analogously to the case of

pure gluonium assignment there is no reason for the decay $J/\psi \to \gamma f_0(1590)$ to be suppressed. However, when $f_0(1590)$ is a convenient mixture of the pure gluonium σ and quarkonium S_0, then again (7) may be satisfied[18], too, and in the following we shall discuss such a possibility in more detail.

The theoretical predictions for the branching ratios of the radiative J/ψ decays with the produced physical scalar mesons as being the orthogonal mixtures of S_0 and σ[17] are done in section 2. These predictions are compared with experiments in section 3, and, in section 4, some conclusions are given.

2. THE PRODUCTION OF THE MIXED SCALAR STATES IN THE RADIATIVE J/ψ DECAYS

To proceed further, let us briefly recall a picture of $f_0(1590)$ which has been suggested[17] very recently. In[17] one has analysed the couplings of pure scalar gluonium σ and $q\bar{q}$ scalar nonet states S_i $(i = 0, 1, \ldots, 8)$ to the pseudoscalar mesons ϕ_i $(i = 0, 1, \ldots, 8)$ on the basis of the low-energy theorems of broken chiral symmetry and scale invariance through anomalous trace[19] $(\theta^\mu_\mu)_{an}$ of the hadronic energy-momentum tensor $\theta_{\mu\nu}$ of QCD implemented by using phenomenological Lagrangians. Supposing σ - gluonium dominance of the corresponding scalar gluonic current $H \equiv -(\theta^\mu_\mu)_{an} = (9\alpha_s/8\pi) G^a_{\mu\nu} G^{\mu\nu}_a$[19], i.e.[4]

$$H = \frac{9}{8} G_0 \left(\frac{\sigma(x)}{\sigma_0}\right)^4 , \tag{8}$$

where $\sigma_0 = \langle 0|\sigma|0\rangle$, and neglecting the quark mass term in the effective Lagrangian under consideration (for more details, see[17]), the mixing between σ and S_0 was investigated. We have assumed that chiral symmetry is spontaneously broken and the fields $\sigma(x)$ and $S_0(x)$ have been reparametrized as follows

$$\sigma(x) = \sigma_0 \exp\left(\frac{\tilde{\sigma}(x)}{\sigma_0}\right), \qquad S_0(x) = \sqrt{\frac{3}{2}}\, f_0 + \tilde{S}_0(x), \tag{9}$$

where $f_0 = -f_\pi = (2/3)^{1/2} \langle 0|S_0|0\rangle$. Taking for the masses of S_0 and σ the values based on estimates of the quark model and of recent QCD lattice calculations[20], respectively, the mixture of $\tilde{S}_0$ and $\tilde{\sigma}$ in the physical states G and ϵ has been found[17] to be approximately half-and-half, i.e.

$$G = \frac{1}{\sqrt{2}}(\tilde{S}_0 - \tilde{\sigma}), \qquad (10)$$

$$\epsilon = \frac{1}{\sqrt{2}}(\tilde{S}_0 + \tilde{\sigma}).$$

Using, in addition, the "standard" values of the gluon condensate[7,21] $G_0 = 0.012 - 0.017\ GeV^4$, i.e. $G_0 = M^2 f_0^2$ with M lying around 1.3 GeV within the interval 1.2-1.4 GeV, one finds[17]

$$\sigma_0 = \sqrt{6}\, f_0. \qquad (11)$$

The masses of G and ϵ are predicted as follows[17]:

$$m_G = \sqrt{\frac{3}{2}}M, \quad m_\epsilon = \frac{1}{\sqrt{2}}M. \qquad (12)$$

Taking the average M = 1.3 GeV, the values of m_G and m_ϵ (12) are 1.59 GeV and 0.92 GeV, respectively.

