PROCEEDINGS OF SCIENCE

Study of $a_0(980) - f_0(980)$ mixing at BES III and study of charged κ at BES II

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Recent BES results on light scalars are reported in this talk, including the observation of a charged $\kappa^{\pm}$ decaying to $K^{\pm}\pi^0$ with 5.8×10^7 J/ψ data at BES II and the direct measurements of $a_0^0(980)-f_0(980)$ mixing in the processes $J/\psi\to\phi f_0(980)\to\phi a_0^0(980)\to\phi\eta\pi^0$ and $\chi_{c1}\to\pi^0 a_0^0(980)\to\pi^0 f_0(980)\to\pi^0\pi^+\pi^-$ with 2.26×10^8 J/ψ data and 1.06×10^8 ψ' data at BES III.

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1. Introduction

There has been much argument whether σ and κ exist, due to the facts that the total phase shifts in the lower mass region are much less than 180 degrees and they do not fit into ordinary meson nonets. For $f_0(980)$ and $a_0(980)$, whether they are $q\bar{q}$ mesons, 4-quark states , hybrids or $K\bar{K}$ molecules is also controversial [1, 2]. The study of their nature has been one of the important topics in the light hadron spectroscopy. BEPC II/BES III [3] is a major upgrade of the BESII experiment at the BEPC accelerator [4] for studies of hadron spectroscopy and τ-charm physics [5]. In this talk, we present recent results from the study of these light scalars at BES II and BES III.

2. Study of charged κ at BES II

The σ and κ were first found in the analysis of $\pi\pi$ and πK scattering data, and they can not be filled into any nonets of ordinary $q\bar{q}$ meson. Evidences for the neutral κ have been reported by E791[6] and FOCUS[7] experiment. In 2006, BESII reported the neutral κ in the decay of $J/\psi \to \bar{K}^{\star}(892)^0 K^+\pi^-$[8]. 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 BES II [9].

Fig. 1 shows the projected invariant mass of $K^{*\pm}\pi^0$ of the selected $J/\psi \to K^*(892)^+\kappa^- \to K_S^0\pi^+K^-\pi^0$ events. Besides strong contributions from $K^*(892)^{\pm}$, $K^*(1410)^{\pm}$ and $K^*(1430)^{\pm}$, a significant $J^P = 0^+$ low mass component is needed to describe the data. The partial wave analysis yields the pole position of that 0^+ component displayed in dark color $m - i\frac{\Gamma}{2} = (849 \pm 1^{+14}_{-28}) - i(288 \pm 01^{+64}_{-30})$ MeV/c^2.

This result is in agreement with a recent CLEO analysis of the resonance structure in $D^0 \to K^+K^-\pi^0$ decays [10], which suggests a $\kappa^{\pm}$ component with parameters $m = (855 \pm 15)$ MeV/c^2 and $\Gamma = (251 \pm 48)$ MeV/c^2. Moreover the results are in reasonable agreement with the properties of the neutral κ^0.

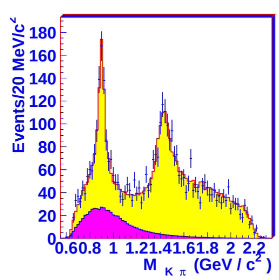

Figure 1: Invariant mass $m(K^+\pi^0) + c.c.$ from $J/\psi \to K^*(892)^+\kappa^- \to K_S^0\pi^+K^-\pi^0$ decays reconstructed by BES II. The crosses represent data and the histogram is the fit result from a partial wave analysis.

3. Study of $a_0(980)$-$f_0(980)$ mixing at BES III

The mixing between $a_0^0(980)$ and $f_0(980)$ is expected to shed light on the nature of these two resonances [11, 16, 12, 13, 14, 15, 17, 18]. The $a_0^0(980) - f_0(980)$ mixing intensity has been predicted to be with a larger uncertainty by various theoretical models. No firm experimental result was available [17, 18]. The leading contribution to the isospin-violating mixing transition amplitudes for $f_0(980) \to a_0^0(980)$ and $a_0^0(980) \to f_0(980)$ is shown to be dominated by the difference of the unitarity cut which arises from the mass difference between the charged and neutral kaons. As a consequence, a narrow peak of about 8 MeV$/c^2$ is predicted between the charged and neutral kaon thresholds [16, 17, 18]. Using the samples of 226 million J/ψ events and 106 million ψ' events collected with the BES III detector in 2009, we perform direct measurements of $a_0^0(980) - f_0(980)$ mixing via the processes $J/\psi \to \phi f_0(980) \to \phi a_0^0(980) \to \phi\eta\pi^0$ and $\chi_{c1} \to \pi^0 a_0^0(980) \to \pi^0 f_0(980) \to \pi^0\pi^+\pi^-$.

