Studies on J/ψ to $\pi^+\pi^-$ + X($\rho\pi$) and J/ψ to $\pi^+\pi^- + X(K^*\bar{K})$ Decays *

(BES Collaboration) presented by Jingtang He

Institute of High Energy Physics, Chinese Academy of Sciences 100039, Beijing, PRC

June 12, 1997

Abstract

The analyses of $J/\psi \to \pi^+\pi^- + X(\rho^0\pi^0)$, $J/\psi \to \pi^+\pi^- + X(\rho^+\pi^-)$, $J/\psi \to \pi^+\pi^- + X(\rho^-\pi^+)$ and $J/\psi \to \pi^+\pi^- + X(K^*\bar{K})$ channels were made to search for possible vector glueball. The peaks of $M_x(\rho\pi)$ and $M_x(K^*\bar{K})$ at around 2.3GeV were found in the above four channels. This X particle could be the explanation of the evidence of exsting vector glueball.

I. Introduction

In the charmonium physics, there is an outstanding puzzle, namely the absence of $\psi\prime$ decays to Vector−Pseudoscaler VP light hadrons. On the basis of perturbative QCD, it is reasonable to expect that for any hadronic final state h, we have

$$R_h = \frac{BR(\psi\prime \to h)}{BR(J/\psi \to h)} = \frac{BR(\psi\prime \to e^+e^-)}{BR(J/\psi \to e^+e^-)} = (14 \pm 2)\%$$

This is well documented for $p\bar{p}\pi^0$,$2\pi^+2\pi^-\pi^0$, $2(\pi^+\pi^-)$,$P\bar{P}\pi^+\pi^-$,$(3\pi^+3\pi^-)\pi^0$ and $b_1\pi$ hadronic channels,[1]but $\psi\prime \to \rho\pi$, $K^*\bar{K}$ channels are suppressed. To solve this problem, Brodsky−Lepage−Tuan[2] proposed a coherent explanation of the puzzle by assuming of the existant of a glueball state with (I,J^{pc}) = $(0, 1^{--})$ made up from three gluons 3g(hence trigluonia). Theorist gave the name of O (Omicron) to this 1^{--} glueball. The Omicron can decay into exclusive light hadron channels h, according to the scheme 3g→O→h. In the earlier times[3] theoritical estimates for the mass of Omicron were around 2.4GeV, some other estimates suggested that it could be as high as 3GeV. Recently the UKQCD collaboration[4] predicted the mass of Omicron would be at 4GeV based on the work of SU(3) Glueball−Comprehensive Lattice Study.
Is there really an Omicron ? What is the mass of Omicron ?

*This work is supported by NSF of China

The $\rho\pi$ channel have been carefully scanned across the J/ψ region in e^+e^- annihilation at BES[5] and there bas been no sign of distortion of J/$\psi \rightarrow \rho\pi$ shape due to Breit−Wigner Omicron interference. This result excludes the mass of Omicron around 3GeV.
If the mass of Omicron is less than 2.7GeV,the following decay processes:

$$J/\psi \rightarrow \pi^+\pi^- + Omicron(\rho\pi)$$

$$J/\psi \rightarrow \pi^+\pi^- + Omicron(K^*\bar{K})$$

could be used as the method to search for Omicron in charmonium physics.
To search for the possible Omicron, we have performed the analyses based on about $8X10^6 J/\psi$ events from BES in the following four channels:

$$J/\psi \rightarrow \pi^+\pi^- + X(\rho^0\pi^0)$$

$$J/\psi \rightarrow \pi^+\pi^- + X(\rho^+\pi^-)$$

$$J/\psi \rightarrow \pi^+\pi^- + X(\rho^-\pi^+)$$

$$J/\psi \rightarrow \pi^+\pi^- + X(K^*\bar{K})$$

The $M_x(\rho\pi)$ and $M_x(K^*\bar{K})$ at around 2.3GeV were found in the above four channels. This X particle could be the explanation of the evidence of exsting of the vector glueball.

