Recent results on light hadron spectroscopy at BES

Xiaobin Ji (for the BESIII Collaboration) [a]

[a]Institute of High Energy Physcis, Chinese Academy of Sciences,
P.O. Box 918-1, 100049, Beijing, China

Several recent BES results are presented, which include the charged κ found in BESII data, confirmation of $p\bar{p}$ mass threshold enhancement and X(1835) at BESIII, the measurement of $a_0(980)$ and $f_0(980)$ mixing at BESIII. All results except $p\bar{p}$ mass threshold enhancement are preliminary.

1. Introduction

BEPCII/BESIII[1] is a major upgrade of the BESII[2] experiment at the BEPC accelerator for studies of hadron spectroscopy and τ-charm physics. The results here are based on the 58 M J/ψ events at BESII and 106 M ψ' and about 226 M J/ψ events at BESIII.

2. Charged κ at BESII

σ and κ were first found in the analysis of $\pi\pi$ and πK scattering data, which can not be filled into any nonets of ordinary $q\bar{q}$ meson. Evidences for the neutral κ have been reported by E791[3] and FOCUS[4] experiment. In 2006, BESII reported the neutral κ found in the decay $J/\psi \to \bar{K^\star}(892)^0 K^+\pi^-$[6]. The existence of a neutral κ motivates the search for a charged partner. In this proceeding, we present the search for a charged κ in $J/\psi \to K^\pm K_S \pi^\mp \pi^0$ at BESII.[5]

Points with error bar in Figure 1 shows the combined invariant mass distribution of $K^\pm\pi^0$ and $K_S\pi^\mp$ of the selected $J/\psi \to K^\pm K_S\pi^\mp\pi^0$ events. The partial wave analysis shows that besides strong contributions from $K^\star(892)$, $K^\star(1410)$, and $K^\star(1430)$, a significant $J^P = 0^+$ low mass component is needed to describe the data. If we use a Breit-Winger function of constant width to parametrize the κ, its pole position is $(849\pm77^{+18}_{-14}) - i(256\pm40^{+46}_{-22})$ MeV/c^2. Three different parametrization are tried to fit the κ, the mass and width obtained by different parametrization are quite different, but their poles are almost the same.

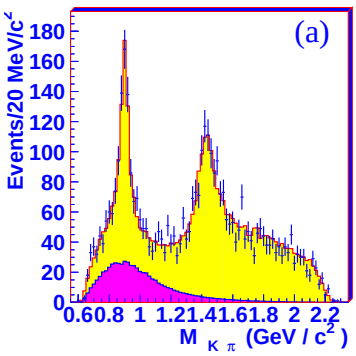

Figure 1. Final fit on $K\pi$ spectrum. Error bar is data, the light shaded histogram is the final global fit, and the dark shaded histogram is the contribution of the κ.

This result is in agreement with a recent CLEO analysis of the resonance structure in $D^0 \to K^+K^-\pi^0$ decays[7], which suggests a $\kappa^\pm$ component with parameters $m = (855 \pm 15)$ MeV/c^2 and $\Gamma = (251\pm48)$ MeV/c^2. Moreover the results are in reasonable agreement with the properties of the neutral κ.

3. Confirmation of $p\bar{p}$ mass threshold enhancement at BESIII

An anomalously strong $p\bar{p}$ threshold enhancement (X(1860)) was observed by the BESII experiment in the radiative decay process $J/\psi \to \gamma p\bar{p}$[8]. An interesting feature of this enhancement is that the corresponding structure is not observed in either $p\bar{p}$ cross section measurements or in B-meson decays[10]. The CLEO Collaboration published results on the radiative decay of the $\Upsilon(1S)$ to the $p\bar{p}$ system[11], where no $p\bar{p}$ threshold enhancement is observed. This enhancement is not observed in BESII $\psi(2S) \to \gamma p\bar{p}$[12] or $J/\psi \to \omega p\bar{p}$[13] data.

This surprising experimental observation has stimulated a number of theoretical interpretations. Some have suggested that it is a $p\bar{p}$ bound state (baryonium). And someone thinks it is primarily due to final state interactions (FSI) between the proton and anti-proton.

Using 106 M $\psi(2S)$ collected by the BESIII detector, the $p\bar{p}$ threshold enhancement is confirmed in the process $\psi(2S) \to \pi^+\pi^- J/\psi$, $J/\psi \to \gamma p\bar{p}$[9](Upper plot in Figure 2). A fit with S-wave Breit-Wigner function yields the mass is $1861^{+6}_{-13}{}^{+7}_{-26}$ MeV/c^2 and the width is smaller than 38 MeV/c^2 at the 90% C.L. The result is consistent with BESII. $\psi(2S) \to \gamma p\bar{p}$ is also studied and no such an enhancement observed (lower plot in Figure. 2), which indicated pure FSI interpretation of the narrow and strong $p\bar{p}$ threshold enhancement in J/ψ radiative decay is disfavored.

