Search for the Vector Glueball by a Scan of the J/ψ Resonance

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ABSTRACT

The vector gluonium state, which was hypothesized by the Brodsky–Lepage–Tuan model to explain the $\rho\pi$ puzzle in charmonium physics , is searched for in a scan data across J/ψ resonance. The data for $e^+e^- \to \rho\pi$ scan are analyzed using the maximum likelihood method. The shape of the $\rho\pi$ cross section is compatible with the shape of the total hadronic cross section within experimental statistics. Within 40 GeV around the J/ψ resonance, no evidence is found to support the existence of such a vector gluonium state.

There is a well known puzzle in charmonium physics. According to quantum chromodynamics, J/ψ and ψ' decay to hadrons via three gluons or, with a smaller probability, via a single direct photon. In either case the partial decay width is proportional to $|\Psi(0)|^2$, where $\Psi(0)$ is the wave function at the origin in the non-relativistic quark model of charmonium states. Thus it is expected on the basis of perturbative QCD that for any final hadronic state h:

$$Q_h \equiv \frac{B(\psi' \to h)}{B(J/\psi \to h)} \cong \frac{B(\psi' \to e^+e^-)}{B(J/\psi \to e^+e^-)} = 0.147 \pm 0.023 \tag{1}$$

where the values of leptonic branching fractions from Particle Data Table[1] are used. This is satisfied for most hadronic channels. But there are the startling exceptions occurring for $\rho\pi$ and $K^*\bar{K}$ where the present experimental limits[1] are

$$Q_{\rho\pi} < 0.0028 \qquad \text{and} \qquad Q_{K^*\bar{K}} < 0.011. \tag{2}$$

This is the so-called $\rho\pi$ puzzle in J/ψ and ψ' physics.

One possible explanation to this anomaly was postulated by Brodsky, Lepage and Tuan[2] (refining the notion of Hou and Soni[3]) by assuming the general validity of the perturbative QCD theorem that total hadron helicity is conserved in high-momentum-transfer exclusive processes, but supplemented by violation of this theorem when the J/ψ decay to hadrons is mediated by an intermediate gluonium state O with quantum number $J^{PC} = 1^{--}$. The decays of both J/ψ and ψ' into vector-pseudoscalar combinations such as $\rho\pi$ and $K^*\bar{K}$ are forbidden by the hadron-helicity conservation; it is the O that causes the enhancement of $J/\psi \to \rho\pi$ and $J/\psi \to K^*\bar{K}$ decay modes. The experimental limits given by Eq.(2) imply that the mass of O is within 80 MeV of the mass of the J/ψ and its total width is less than 160 MeV[2].

Experimentally the search for such a vector gluonium state could be carried out in three gluon sources such as some specific hadronic decays of the ψ'. It has been suggested to use the decays $\psi' \to \pi\pi + X, \eta + X, \eta' + X$, where X decays into vector-pseudoscalar (VP) modes[3]. However, the most direct way to verify the existence of O is to scan the $e^+e^- \to VP$ cross secection across the J/ψ resonance[4]. The O, being close in mass to the J/ψ and having decay width Γ_O substantially larger than Γ_ψ, should interfere with the J/ψ; and this results in a distortion of the shape of the J/ψ obtained from the $e^+e^- \to VP$ cross section with respect to that from the total hadronic cross section or lepton pair cross section. In this paper, we report on such a search based on the scan data taken by the BES at the BEPC e^+e^- collider.

The scan is performed within 40 MeV around the J/ψ resonance in small steps. The original purpose of the scan was to measure the total width and lepton partial widthes of the J/ψ. The results are published elsewhere[5]. These data serve well in the search for the O as well. Also some extra data which were taken off the J/ψ resonance are included in this analysis. The total integrated luminosity used here is 237.94 nb^{-1}. The uncertainty in the center-of-mass energy of the collider is estimated to be 0.07 MeV, and the spread of the center-of-mass energy at this energy range is 1 MeV[6]. A summary of the energy points at which the data were taken is listed in Table I.