Figure 2 (a) shows the fitting results of the mass spectrum of $\eta\pi^0$ recoiling against ϕ signal in $J/\psi \to \phi f_0(980) \to \phi a_0^0(980) \to \phi\eta\pi^0$. The dots with error bars are data. There is an evidence for a narrow peak over the background in the expected resonance region. The dotted line is signal. The dash-dotted line is $a_0(980)$ contribution from other virtual photons and K^*K loops. The dashed line is polynomial background. The shape is constrained to the ϕ sideband. The fit yields $N(f_0 \to a_0^0) = 24.7 \pm 8.6$ (stat.) of $f_0(980)$ to $a_0(980)$ mixing signals with a significance of 3.3 σ. The upper limit on the mixing branching ratio is determined to be $Br(J/\psi \to \phi f_0(980) \to \phi a_0^0(980) \to \phi\eta\pi^0) < 5.5 \times 10^{-6}$ at the 90% confidence level (C.L.).

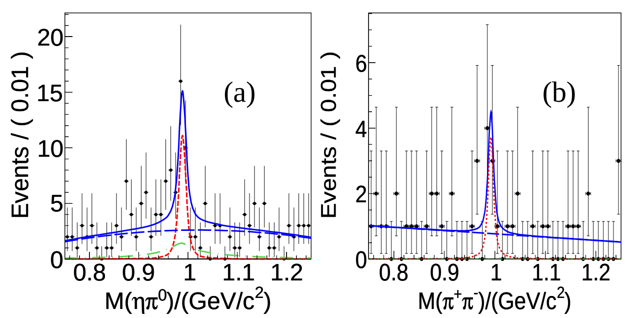

Figure 2: (a) Fitting result of the $\eta\pi^0$ mass spectrum recoiling against the ϕ signal. (b) Fitting result of the $\pi^+\pi^-$ mass spectrum in the χ_{c1} mass window. The dotted lines show the mixing signal. The dash-dotted lines indicate underlying $a_0^0(980)$ of $f_0(980)$ from other processes. The dashed lines denote the polynomial background.

Figure 2 (b) shows the fitting results of $\pi^+\pi^-$ invariant mass spectrum in $\chi_{c1} \to \pi^0 a_0^0(980) \to \pi^0 f_0(980) \to \pi^0\pi^+\pi^-$. The fit to the signal region is performed in a similar style as in the previous $J/\psi \to \phi a_0(980)$ analysis. The fit yields $N(a_0^0 \to f_0) = 6.5 \pm 3.2$ (stat.) events for the mixing signal with a significance of 2.0 σ. The upper limit on the mixing branching ratio is determined to be $Br(\psi' \to \gamma\chi_{c1} \to \gamma\pi^0 a_0^0(980) \to \gamma\pi^0 f_0(980) \to \gamma\pi^0\pi^+\pi^-) < 5.5 \times 10^{-7}$ at the 90% C.L.

The upper limit of the mixing intensity ξ_{fa} for the $f_0(980) \to a_0^0(980)$ transition at 90% C.L. is calculated to be:

$$\xi_{fa} = \frac{Br(J/\psi \to \phi f_0(980) \to \phi a_0^0(980) \to \phi\eta\pi^0)}{Br(J/\psi \to \phi f_0(980) \to \phi\pi\pi)\ [19]} < 1.1\%.$$

The upper limit of the mixing intensity ξ_{af} for the $a_0^0(980) \to f_0(980)$ transition at 90% C.L.

is calculated to be:

$$\xi_{af} = \frac{Br(\chi_{c1} \to \pi^0 a_0^0(980) \to \pi^0 f_0(980) \to \pi^0\pi^+\pi^-)}{Br(\chi_{c1} \to \pi^0 a_0^0(980) \to \pi^0\pi^0\eta)\ [20]} < 0.9\%.$$

The measurements of $f_0(980) \to a_0^0(980)$ and $a_0^0(980) \to f_0(980)$ mixing transitions will be very helpful to probe the properties of these two scalar states.

4. Summary

The charged κ is observed at BESII in $J/\psi \to K^\pm K_S \pi^\mp \pi^0$. Partial wave analysis on it gives the consistent parameters with neutral κ. A new facility for physics in the charm-τ region BEPC II/BES III has become operational. With the world's largest samples of J/ψ and ψ' collected at BES III, the direct measurement of a_0 and f_0 mixing is performed for the first time.

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