CLEOc also observes a $p\bar{p}$ threshold enhancement in $\psi(2S) \to \pi^+\pi^- J/\psi$, $J/\psi \to \gamma p\bar{p}$ and obtains a consistent fitted mass.[18]

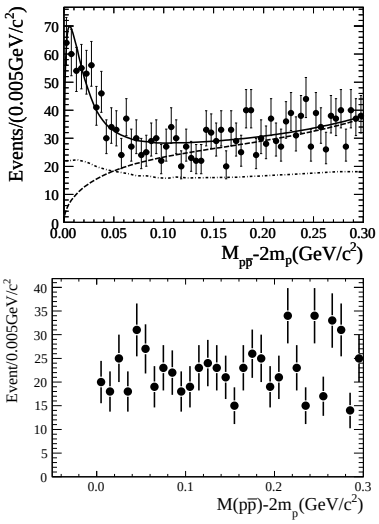

Figure 2. Upper: The fitting of the $p\bar{p}$ mass spectrum in the threshold region in the decay $\psi(2S) \to \pi^+\pi^- J/\psi$, $J/\psi \to \gamma p\bar{p}$. The solid curve is the fit result, the dashed curve shows the fitted background function, and the dot-dash line shows the efficiency curve. Lower: The $p\bar{p}$ invariant mass spectrum in the threshold region for the selected $\psi(2S) \to \gamma p\bar{p}$ candidate events.

4. Confirmation of X(1835) at BESIII

X(1835) was observed in the $\pi^+\pi^-\eta'$ invariant mass spectrum with a statistical significance of 7.7σ at BESII.[14] A fit with a Breit-Wigner function yields a mass $1833.7 \pm 6.1 \pm 2.7$ MeV/c^2, a width $67.7 \pm 20.3 \pm 7.7$ MeV/c^2, and a production branching fraction $B(J/\psi \to \gamma X) \times B(X \to \pi^+\pi^-\eta') = (2.2 \pm 0.4 \pm 0.4) \times 10^{-4}$. The mass and width of X(1835) are not compatible with any known meson resonance.

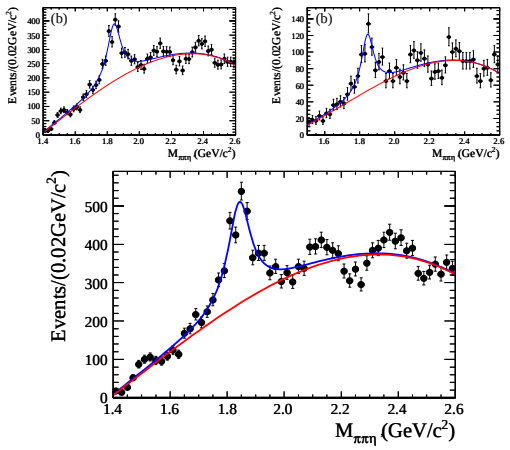

Figure 3. Fitting the invariant mass spectrum of $\pi^+\pi^-\eta'$ in $J/\psi \to \gamma\pi^+\pi^-\eta'$ at BESIII. Upper-left: $\eta' \to \gamma\rho$; Upper-right: $\eta' \to \pi^+\pi^-\eta$; Lower: The combined invariant mass spectrum of $\eta' \to \gamma\rho$ and $\eta' \to \pi^+\pi^-\eta$. The mass spectrum is fitted with a resonance plus polynomial background shape.

With about 226 M J/ψ events collected at BESIII, $J/\psi \to \gamma\pi^+\pi^-\eta'$ ($\eta' \to \gamma\rho$, $\eta\pi^+\pi^-$) is studied to verify the BESII observation. The upper-left plot in Figure 3 shows the invariant mass spectrum of $\pi^+\pi^-\eta'$ for $J/\psi \to \pi^+\pi^-\eta'$ ($\eta' \to \gamma\rho$). A significant peak at $M \sim 1835$ MeV/c^2 is observed. If it is fitted with one resonance plus a polynomial background shape, the statistical significance of the resonance is about 18σ. The upper-right plot in Figure 3 is the result of the another decay mode $\eta' \to \gamma\pi^+\pi^-$. There is also a significant peak around 1835 MeV/c^2. The fitting shows the statistical significance is about 9σ. Extensive studies of potential background processes using both data and MC is made, none can produce a peak around 1835 MeV/c^2 in the $\pi^+\pi^-\eta'$ mass spectrum. The lower plot of Figure 3 shows the $\pi^+\pi^-\eta'$ invariant mass spectrum for the combined channels. The mass and width obtained from the Breit-Wigner fit are $M = 1842.4 \pm 2.8(stat.)$ MeV/c^2 and $\Gamma = 99.2 \pm 9.2(stat)$ MeV/c^2 with a statistical significance of 21σ. These values are consistent with the published BESII results. More studies will be performed on the high $\pi^+\pi^-\eta'$ mass region of $2.1 \sim 2.5$ GeV/c^2.

