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DM2 RESULTS ON J/Ψ AND η_c DECAYS.

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Final results are presented on $J/\psi \to \gamma\rho^0\rho^0$. The multichannel analysis shows a large pseudoscalar contribution which can be fitted with 3 Breit-Wigners and a small background. In this channel are observed η_c and $f_1(1285)$ productions. $\eta_c \to \rho\rho, \omega\omega, \phi\phi, K^*\bar{K}^*$ are analysed in the framework of SU(3) and are consistent with nonet symmetry. At last, Vector+Pseudoscalar final states are studied. η and η' wave functions can be saturated by their quark content. The pseudoscalar mixing angle is measured to be $-(20.0\pm1.6)°$.

1. $J/\psi \to \gamma$ + (Vector-Vector) (1).

Large pseudoscalar productions have already been observed near the $\omega\omega$[1] and $\rho^0\rho^0$[2] threshold in decays (1). The same feature appears to be also consistent with data in the $\phi\phi$ mode [3]. Using 8.6× 10^6 J/ψ decays, we present a large statistics multichannel analysis of the decay $J/\psi \to \gamma 4\pi^\pm$[4]. Using a maximum likelihood method, 14 components are investigated in the 4π final state: *phase space 4π, isotropic $\rho\rho$, $\rho\pi\pi$, $A_2\pi$, and 10 $\rho\rho$ pure waves* $0^-, 0^+(L=0,2), 1^-, 1^+, 2^-(L=1,3), 2^+(L=0, L=2(S=0,2))$.

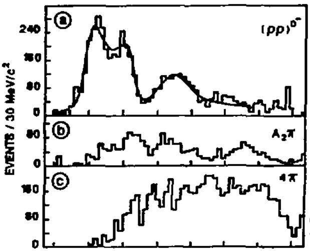


Fig. 1 4π mass in $J/\psi \to \gamma 4\pi^\pm$

From these 14 hypotheses, only $(\rho\rho)^{0^-}$, 4π and $A_2\pi$(the last two including in fact a large fraction of a possible $\rho\pi\pi$ production) are found with large contributions. Fig 1 gives their 4π mass spectrum. Let us now discuss the main results of this study.

- The large pseudoscalar $\rho\rho$ production evidenced in [2] appears in our data with a clear resonnant dynamics. The fit given in Fig. 1-a involves 3 Breit-Wigner distributions, corresponding to particles L_1, L_2, L_3 in Table 1, and a small polynomial background.

- A large signal is present in Fig. 1-b at about 1.28 GeV/c². When fitted to a Breit-Wigner, its mass (1283.2±2.0 MeV/c²) and width (23.9± 7.0

	Mass* Width*	BR** ×10³
L_1	1497 ± 3 126 ± 2	1.10 ± 0.27
L_2	1812 ± 4 110 ± 8	0.07 ± 0.02
L_3	2107 ± 9 244 ± 23	0.39 ± 0.09

* MeV/c^2
** $BR(J/\psi \to \gamma L_i)\times BR(L_i \to \rho^0\rho^0)$

Table 1- Summary on resonnant production $J/\psi \to \gamma L_i$, $L_i \to \rho^0\rho^0$

MeV/c^2) are consistent with the $f_1(1285)$ ones. Let us note that the assignment of this decay to the $A_2\pi$ dynamics is not very reliable since $\rho\pi\pi$ and $A_2\pi$ final states are not clearly distinguished by this analysis. Then one gets:

$$BR(J/\psi \to \gamma f_1) \times BR(f_1 \to \rho\pi\pi) = (3.4 \pm 0.8 \pm 0.5) \times 10^{-5}$$

• The decay $\eta_c \to 4\pi$ is dominated by the $(\rho\rho)^{0^-}$ dynamics[4,5] while a small $(4\pi)^{ph.\ sp.}$ contribution cannot be excluded. This work needed a very carefull analysis and 50 million events were generated (*500* hours of equivalent *VAX 8600*) in order to get very reliable conclusions. The corresponding branching ratio is given in Table 2 summarizing all the Vector-Vector decay mode of the η_c. This result contradicts the MARK III one[6] which indicated the dominance of 4π over $\rho\rho$ dynamics.