The couplings of ϵ and G to the pseudoscalar meson pairs have been found[17] to be:

$$\mathcal{L}_{\epsilon\phi\phi}(x) = \frac{1}{2\sqrt{3}} \frac{1+\beta}{f_0} \epsilon(x)(\partial_\mu \phi_i(x))^2, \qquad (13)$$

and

$$\mathcal{L}_{G\phi\phi}(x) = \frac{1}{2\sqrt{3}} \frac{3\beta-1}{f_0} G(x)(\partial_\mu \phi_i(x))^2, \qquad (14)$$

where $\beta = 0.3$ in accordance with the decays of the scalar $q\bar{q}$ mesons, e.g. $K^*_0(1350) \to K\pi$, etc. Eq. (13) gives the width $\Gamma(\epsilon(920) \to \pi\pi) = 360$ MeV while (14) shows that G is strongly suppressed to decay into $\pi\pi$ and KK with $\Gamma(G(1590) \to \pi\pi) = 11$ MeV and $\Gamma(G(1590) \to KK) = 12$ MeV, respectively. Thus, G should be identified with the GAMS $f_0(1590)$ meson[9] while $\epsilon(920)$ is to be identified with not easily observable broad $\pi\pi$ s- wave state lying below 1 GeV and seen probably again very recently[8] (see also[22]). It is worth noting that using the value of $\Gamma(f_0(1590) \to all) = 287$ MeV[2] we estimate $BR(f_0(1590) \to \pi\pi) \equiv \Gamma(f_0(1590) \to \pi\pi)/\Gamma(f_0(1590) \to all) = 3.8\%$ in a good agreement with experiment[9,12]. On the basis of

large colour number dynamics the heavier state $G \equiv f_0(1590)$ has been shown to play the role of the effective $SU(3)_f$ singlet scalar quarkonium while the lighter $\epsilon(920)$ was shown to play the role of an effective scalar gluonium[17].

From (8)-(12) the couplings of gluons to G and ϵ are found to be of the form:

$$\langle 0|\alpha_s G^a_{\mu\nu} G^{\mu\nu}_a|\epsilon\rangle = -\langle 0|\alpha_s G^a_{\mu\nu} G^{\mu\nu}_a|G\rangle = \frac{2\pi}{\sqrt{3}} M^2 f_0. \qquad (15)$$

Combining (2), (4), (15) and using M = 1.3 GeV we easily obtain the following estimates:

$$BR(J/\psi \to \gamma G) = 4.2 \times 10^{-4} \qquad (16)$$

and

$$BR(J/\psi \to \gamma\epsilon) = 7.9 \times 10^{-4}. \qquad (17)$$

We see that the branching ratio (17) for the production of the effective gluonium $\epsilon(920)$ is approximately equal to the branching ratio (6) for the production of the pure gluonium σ with the near mass $m_\sigma = 1$ GeV. These branching ratios are large, of an order of 0.1%, but as we shell show later the state $\epsilon(920)$ is not seen in the $J/\psi \to \gamma\pi\pi$ decay because $\epsilon(920)$ is wide with the full width $\Gamma > \Gamma(\epsilon(920) \to \pi\pi) = 360$ MeV. On the other hand, (16) is a factor 3 smaller than $BR(J/\psi \to \gamma f_0(1590))$ would be if $f_0(1590)$ is the pure gluonium (see (6)), and at least by an order of magnitude smaller than the naive estimate (1). This may give some appreciation of the uncertainties in estimating productions of scalar "gluonium-rich" mesons in the radiative J/ψ decay. We note that (16) already satisfies (7).

We mention here that since couplings (15) of ϵ and G to gluons are of the same strength, the decay $J/\psi \to \gamma G$ is suppressed relative to the decay $J/\psi \to \gamma\epsilon$ only due to the phase space factors, i.e. by $(P_G/P_\epsilon)^3 = 0.53$. Thus, we hope that the estimate (16) for the production of the heavier $G \equiv f_0(1590)$ mesons is as reliable as (17) obtained for the production of the lighter $\epsilon(920)$ states. This together with the success of (3) in predicting the production of the η' mesons of comparable masses, i.e. $m_{\eta'} \approx m_\epsilon$, encourages us to believe that both the estimates (16) and (17) could be successful as well.