5. $a_0(980) - f_0(980)$ mixing

The $f_0(980)$ and $a_0(980)$ are controversial particles. They have been described as $q\bar{q}$ or $q\bar{q}q\bar{q}$ states, $K\bar{K}$ molecules, or $q\bar{q}G$ hybrid states. Mixing was first suggested by Achasov[15], and mixing measurements may be important to clarify the nature of these particles. There have been suggestion[16] for BESIII to search for mixing signals in $J/\psi \to \phi f_0 \to \phi a_0 \to \phi\eta\pi^0$, where the f_0 mixes to a_0, and in the process[17] $\chi_{c1} \to \pi^0 a_0 \to \pi^0 f_0 \to \pi^+\pi^-\pi^0$, where a_0 mixes to f_0. The signal for the former case is shown in the upper-left plot in Figure 4, and the upper-right plot in Figure 4 shows the latter case.. The expected mixing signal is very narrow (8 MeV/c^2) between the K^+K^- and K_SK_S thresholds (987 – 995 MeV/c^2). Backgrounds are sideband and a wide a_0 from $J/\psi \to \gamma^\star/K^\star K \to \phi a_0$. Fitting to signal plus backgrounds determines 24.7±8.6 mixing events or < 36.7 at the 90% confidence level. This gives a mixing intensity $\xi_{fa} = (0.6 \pm 0.2 \pm 0.2)\%$ or $< 1.1\%$ at the 90% C.L. For the latter mixing case, we determine $\xi_{af} = (0.32 \pm 0.16 \pm 0.12)\%$ or $< 0.91\%$ at the 90% C.L. The lower plot in Figure 4 shows our results and upper limits compared to models ($q\bar{q}$, $q^2\bar{q}^2$, $K\bar{K}$, and $q\bar{q}g$) and calculated values (SND, KLOE, BNL, and CB) based on f_0 and a_0 parameters. Ours are the first direct measurements.

6. Summary

Charged κ is observed at BESII with $J/\psi \to K^\pm K_S \pi^\mp \pi^0$. Partial wave analysis on it gives the consistent parameters with neutral κ. With 106 M $\psi(2S)$ and about 226 M J/ψ data samples collected by BESIII, the $p\bar{p}$ threshold enhancement found at BESII in $J/\psi \to \gamma p\bar{p}$ is confirmed using the decay process $\psi(2S) \to \pi^+\pi^- J/\psi$, $J/\psi \to \gamma p\bar{p}$, and X(1835) found in $J/\psi \to \pi^+\pi^-\eta'$ is also confirmed with much higher statistical. And the direct measurement of a_0 and f_0 mixing is per-

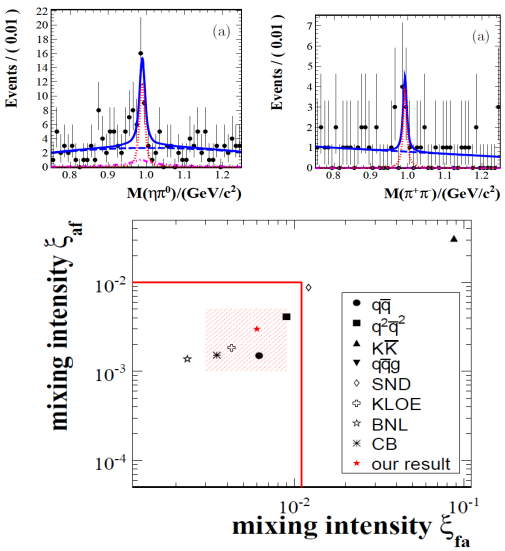

Figure 4. Upper-left: Invariant mass of $\eta\pi^0$ in $J/\psi \to \phi f_0 \to \phi a_0 \to \phi\eta\pi^0$; Upper-right: Invariant mass of $\pi^+\pi^-$ in $\chi_{c1} \to \pi^0 a_0 \to \pi^0 f_0 \to \pi^+\pi^-\pi^0$. The mixing signal is very narrow (¡ 8 MeV/c^2). Lower: Mixing intensity ξ_{fa} versus ξ_{af} for various models and calculations and our results (shaded square) and upper limits (lines).

formed firstly. We expect that more BESIII results will be published soon.

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