Notice that this first observation of the $\eta_c \to \rho^0\rho^0$ decay gives the best evidence of the pseudoscalar nature of the η_c.

2. $\eta_c \to$ Vector-Vector (2).

Table 2 sums up the branching ratios measured by DM2 for decays (2) and Fig. 2 shows the corresponding signals. Assuming $SU(3)_F$ is a good symmetry to describe these processes, Table 3 gives the amplitudes which are predicted in this framework.

FINAL STATE	BR ($\times 10^4$)
$\phi\phi$ [7]	0.39 ± 0.09
$\omega\omega$ [8]	< 0.8
$K^{*0}\bar{K}^{*0}$ + c.c.	0.55 ± 0.18
$\rho^0\rho^0$ [5]	1.1 ± 0.2

Branching ratios for $J/\psi \to \gamma\eta_c$; $\eta_c \to Vector - Vector$
Table 2

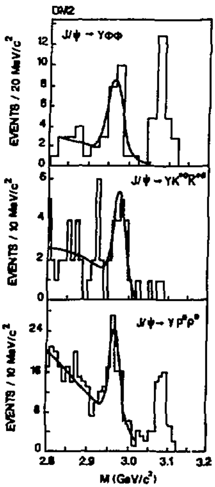


Fig. 2 VV mass

	AMPLITUDE
$\phi\phi$	$g_8 \cos^2\theta_V + g_1 \sin^2\theta_V$
$\omega\omega$	$g_8 \sin^2\theta_V + g_1 \cos^2\theta_V$
$\omega\phi$	$\sin\theta_V \cos\theta_V (g_8 - g_1)$
$\phi\omega$	$\sin\theta_V \cos\theta_V (g_8 - g_1)$
$K^*\bar{K}^*$	$-\sqrt{2}g_8$
$\bar{K}^*K^*$	$\sqrt{2}g_8$
$\rho\rho$	$-\sqrt{3}g_8$

Table 3

θ_V denotes the vector meson mixing angle, g_1 and g_8 the coupling constants for the decays: $\eta_c \to 1 \otimes 1$; $\eta_c \to 8 \otimes 8$ where 1 and 8 denote respectively the singlet and octet vector mesons. Tensor ideal mixing has been assumed in this study, i.e. $\theta_V = 35.26^\circ$. Then, data are found to correctly fit with nonet symmetry since one obtains: $\mid g_8/g_1 \mid = 0.65^{+0.29}_{-0.14}$. This result disagrees with a previous analysis by MARK III Collaboration which invoked large mass effects[8] to interpret its data. A more detailed analysis is in progress to include small s-quark mass corrections in our fit.

3. Analysis of the decays $J/\psi \to Vector + Pseudoscalar$ (3).

Channel	Decay mode	BR ($\times 10^4$) (Average)
$J/\psi \to \rho^0\pi^0$		42.3 ± 3
$J/\psi \to \omega\pi^0$	$\gamma\gamma$	5.1 ± 0.5
$J/\psi \to \rho^0\eta$	$\pi^+\pi^-\pi^0$	1.9 ± 0.5
$J/\psi \to \omega\eta$	$\gamma\gamma$	14.4 ± 1.4
	$\pi^+\pi^-\pi^0$	
$J/\psi \to \phi\eta$	$\pi^+\pi^-\pi^0$	
	$\pi^+\pi^-\gamma$	6.4 ± 0.6
	$\gamma\gamma$	
$J/\psi \to \rho^0\eta'$	$\rho^0\gamma$	0.83 ± 0.3
$J/\psi \to \omega\eta'$	$\pi^+\pi^-\eta$	1.9 ± 0.5
$J/\psi \to \phi\eta'$	$\pi^+\pi^-\eta$	4.05 ± 0.45
	$\rho^0\gamma$	

Table 4

The study of all branching ratios for decays (3) involving η or η' mesons has been achieved using our large sample of J/ψ. Best measurements than already published are obtained for most of these decays (Table 4) and we made the first observation of the rare $\rho^0\eta'$ channel[8].