The BES is a conventional cylindrical detector, which has been described in detail in Ref.[6]. A four-layer central drift chamber(CDC) surrounding the beampipe provides trigger information. Outside the CDC, the forty-layer main drift chamber(MDC) provides the tracking and energy loss (dE/dx) information on charged tracks over 85% of the total solid angle. The momentum resolution is $\sigma_p/p = 0.017\sqrt{1+p^2}$ (p in GeV/c), and the dE/dx resolution is $\sim$ 11% for hadron tracks. An array of 48 scintillation counters surrounds MDC which measures the time-of-flight (TOF) of charged tracks with a resolution of $\sim$ 450 ps for hadrons. Outside the TOF system, a 12 radiation length, lead-gas barrel shower counter (BSC), operating in self-quenching streamer mode, measures the energies of electrons and photons over $\sim$ 80% of the total solid angle. The energy resolution is $\sigma_E/E = 0.22/\sqrt{E}$ (E in GeV), and the spatial resolution $\sigma_\phi = 4.5$ mrad, $\sigma_z = 2$ cm. Surrounding the BSC is a solenoidal magnet providing a 0.4 Tesla magnetic field in the central tracking region of the detector. Three double layers of muon counters instrument the magnet flux return and serve to identify muons of momentum greater than 0.5 GeV/c. Endcap time-of-flight and shower counters extend coverage to the forward and backward regions.

In this analysis, the candidate events for $e^+e^- \to \rho\pi$ are firstly required to have exactly two oppositely charged and well reconstructed tracks, and two to six neutral tracks. Each charged track is identified as a pion using a combination of time-of-flight and dE/dx information. In order to remove the lepton pair events, also applied are the cuts that the angle between two charged tracks is less than 170°, the total energy deposit in the calorimeter for two charged tracks is less than 1.6 GeV, and at least one charged track is identified not to be a muon by the muon counter. The events are required to have at least two "good" photons, which are defined to have an energy larger than 80 MeV and to be separated from the nearest charged track by more than 8°. The selected events are kinematically fitted to the $\pi^+\pi^-\gamma\gamma$ hypothesis by imposing different energy and momentum constraints corresponding to each scan point. When the number of good photons in an event exceeds two, all two-photon combinations are fitted, and the combination with the minimum χ^2 and $P(\chi^2) > 0.01$ is retained. Finally, the mass cuts $|M_{\gamma\gamma} - M_{\pi^0}| < 50$ MeV/c^2 and $|M_{\pi\pi} - M_\rho| < 200$ MeV/c^2 are also applied. The number of $\rho\pi$ candidates found in each scan point is listed in the last column of Table I.

The data of the $\rho\pi$ scan are analyzed using the maximum likelihood method. The likelihood function is a product of Poission distributions, one for each center-of-mass energy W_i, and takes the form

$$L = \prod_i \nu_i^{N_i} e^{-\nu_i}/N_i! \tag{3}$$

where N_i is the number of observed $\rho\pi$ events at each scan point; ν_i is the corresponding number of events expected and is given by

$$\nu_i = [\epsilon\sigma_{\rho\pi}(W_i) + \sigma_B(W_i)]\mathcal{L}_i \tag{4}$$

where ϵ is the overall efficiency for identifying $\rho\pi$ events; $\mathcal{L}_i$ is the integrated luminosity for the data taken at the scan point i; $\sigma_{\rho\pi}(W_i)$ is the corresponding cross section for $\rho\pi$ prodution; and $\sigma_B(W_i)$ is the background cross section.

The efficiency combines the trigger efficiency which is estimated to be 98.4% for two prong hadron events[5], and the reconstruction and selection efficiency which is determined by Monte Carlo simulation and found to be virtually independent of energy over the scan region; a value of 13.1% for the reconstruction and selection efficiency is obtained.

The background comes from sources of $e^+e^- \to J/\psi \to \pi^+\pi^-\pi^0$ (direct), $K^+K^-\pi^0$, etc. Assuming that the shape of the background is compatible with the shape of $e^+e^- \to J/\psi \to$ *hadrons*, the background cross section can be written as

$$\sigma_B(W) = \sum_k \epsilon_k B_k \sigma_{tot}(W) \tag{5}$$

where ϵ_k is the overall efficiency for a specific background process k; B_k is the corresponding branching fraction; $\sigma_{tot}(W)$ is the total observed cross section of J/ψ resonance in which radiative corrections and collider beam energy spread are taken into account. The resonance parameters of the J/ψ determined from the same scan[5] are used to estimate the background of Eq.(5). For the main background processes $\pi^+\pi^-\pi^0$(direct) and $K^+K^-\pi^0$, Monte Carlo simulation yields the efficiencies for reconstruction and selection to be 5.86% and 0.75%, respectively.

TABLE I. A summary of the data of the $\rho\pi$ scan.