Using (16), (17) and $BR(f_0(1590) \to \eta\eta) = 0.12$[13], and assuming $BR(\epsilon(920) \to \pi\pi) = 1$ (i.e. neglecting possible contributions like $BR(\epsilon(920) \to 4\pi)$, etc.), we get the following combined branching ratio estimates:

$$BR(J/\psi \to \gamma f_0(1590) \to \gamma\eta\eta) = 5.0 \times 10^{-5} \qquad (18)$$

and

$$BR(J/\psi \to \gamma\epsilon(920) \to \gamma\pi\pi) = 7.9 \times 10^{-4}. \qquad (19)$$

If we do not neglet the possible contributions like $BR(\epsilon(920) \to 4\pi)$, etc. (where we can roughly estimate e.g. $BR(\epsilon(920) \to KK) \geq 10\%$ since the couplings (13) between the wide meson ϵ (920) and the $K\bar{K}$ system are known), then $BR(\epsilon(920) \to \pi\pi) \lesssim 90\%$ and from (17) we get

$$BR(J/\psi \to \gamma\epsilon(920) \to \gamma\pi\pi) \lesssim 7.1 \times 10^{-4}. \qquad (20)$$

The predictions (18) and (19) (or probably the more realistic one (20)) are already convenient for direct comparison with experiment, which we shall do in the following section.

3. THE COMPARISON WITH EXPERIMENT

To compare (18) with experiment, we shall use the published data about the $\eta\eta$ effective mass spectrum in the $J/\psi \to \gamma\eta\eta$ decay obtained by the Crystal Ball collaboration at SPEAR/23/. We try to describe these data by using various assumptions concerning the presence of the 2^{++} resonances as claimed by the authors of refs./23/ on the basis of the analysis of decay angles. We fit the $\eta\eta$ spectrum with the flat background and two or three incoherent Breit - Wigner line shapes. One of the shapes corresponds to the meson f_0 (1590) and the others correspond to f_2(1720) and/or f_2'(1525) with the masses and widths of f_2(1720) and f_2'(1525) being fixed in their tabulated values/2/. The results of our fit represent the upper limits (90% C.L.) for the combined branching ratio $BR(J/\psi \to \gamma f_0(1590)) \times BR(f_0(1590) \to \eta\eta)$ and are presented in Fig.1. The dependence of this branching ratio on a change of the mass and width of f_0 (1590) within one standard deviation around their measured values/9/ is also demonstrated in Fig.1. The curves a and b represent the systematic uncertainties resulting from different assumptions concerning the presence of the 2^{++} resonances. The curve a labels the result of the fit when both the mesons f_2(1720) and f_2'(1525) are included into the analysis while the curve b represents the result of the fit with only one meson f_2(1720) included. We have also tried to change the parameters of f_2(1720) so as to use both the original ones/23/ and the ones from/2/, but we have found that the results are not very sensitive to such changes.

As the dashed line in Fig.1 (the case when m_G = 1592 MeV) shows, the predicted value (18) (the very small changes of (18) when $m_G \neq$ 1592 MeV are also taken into account in Fig.1)