II.Events selections

(1) The criteria of selections for charged tracks:
The numbers of charged tracks N_{charge}=4 was required. Requiring M_{fit}=2 or -19 to get good quarlity of charged tracks. The total charge of these four charged tracks should equal to zero. To guarantee the tracks come from interaction point, requiring:

$$\sqrt{X_0^2 + Y_0^2} < 2cm$$

$$\mid Z_0 \mid < 20cm$$

We take the tracks in the barrel part only. Using TOF or dE/dX information to identify pions, requiring W(π)>W(K,P).
(2)The criteria of selections for photons:
The numbers of photon are larger than 2 and less than 6. To reject fake photons, $E_\gamma > 80MeV$ was required. From selected photons and 4π informations, a 4C-fit was made to select 2 good photons, if $\chi^2<50$, then take the selected 2 photons as 2 real photons.
(3)For π^0 selections:
To reject fake photons, M($\pi^+\pi^-$ $\pi^+\pi^-$)<(3.1GeV-0.15GeV)<2.9GeV was required.

Fig.1.a. is the invariant mass distribution of M($\pi^+\pi^-\pi^+\pi^-$) from J/$\psi \rightarrow \pi^+\pi^-\pi^+\pi^- +$ $N\gamma$. A small peak at about 3.1GeV comes from J/$\psi \rightarrow \pi^+\pi^-\pi^+\pi^- + \gamma$ and J/$\psi \rightarrow$ $\pi^+\pi^-\pi^+\pi^-$ + (fake photons) is clearly seen. Fig.1.b. is the Monte Carlo result of the invariant mass distribution of M($\pi^+\pi^-\pi^+\pi^-$) from J/$\psi \rightarrow \pi^+\pi^-\pi^+\pi^- + \pi^0$. The small peak at about 3.1GeV comes from J/$\psi \rightarrow \pi^+\pi^-\pi^+\pi^- + \gamma$ and J/$\psi \rightarrow \pi^+\pi^-\pi^+\pi^- +$ (fake photons) is disapeared. Fig.1.c. is the invariant mass distribution of M($\gamma\gamma$). The π^0 peak is clearly seen. Fig.1.d. is the invariant mass distribution of M($\gamma\gamma$) after fake photon rejections. Requiring $|M_{\gamma\gamma}$-0.135$|$<30MeV for the final π^0 selection.
(4)Using 5C-fit, requiring χ^2<30 to select $\pi^+ \ \pi^-\pi^+\pi^-\pi^0$ events.
(5) To select ρ^0, defining:
$\Delta\rho^0$=$|$M($\pi_i^+\pi_j^-$)-0.77$|$ ^{2} i,j=1,2
ΔK^0=$|$M($\pi_i^+\pi_j^-$)-0.498$|$ ^{2} i,j=1,2
Δf_0=$|$M($\pi_i^+\pi_j^-$)-0.98$|$ ^{2} i,j=1,2
Requiring $\Delta\rho<\Delta$K and $\Delta\rho<\Delta f_0$.
(6) To select ρ^+, defining:
$\Delta\rho_i^+$=$|$M($\pi_i^+\pi^0$)-0.77$|$ ^{2} i=1,2
the minimum value of $\Delta\rho_i^+$ was taken for the ρ^+ candidate. Then make a cut of $| M(\rho_i^+) - 0.77 |$ <0.075GeV for ρ^+ selections.
(7) To select ρ^-, defining:
$\Delta\rho_i^-$=$|$M($\pi_i^-\pi^0$)-0.77$|$ ^{2} i=1,2
the minimum value of $\Delta\rho_i^-$ was taken for the ρ^- candidate. Then make a cut of $| M(\rho_i^-) - 0.77 |$ <0.075GeV for ρ^- selections.
Fig.2.a. is the invariant mass distribution of M($\pi^+\pi^-$). There are many peaks, mainly the K_s^0, ρ^0, $f_0(980)$ and $f_2(1270)$. Fig.2.b. is the invariant mass distribution of M($\pi^\pm\pi^0$). The ρ peak is clearly seen. Fig.1.c. is the invariant mass distribution of M($\pi^+\pi^-$) after rough selections for ρ^0. Fig.1.c. is the invariant mass distribution of M($\pi^+\pi^-$) after comparing the $\Delta\rho<\Delta$K and $\Delta\rho<\Delta f_0$. The ρ^0 peak is sharply seen.
(8) $K^*\bar{K}$ selections:
The TOF or dE/dX informations were used to select two K tracks, then made $K^+\pi^0$ or $K^-\pi^0$ combination to select K^*, the M(K*) distribution is shown in fig.3. Requiring $| M(K\pi^0) - 0.892 |$ <0.05GeV for the final M(K*) selection.