Scan point	W (MeV)	$\mathcal{L}$ (nb^{-1})	N
1	3079.1	11.434	0
2	3080.5	51.378	0
3	3084.9	12.086	1
4	3085.5	10.767	0
5	3087.7	9.142	0
6	3090.0	12.318	0
7	3090.6	5.801	0
8	3091.9	6.019	0
9	3092.6	2.826	0
10	3093.6	6.866	1
11	3094.5	5.715	4
12	3095.3	5.498	12
13	3095.7	5.459	26
14	3096.1	3.353	14
15	3096.5	5.617	24
16	3096.9	5.414	17
17	3097.3	1.833	10
18	3097.7	6.161	15
19	3098.1	5.853	8
20	3098.5	4.384	2
21	3098.9	1.818	1
22	3099.3	4.036	0
23	3099.7	1.738	0
24	3100.1	13.470	3
25	3100.7	1.990	1
26	3102.7	11.376	2
27	3105.5	11.226	1
28	3110.1	5.659	0
29	3116.4	8.709	1

The $\rho\pi$ cross section $\sigma_{\rho\pi}(W)$ is the sum of a nonresonant direct-channel part due to virtual photon annihilation and a resonant part which is convoluted with the gaussian function describing the collider beam energy spread

$$\sigma_{\rho\pi}(W) = R_{\rho\pi}\sigma_{\mu\mu}(W) + \frac{1}{\sqrt{2\pi}\Delta}\int_0^\infty dW' e^{-\frac{(W-W')^2}{2\Delta^2}}\sigma(W') \tag{6}$$

where $\sigma_{\mu\mu}$ is the pure QED $e^+e^- \to \mu\mu$ cross section which the nonresonant direct-channel part of $\sigma_{\rho\pi}$ is proportional to with the coefficient $R_{\rho\pi}$; Δ is the standard deviation of the gaussian function which describes the energy spread of the collider in the C.M. system; $\sigma(W)$ is the Breit-Wigner cross section due to the J/ψ as well as O propagators for the process $e^+e^- \to \rho\pi$

$$\frac{B}{W^2 - M_{J/\psi}^2 - iM_{J/\psi}\Gamma_{J/\psi}} + \frac{D}{W^2 - M_O^2 - iM_O\Gamma_O} \tag{7}$$

where B can be taken real and given by the J/ψ partial width to e^+e^- (denoted as $\Gamma_{J/\psi}^{ee}$) and $\rho\pi$ (denoted as $\Gamma_{J/\psi}^{\rho\pi}$) in the form $|B|^2 = 12\pi\Gamma_{J/\psi}^{ee}\Gamma_{J/\psi}^{\rho\pi}$; $D = |D|\exp(i\theta)$ is a complex variable which is a measurement of the contribution of the O; $M_{J/\psi}, \Gamma_{J/\psi}$ are the mass and total width of the J/ψ; M_O, Γ_O are the mass and total width of O. Taking into account the radiative correction[7], $\sigma(W)$ can be expressed as

$$\begin{aligned}
\sigma(W) &= [1 + \frac{3}{4}\beta + \frac{\alpha}{\pi}(\frac{\pi^2}{3} - \frac{1}{2}) - \beta^2(\frac{\pi^2}{12} - \frac{9}{32})] \int_0^1 dx\beta x^{\beta-1} \\
&\quad (\frac{|B|^2}{(W^2(1-x) - M_{J/\psi}^2)^2 + M_{J/\psi}^2\Gamma_{J/\psi}^2} + \frac{|D|^2}{(W^2(1-x) - M_O^2)^2 + M_O^2\Gamma_O^2} \\
&\quad + \frac{2Re\{DB[W^2(1-x) - M_O^2 - iM_O\Gamma_O][W^2(1-x) - M_{J/\psi}^2 + iM_{J/\psi}\Gamma_{J/\psi}]\}}{[(W^2(1-x) - M_O^2)^2 + M_O^2\Gamma_O^2][(W^2(1-x) - M_{J/\psi}^2)^2 + M_{J/\psi}^2\Gamma_{J/\psi}^2]}) \\
&\equiv \sigma_{J/\psi}(W) + \sigma_{O+I}(W)
\end{aligned} \tag{8}$$

where $\beta = \frac{2\alpha}{\pi}(ln\frac{W^2}{m_e^2} - 1)$. For the analysis in this work, $\sigma(W)$ is decomposed into two parts: $\sigma_{J/\psi}(W)$ is the first term in Eq.(8) due to the normal J/ψ resonance; $\sigma_{O+I}(W)$ is the sum of the second and third term due to the O and its interference with the J/ψ.

