NEW RESULTS ON STUDY OF $\xi(2230)$ AT BES

LI JIN

IHEP, CAS, Beijing 100039, China,Representing the BES Collaboration

Using 8 million J/ψ hadron events and 7 million neutral events collected at Beijing Electron-Positron Collider(BEPC), the BES collaboration has performed studies of the $\xi(2230)$ in J/ψ radiative decays. The paper concentrates on the new preliminary results from decay channels of $J/\psi \to \gamma\pi^0\pi^0$ and $\gamma\eta\eta'$.

1 Introduction

According to the QCD strong interaction theory, there may exist, due to the self-interaction between gluons, gluon bound states — glueball (gg, ggg) in addition to the conventional $q\overline{q}$ meson states. So, search for and study of glueball will be of great significance in testing QCD and understanding the nature of the strong interaction.

The particle $\xi(2230)$, a narrow state with a width of about $20MeV$, was first observed by the MARKIII Collaboration in the radiative decays of J/ψ to K^+K^- and K_sK_s final states[1]. Some experiments claimed that they found structure around $2.2GeV/c^2$ in different process[2,3,4], but no other groups found such narrow structure in J/ψ decay[5]. There are many speculations about the nature of $\xi(2230)$. It could be an ordinary $s\overline{s}$ state, 4-quark state, $\Lambda\overline{\Lambda}$ bound state, hybrid state, or a glueball[7,8,9,10].

Recently, the BES Collaboration at BEPC has found the signal of $\xi(2230)$ in $J/\psi \to \gamma p\overline{p}$ and $J/\psi \to \gamma\pi^+\pi^-$ after confirmed in $J/\psi \to \gamma K^+K^-$ and $J/\psi \to K_sK_s$. The measured masses, widths and branching ratios are given[11].

These results indicate that $\xi(2230)$ decays are probably flavor symmetric, and its total width is as narrow as about $20MeV$. These features may make $\xi(2230)$ distinguishable from many other states if the production rate of $\xi(2230)$ in J/ψ radiative decay is relatively large.

However, the knowledge about $\xi(2230)$ is still limited by the experimental results. Therefore, the study of other decay modes, such as $J/\psi \to \gamma\pi^0\pi^0, \gamma\eta\eta'$, etc, is very important in understanding the nature of $\xi(2230)$. for η and η' being considered to be strongly coupled to gluon, the signal appearing to be prominent in $\eta\eta'$ is traditionally regarded as glueball signature.

In other words, if $\xi(2230)$ is a glueball, it sounds that it should appear in $\eta\eta$ and $\eta\eta'$. So far, no obvious $\xi(2230)$ signal was found in final state of $\eta\eta'$, only GAMS has found a peak near $2.22GeV$ in the process:$\pi^- p \to n\eta\eta' \to n4\gamma$, the width is smaller than $100MeV$. It was the first experiment which observed the $\xi(2230)$ in $\eta\eta'$ mass spectrum.

Using 8 million J/ψ events and 7 million neutral events collected at BEPC, the BES collaboration has studied the $\xi(2230)$ in J/ψ radiative decays: $J/\psi \to \gamma\pi^0\pi^0, \gamma\eta\eta'$. Now very preliminary new results have been given.

2 Analysis and Results

1. The study of $J/\psi \to \gamma\pi^0\pi^0(\pi^0 \to 2\gamma)$

   The analysis of J/ψ decay channel $J/\psi \to 5\gamma$ is based on 7×10^6 neutral J/ψ events recorded by BES detector.

   In the events selection of $J/\psi \to \gamma\pi^0\pi^0$, the main background comes from fake photons or $J/\psi \to \omega\eta(\gamma\pi^0\eta)$, $\omega f_2(\gamma 3\pi^0)$, $\gamma\eta(\gamma 3\pi^0)$ or $\gamma\eta'(\gamma\pi^0\pi^0)$. In order to reduce the fake photons from events with no charged tracks, the first level of event selection requires that:

   (1) The hit number in the first layer of BSC should be less than 6;

   (2) Total number of hitted layers is at least 2;

   (3) The energy of photon is greater than $50MeV$;

   (4) The photons should come from interaction region.

2. In the event selection of $J/\psi \to \gamma\pi^0\pi^0$, perform 4-c kinematic fit and get the best five

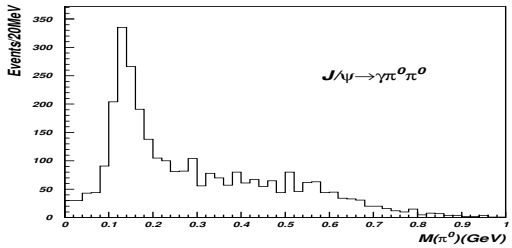

Figure 1: Mass spectrum of π^0 in $J/\psi \to \gamma\pi^0\pi^0$

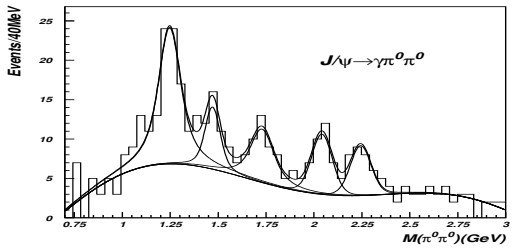

Figure 2: Fitted mass spectrum of $\pi^0\pi^0$ in $J/\psi \to \gamma\pi^0\pi^0$

photons with the smallest χ^2. Use the smallest δ value

$$\delta = (m_{\gamma_1\gamma_2} - 0.135)^2 + (m_{\gamma_3\gamma_4} - 0.135)^2$$

to obtain the best combination of $2\pi^0$. Finally, we let $\chi^2 < 10.0$ to get five photons in seven clusters and selected the π^0 by $|m_{\pi^0} - 0.135| < 0.05GeV$. Fig 1 shows the π^0 invariant mass. Fig 2 shows the fitted spectrum of $\pi^0\pi^0$ mass. From the Fig 2 we know that