Due to the large number of analyzed channels and the good precision of the measurements, we use these data to give indications on η and η' structure. This is made by using models[9],[10] relating Vector-Pseudoscalar final states by SU(3) symmetry and using the J.E. ROSNER description of mesons[11]. Results of this analysis are summed up in Table 5.

	Hypothesis 1	*Hypothesis* 2	*Hypothesis* 3
g	1.11 ± 0.04	1.12 ± 0.041	1.11 ± 0.02
h	0.205 ± 0.015	0.197 ± 0.033	0.19 ± 0.011
e	0.138 ± 0.006	0.137 ± 0.006	0.138 ± 0.006
ϕ	1.17 ± 0.09	1.17 ± 0.09	1.17 ± 0.07
X_η	0.624 ± 0.034	0.637 ± 0.044	0.625 ± 0.007
$X_{\eta'}$	0.268 ± 0.033	0.436 ± 0.044	0.415 ± 0.021
$\mid Y_\eta \mid$	0.806 ± 0.045	0.771 ± 0.037	0.78 ± 0.06
$Y_{\eta'}$	0.747 ± 0.047	0.900 ± 0.021	0.898 ± 0.007
r		-0.088 ± 0.019	-0.89 ± 0.53
$Z_{\eta'}$			0.148 ± 0.065

Hypothesis 1: 9 BR's are fitted assuming that only connected diagramms contribute. ($\chi^2 = 2.97/d.o.f$)

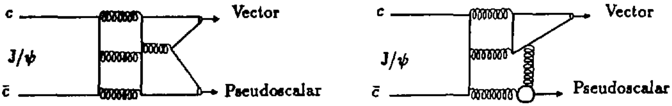
Hypothesis 2: as Hypothesis 1 + including the contribution of disconnected diagramms assuming $X_\eta^2 + Y_\eta^2 = 1$ and $X_{\eta'}^2 + Y_{\eta'}^2 = 1$. ($\chi^2 = 0.047/d.o.f.$)

Hypothesis 3: Includes a glue component $Z_{\eta'}$ in η' with $\mid X_{\eta'} \mid^2 + \mid Y_{\eta'} \mid^2 + \mid Z_{\eta'} \mid^2 = 1$ ($\chi^2 = 0.34/d.o.f.$)

Table 5

g denotes the strong coupling of V+P final states to J/ψ via 3 gluon without SU(3) breaking. h gives the amplitude of SU(3) breaking produced by s quark mass. e is the electromagnetic amplitude and ϕ the phase between e and (g,h). X_η,$X_{\eta'}$ are the light quark components inside mesons and Y_η,$Y_{\eta'}$ the s-quark components. $Z_{\eta'}$ is a possible glue content inside η'.

Hypothesis 1 assumes strong dominance of connected diagrams (Fig. 3-a) versus disconnected ones (Fig. 3-b).



(a) Fig. 3 (b)

In this hypothesis, one gets: $X_\eta^2 + Y_\eta^2 = 1.08 \pm 0.04$; $X_{\eta'}^2 + Y_{\eta'}^2 = 0.63 \pm 0.07$ which shows that η' is not saturated by quark-antiquark pairs. This confirms with better statistical significance the result of MARK III Collaboration[12] and indicates that something is missing in this description.

The singlet mesonic component (mainly η') is enhanced by introducing the contribution of disconnected diagrams with a weight (r/g). This is made in hypothesis 2 and data are found consistent with the standard quark model description of the η and η' mesons. Assuming $X^2 + Y^2 = 1$ for both mesons and the classical mixing relation : $X_\eta = Y_{\eta'}$; $X_{\eta'} = -Y_\eta$, one gets the pseudoscalar mixing angle: $\theta_P = -20.0^o \pm 1.6^o$. This value is in good agreement with the value obtained from 2γ physics: $\theta_P = -19.4^o \pm 1.4^o$[13] or from radiative productions J/$\psi \to \gamma\eta, \gamma\eta'$: $\theta_P = -22^o \pm 1^o$[14].

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