In fitting the cross section $\sigma_{\rho\pi}$ in Eq.(6) to the data in Table I, $|B|$, $|D|$ and $R_{\rho\pi}$ are treated as free, independent parameters. Different sets of input values of M_O, Γ_O and θ are taken within the ranges suggested by Ref.[2]: M_O is varied from $M_{J/\psi} - 80$ MeV to $M_{J/\psi} + 80$ MeV , Γ_O from 10 to 160 MeV, and θ from 0 to 90 degrees. For $M_{J/\psi}, \Gamma_{J/\psi}, \Gamma_{ee}$ as well as Δ, the measured values[5] by the BES from the same set of the scan data are used. The fits yield an upper limit on the ratio

$$\frac{\sigma_{O+I}}{\sigma_{J/\psi}} < 2.2 \times 10^{-3} \;\; (90\% \; C.L.) \tag{9}$$

at $W = M_{J/\psi}$.

However, for the proposed model of Ref.[2] to be true, the contribution of $\sigma_{J/\psi}$ should observe the relation in Eq.(1) predicted by perturbative QCD, which means

$$\frac{B(\psi' \to \rho\pi)}{\sigma_{J/\psi}/\sigma_{tot}} = 0.147; \tag{10}$$

while the anomalous enhancement of $J/\psi \to \rho\pi$ decay mode is caused by the contribution of σ_{O+I}, which means

$$\frac{B(\psi' \to \rho\pi)}{(\sigma_{J/\psi} + \sigma_{O+I})/\sigma_{tot}} = Q_{\rho\pi}. \tag{11}$$

Combining Eq.(10) and Eq.(11) and using the experimental limit of $Q_{\rho\pi}$ in Eq.(2), it is found that

$$\begin{aligned}
\frac{\sigma_{O+I}}{\sigma_{J/\psi}} &= 0.147/Q_{\rho\pi} - 1 \\
&> 51.5
\end{aligned} \tag{12}$$

which is definitely in contradiction with the obtained upper bound in Eq.(9).

On the other hand, the likelihood ratio λ of $L(H_0)$, the maximum value of the likelihood function for the null hypothesis ($|D| = 0$ in Eq.(7)), to $L(H_1)$, the maximum value of the likelihood function for the vector glueball hypothesis, yields $-2\ln\lambda = 0.84$. In the limit where the distribution of $-2\ln\lambda$ approches the χ^2 distribution for 1 degree of freedom and for a given significance level $\alpha = 0.10$, $-2\ln\lambda < \chi^2_{0.10}(1) = 2.71$. This implies that the null hypothesis should be accepted and the vector glueball hypothesis be rejected.

Such being the case, $\sigma_{\rho\pi}(W)$ can be simply expressed as

$$\sigma_{\rho\pi}(W) = R_{\rho\pi}\sigma_{\mu\mu}(W) + B_{\rho\pi}\sigma_{tot}(W). \tag{13}$$

In fitting to the data, both $B_{\rho\pi}$ and $R_{\rho\pi}$ are treated as free parameters. The fit yields

$$B_{\rho\pi} = B(J/\psi \to \rho\pi) = (1.21 \pm 0.20)\%. \tag{14}$$

The error includes the statistical and the systematic errors added in quadrature. This is the first measurement of the $B_{\rho\pi}$ of the J/ψ from the scan across the resonance, and the result is in reasonable agreement with the Particle Data table[1] which comes from the data taken at the J/ψ. The observed cross section data corrected by the efficiency and the background as a function of the center-of-mass energy and the curve which results from the likelihood fit are shown in Fig. 1. For comparision, the measured total hadronic cross section and the fitted curve from Ref.[5] are shown in Fig. 2. The quality of the fit in Fig. 1 is checked by forming the likelihood ratio λ with the result $-2\ln\lambda = 22.0$; in the large statistics limit , this should obey a χ^2 distribution for 27 degrees of freedom which implies that a good fit has indeed been achieved.

In conclusion, the data from the scan across the J/ψ resonance have been analyzed to search for the vector gluonium state O which was hypothesized to solve the $\rho\pi$ puzzle in J/ψ and ψ' physics. No evidence was found to support the existence of such a vector gluonium state by using the likelihood fit to the data of the $\rho\pi$ scan. The shape of the $\rho\pi$ curve is found to be consistent with the shape of the total hadronic curve and no distortion is observed within this experimental statistics. The $\rho\pi$ branching fraction of J/ψ can be obtained by fitting the shape of the scan data which yields the result $B(J/\psi \to \rho\pi) = (1.21 \pm 0.20)\%$. So far, the $\rho\pi$ puzzle in charmonium physics remains as a puzzle.