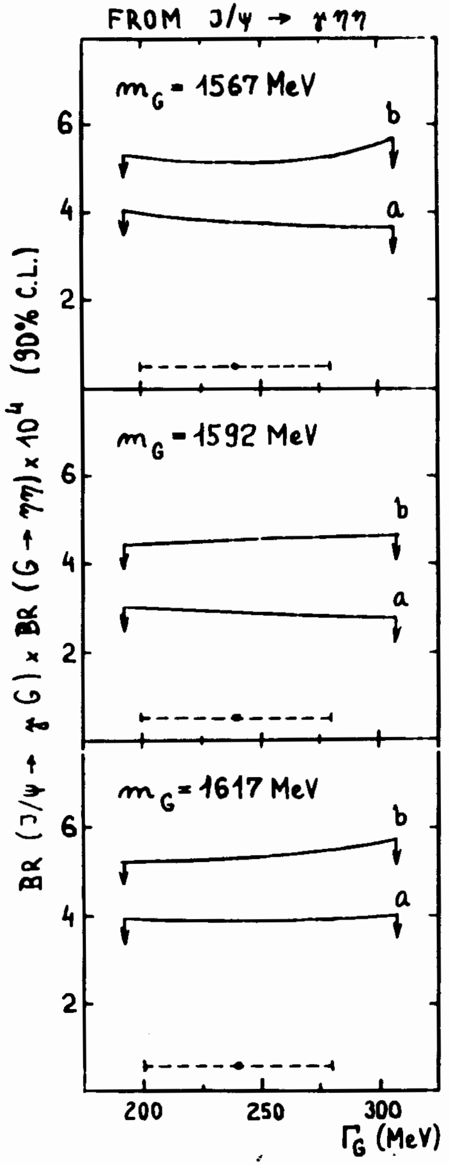


Fig.1. The upper limit (90% C.L.) for the combined branching ratio $BR(J/\psi \to \gamma G \to \gamma\eta\eta)$ as a function of the mass and width of the meson G-solid line. (For the curves a and b see the text). Dushed lines - predicted estimates.

lies well inside the allowed region. However, we see that uncertainties given in Fig.1 allow also estimate (6) and probably even still higher estimate (1).

Thus, we conclude on this basis that the decay $J/\psi \to \gamma\eta\eta$/23/ is not probably very restrictive for the interpretation of f_0(1590). For this aim the decay $J/\psi \to \gamma\eta\eta'$ should be more convenient since the combined branching ratios $BR(J/\psi \to \gamma f_2(1720) \to \gamma\eta\eta')$ and $BR(J/\psi \to \gamma f_2'(1525) \to \gamma\eta\eta')$ are expected to be strongly suppressed in comparison with $BR(J/\psi \to \gamma f_0(1590) \to \gamma\eta\eta')$ because of the phase space factors. But as we have already mentioned before, the lack of the decay $J/\psi \to \gamma\eta\eta'$ in the f_2(1720) region gives, unfortunately, only the upper bound/11/ which, applied also to f_0(1590), means that $BR(J/\psi \to \gamma f_0(1590) \to \gamma\eta\eta') < 2.1 \times 10^{-4}$. We see that this upper limit is satisfied by our theoretical estimate of the combined branching ratio $BR(J/\psi \to \gamma f_0(1590)) \times BR(f_0(1590) \to \eta\eta') \approx 1.5 \times 10^{-4}$ obtained from (18) when using the experimental ratio/9,13/