III. Background rejections

There are four charged tracks in $J/\psi \rightarrow \pi^+\pi^- + X(\rho^+\pi^-)$ and $J/\psi \rightarrow \pi^+\pi^- + X(\rho^-\pi^+)$ channels, the main backgrounds come from $J/\psi \rightarrow \gamma + \rho^0\rho^0$ and $J/\psi \rightarrow \gamma + K_s^0K_s^0$. The events which contained $| M(\pi^+\pi^-) - M(K_s^0) |$ <0.025GeV or $| M(\pi^+\pi^-) - M(\rho) |$ <0.075GeV were rejected. A cut of $M(\pi^+\pi^-)$<0.62GeV was used to reject the background comes from J/$\psi \rightarrow \rho^0(\pi^+\pi^-) + a_2(\rho^0\pi^0)$.

IV. Preliminary results

A. $J/\psi \to \pi^+\pi^- + X(\rho\pi)$

The preliminary results of $J/\psi \to \pi^+\pi^- + X(\rho\pi)$ are shown in Fig.4. The preliminary results of $J/\psi \to \pi^+\pi^- + X(\rho^0\pi^0)$ are shown in Fig.4.a. Fig.4.a. is the invariant mass distribution of $M(\rho^0\pi^0)$ with a cut of $M(\pi^+\pi^-)<0.62$GeV to reject background comes from $J/\psi \to \rho^0(\pi^+\pi^-) + a_2(\rho^0\pi^0)$. The preliminary results of $J/\psi \to \pi^+\pi^- + X(\rho^+\pi^-)$ and $J/\psi \to \pi^+\pi^- + X(\rho^-\pi^+)$ are shown in Fig.4b.and Fig.4.c. Fig.4.b. is the invariant mass distribution of $M(\rho^+\pi^-)$. Fig.4.c. is the invariant mass distribution of $M(\rho^-\pi^+)$. In fig.4.a,b and c, there are one peak at about 1.3GeV and another peak at around 2.3GeV. The peak of 1.3GeV comes from $J/\psi \to \rho^0(\pi^+,\pi^-) + a_2(\rho,\pi)$. This peak can be used as calibration peak.

B.$J/\psi \to \pi^+\pi^- + X(K^*\bar{K})$

The preliminary results of $J/\psi \to \pi^+\pi^- + X(K^*\bar{K})$ are shown in Fig.4.d. Fig.4.d. is the invariant mass distribution of $M(K^*\bar{K})$, there is one peak at about 2.3GeV.

The Monte Carlo simulation studies of background come from $J/\psi \to \pi^+\pi^- + \rho + \pi$ phase space were made. In Fig.5.c, we present the result of the Monte Carlo simulation for $J/\psi \to \pi^+\pi^- + \rho^0 + \pi^0$ phase space. In Fig.5.d, we present the result of the Monte Carlo simulation for $J/\psi \to \pi^+\pi^- + \rho^- + \pi^+$ phase space. One can see that there are no any peak of $M(\rho,\pi)$ around 1.3 GeV or 2.3GeV in both Fig.5.c and Fig.5.d.

V. Discussion and Conclusion

In fig.4.a,b and c, there is a peak from $a_2(1320) \to \rho\pi$ due to $J/\psi \to \rho^0(\pi^+,\pi^-) + a_2(\rho,\pi)$ background. This peak can be used as calibration peak. The peaks of M_x at about 2.3GeV are appeared in $\rho^0\pi^0$, $\rho^+\pi^-$ and $\rho^-\pi^+$ channels and are also appeared in $K^*\bar{K}$ channel. These behaviours imply that these peaks of $M_x(\rho\pi)$ and $M_x(K^*\bar{K})$ at about 2.3GeV can not be due to statistical fluctuations. This X particle could be the explanation of the evidence of existing of the Vector Glueball(the Omicron).

References

[1] Review of Particle Properties Phys.Rev.D50(1994)

[2] S.J.Brodsky,G.P.Lepage and S.F.Tuan Phys.Rev.Lett.59(1987)621 S.F.Tuan Proc.of Hadron '95(1995) p.361

[3] Wei−Shu Hou and A.Soni Phys.Rev.D29(1984)101 C.P.Van den Doel and D.Horn Phys.Rev.D35(1987)2824 Jueping Liu and Dunhuan Liu Chinese Phys.Lett.7(1990)252

[4] G.S.Bali et al Phys.Lett.B309(1993)378

[5] Y.Chen et al Proc. of the XVI LeptonPhoton Symposiom.(1994)p.530