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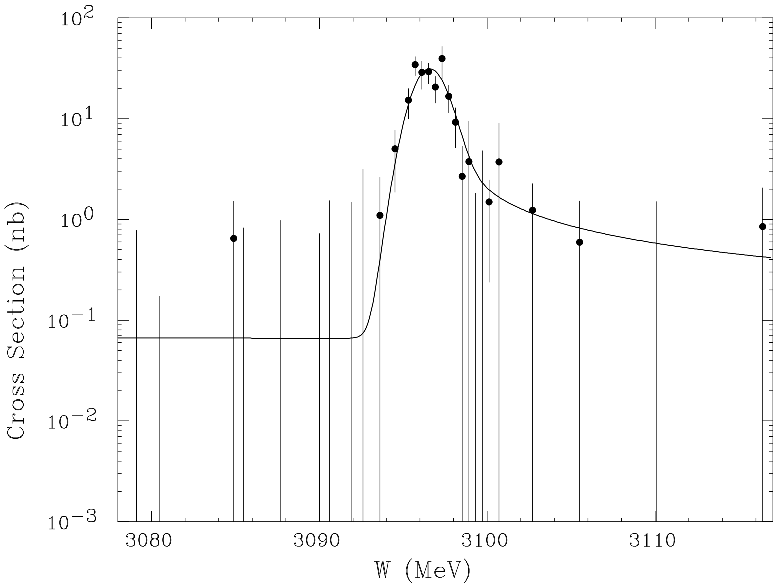

FIG. 1. The center-of-mass energy dependence of the $\rho\pi$ cross section resulting from the likelihood fit (curve), compared to the data corrected by the efficiency and background.

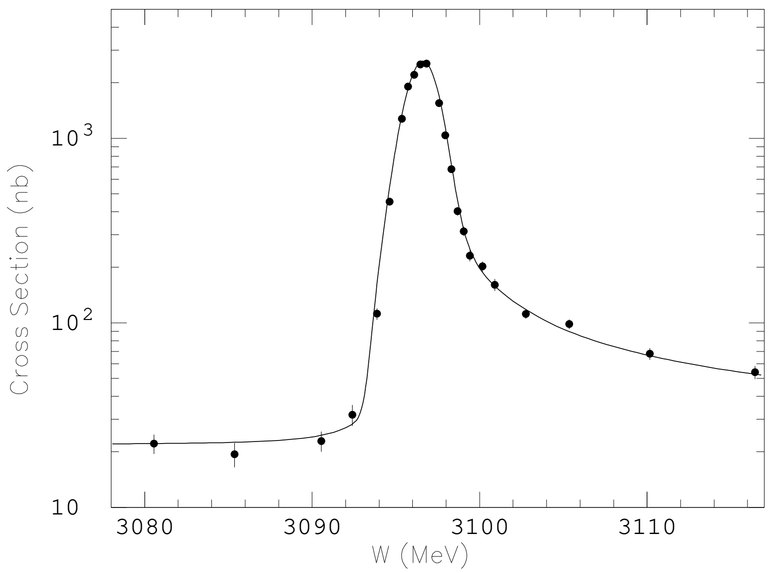

FIG. 2. The total cross section for $e^+e^- \rightarrow hadrons$.

References

[1] Particle Data Group, Phys. Rev. D50(1994). Here $Q_{\rho\pi}$ is calculated by using the new measurement of BES, $B(\psi' \to \rho\pi) < 3.6 \times 10^{-5}$ (90% C.L.), and $Q_{K^*\bar{K}}$ by using corrected value $B(\psi' \to K^*\bar{K}) < 5.4 \times 10^{-5}$ (90% C.L.), instead of the erroneous PDG value of 1.79×10^{-5}.

[2] S. J. Brodsky, G. P. Lepage and S. F. Tuan, Phys. Rev. Lett. 59(1987)621.

[3] W-S. Hou and A. Soni, Phys. Rev. Lett. 50(1983)569; The existence of a vector gluonium state was first postulated by P. G. O. Freund and Y. Nambu, Phys. Rev. Lett. 34(1975)1645.

[4] Y. Chen, Y. F. Gu and P. Wang, CCAST-WL Workshop Series: Volume 22, Charm and τ Physics at BES/BEPC(I)(1992)98.

[5] BES Collaboration, Phys. Lett. B(1995)(to be published).

[6] BES Collaboration, Nucl. Inst. and Meth. A344(1994)319.

[7] E. A. Kuraev and V. S. Fadin, Sov. J. Nucl. Phys. 41(1985)466.