$$BR(f_0(1590) \to \eta\eta')/BR(f_0(1590) \to \eta\eta) \approx 3.$$

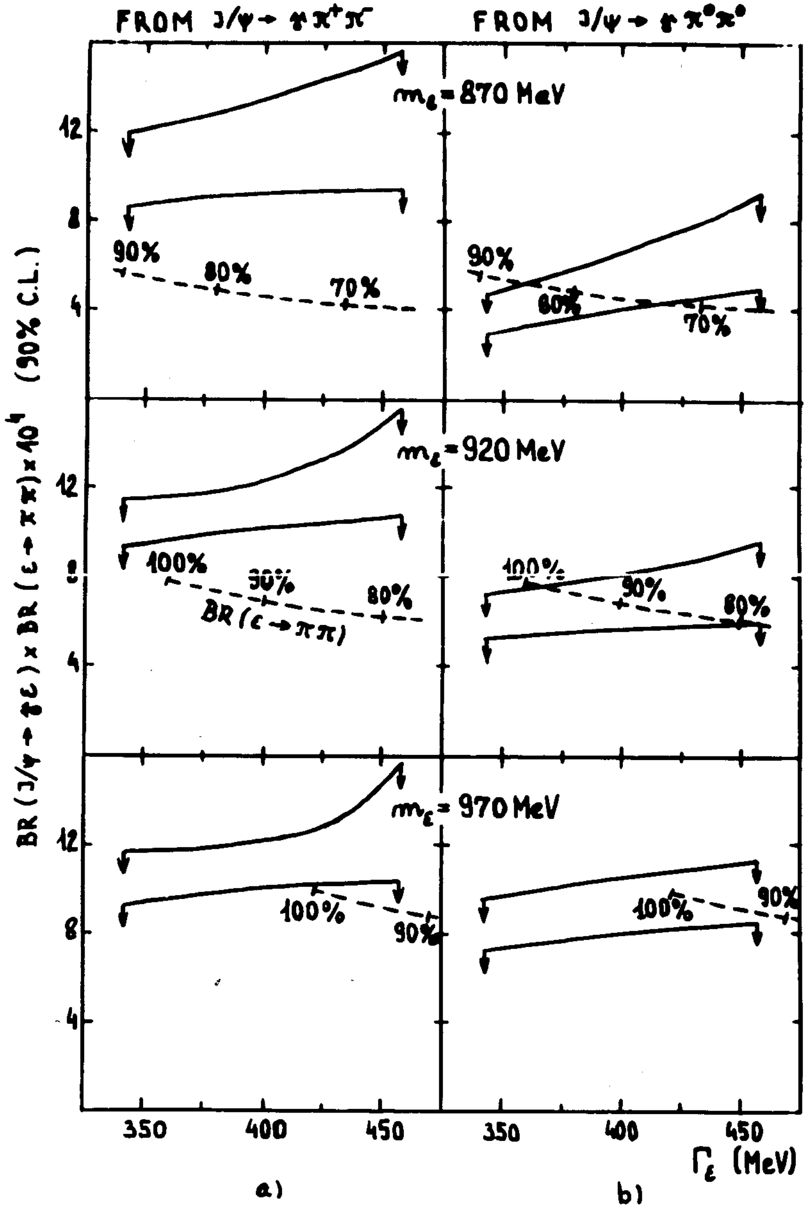
To compare prediction (19) (or (20)) with experiment, we use the MARK III [24] and DM2 [25] collaboration data about the $J/\psi \to \gamma\pi^+\pi^-$ decay. There are two large structures present in the $\pi^+\pi^-$-effective mass spectrum. The peak below the mass of $\epsilon(920)$ is due to feed-through from the $J/\psi \to \pi^0\rho^0$ events with one undetected γ. The second peak corresponds to the meson $f_2(1270)$. Hence, we fit the $\pi^+\pi^-$- effective mass distribution from the threshold up to 1.5 GeV with three incoherent Breit - Wigner line shapes where the first one corresponds to the predicted ϵ state while the others correspond to ρ^0 and $f_2(1270)$. We add the polynomial background and vary its degree from 2 to 4. In this way we estimate the upper limits (90% C.L.) for the combined branching ratio BR($J/\psi \to \gamma\epsilon(920) \to \gamma\pi\pi$) and we find that for both the samples [24,25] of the experimental data these upper limits are practically the same.

The results are displayed in Fig.2a. The curves again represent the systematic uncertainties coming in this case mainly from the background parametrization. We see that predictions (19) and (20) do not contradict the upper limit derived from the experimental data [24,25]. We should mention here that although relatively high statistics data are available, nevertheless the obtained upper limit is large because of bad background conditions connected with the fact that the searched effect is surrounded by large resonance signals from both the sides.

The situation could be better when we use the data on the $J/\psi \to \gamma\pi^0\pi^0$ decay obtained by the Crystal Ball collaboration at SPEAR [26]. The statistics is not so high, however, the estimate of the upper limit for BR($J/\psi \to \gamma\epsilon(920) \to \gamma\pi\pi$) is expected to be better than in the case of the $J/\psi \to \gamma\pi^+\pi^-$ decay since the $\gamma\pi^0\pi^0$ final state does not suffer from the hadronic $\rho\pi$ background problems inherent in the charged state (see also [27]).