(1) There are 5 peaks in $\pi^0\pi^0$ mass spectrum. the masses of them are

$$\begin{aligned} m &= (1.246 \pm 0.024)GeV/c^2 \\ m &= (1.477 \pm 0.031)GeV/c^2 \\ m &= (1.724 \pm 0.036)GeV/c^2 \\ m &= (2.042 \pm 0.031)GeV/c^2 \\ m &= (2.244 \pm 0.035)GeV/c^2 \end{aligned}$$

respectively.

(2) When we fixed the width $\Gamma = 20MeV$, we obtained the mass and branching ratio of $J/\psi \to \gamma\xi$ and $\xi \to \pi^0\pi^0$.

$$\begin{aligned} M &= (2.244 \pm 0.035)GeV/c^2 \\ Br(J/\psi \to \gamma\xi) \cdot Br(\xi \to \pi^0\pi^0) &= (4.40 \pm 2.20 \pm 1.32) \times 10^{-5} \end{aligned}$$

3. The study on $J/\psi \to \gamma\eta\eta'$

An analogous analysis is performed to select $J/\psi \to \gamma\eta\eta', (\eta \to 2\gamma, \eta' \to \gamma\rho^0, \rho^0 \to \pi^+\pi^-)$, the main background coming from $J/\psi \to \rho\pi(\pi^0\pi^+\pi^-)$. Based on 8 million hadron events, we selected two charged tracks events with at least 6 isolated photons only. The charged track need to be come from interaction point region. The deposited energy in shower counter is smaller than $600MeV$. To exclude the $\rho\pi$ events we required $|m_{\pi^+\pi^-} - 0.77| < 0.07GeV/c^2$ and $|p_\rho - 1.45| < 0.04$, where p_ρ is the momentum of ρ. After performing 4-c fit to get best $4\gamma\pi\pi$ events and selecting the events which satisfy $|m_{\pi^+\pi^-} - 0.77| < 0.1GeV/c^2$, we used the smallest δ value to set the best combination of $\eta\eta'$. The definition of δ is

$$\delta = \frac{(m_\eta - 0.547)^2}{\sigma_\eta^2} + \frac{(m_{\eta'} - 0.958)^2}{\sigma_{\eta'}^2}$$

finally we had further cuts:

$$\begin{aligned} |m_{\pi^+\pi^-} - 0.77| &< 0.08GeV/c^2 \\ |m_\eta - 0.547| &< 0.05GeV/c^2 \\ |m_{\eta'} - 0.958| &< 0.05GeV/c^2 \end{aligned}$$

and require $\chi^2 < 15.0$ Fig 3 shows the mass spectrum of $m_{\eta\eta'}$. We found the peak at $2.2GeV/c^2$ region. We also can get the mass with fixed width of $20MeV$:

$$M = (2.249 \pm 0.018)MeV/c^2$$

3 Discussion

The existence of $\xi(2230)$ in radiative decay mode of $J/\psi \to \gamma\pi^0\pi^0$ has been tested. The structures near $1500MeV/c^2$, $1750MeV/c^2$ and $2100MeV/c^2$ which were observed by some other experiments are also found in this study. The signal of $\xi(2230)$ was observed in decay mode of $J/\psi \to \gamma\eta\eta'$ with large statistical error.

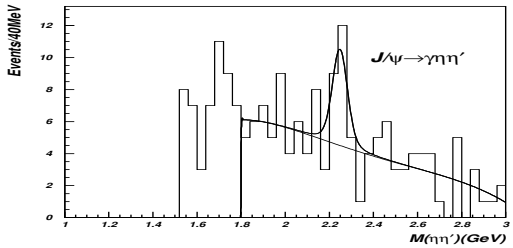

Figure 3: Mass spectrum of $\eta\eta'$ in $J/\psi \to \gamma\eta\eta'$

Acknowledgments

We would like to thank the stuff of the BEPC accelerator and IHEP Computing Center. This work was supported in part by the National Natural Science Foundation under Contract No 19290400(IHEP) and by Academia Sinica under Contract No KJ85.

The author gratefully acknowledges the support of K. C. Wang Education Foundation, Hong Kong.

References

1. R. M. Bultrusaitis et al., Phys. Rev. Lett. 56, 107(1986)
2. D. Alde et al., Phys. Lett. B177, 120(1986)
3. D. Aston et al., Nucl. Phys. B301, 525(1988) and Phys. Lett. B215, 199(1988)
4. B. V. Bolonkin et al., Nucl. Phys. B309, 426(1988)
5. J. Augustin et al., Phys. Rev. Lett. 60, 2238(1988)
6. S. Godfrey et al., Phys. Lett. 141B, 439(1984)
7. K. T. Chao, Phys. Rev. Lett. 60, 3579(1988)
8. S. Pakvasa et al., Phys. Lett. 145B, 135(1984)
9. S. Oho, Phys. Rev. D35, 944(1987)
10. B. F. L. Ward, Phys. Rev. D31, 2849(1985)
11. BES collaboration, Phys. Rev. Lett. 76, 3502(1996)