Fig.2. The upper limit (90% C.L.) for the combined branching ratio BR($J/\psi \to \gamma\epsilon \to \gamma\pi\pi$). Dashed curves show our predictions and the quoted numbers (in per cent) label the values of BR($\epsilon \to \pi\pi$); a - fit from the $J/\psi \to \gamma\pi^+\pi^-$ decay, the upper solid lines correspond to the quadratic polynomial background parametrization while the lower ones correspond to the fourth-degree polynomial parametrization; b - the same from the $J/\psi \to \gamma\pi^0\pi^0$ decay, the upper solid lines represent the results when the linear background parametrization is used and the lower solid lines describe the results if the third-degree polynomial background parametrization is used.

To find such an upper limit, we use the same procedure as before in the case of the charged state, but without the ρ^0- Breit - Wigner. As a background we have used the polynomials of degree 1 or 3. The resulted upper limit (90% C.L.) for



$BR(J/\psi \to \gamma\epsilon \to \gamma\pi\pi)$ as well as its dependence on the parameters of the wide meson ϵ are displayed in Fig.2b. We mention here that Figs.2a and 2b can be compared directly since the isospin factors for the $\epsilon \to \pi\pi$ decay are already taken into account there. The dashed curves in Figs.2a and 2b (the case when m_ϵ = = 920 MeV) correspond to our predictions (19) and (20), and the quoted numbers (in per cent) label the values of $BR(\epsilon(920) \to \pi\pi)$. Thus, allowing $BR(\epsilon(920) \to \pi\pi) \lesssim 90\%$ we see that even a more reliable upper limit estimate (Fig.2b) is well consistent with the predicted value (20) and so the data [24-26] on the $J/\psi \to \gamma\pi\pi$ decays cannot probably exclude the existence of the predicted wide effective gluonium $\epsilon(920)$[17] lying below 1 GeV.

We have also tried to deduce the upper limits for the production of narrow states like $f_0(975)$[2] or $S_1(991)$[8] in the $J/\psi \to \gamma\pi\pi$ decays. Using the data [24-26] we have obtained the upper limit (90% C.L.) for $BR(J/\psi \to \gamma S) \times BR(S \to \pi\pi) <$ $< (3\div5)\cdot 10^{-5}$ for the narrow (with the width $\lesssim 50$ MeV) state S lying below the $K\bar{K}$ threshold (see also [10]), and this probably invalidates the interpretation of such states as gluonia (compare, e.g., with (6)).

4. CONCLUSION

We have shown here that decays $J/\psi \to \gamma$ + two pseudoscalars probably invalidate the gluonium interpretation of the GAMS $f_0(1590)$ meson[9] and a narrow state like $S_1(991)$[8] lying below 1 GeV. If, however, the state $f_0(1590)$ is interpreted[17] as an approximate half-and-half mixture (10) of σ and S_0, then as we have seen there is no disagreement with the experimental data on the $J/\psi \to \gamma\eta\eta$ [23] and $J/\psi \to \gamma\eta\eta'$ [11] decays. Also, the predicted[17] wide scalar effective gluonium $\epsilon(920)$ has been shown not to be excluded by the data [24-26] on the decay $J/\psi \to \gamma\pi\pi$.

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Received by Publishing Department
on June 29, 1988.

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Кандидаты в скалярный глюоний
и радиационные J/ψ распады

Обсуждаются возможные продукции кандидатов в скалярный глюоний в радиационных распадах J/ψ.

Работа выполнена в Лаборатории теоретической физики и в Лаборатории ядерных проблем ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1988

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Scalar Gluonium Candidates and the Radiative
J/ψ Decays

We discuss possible productions of scalar gluonium candidates in the radiative J/ψ decays.

The investigation has been performed at the Laboratory of Theoretical Physics and at the Laboratory of Nuclear Problems, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna 1988