$\psi(2S) \to K\bar{K}\pi$

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Abstract

$\psi(2S) \to K\bar{K}\pi \to K^0K^{\pm}\pi^{\mp} \to \pi^+\pi^-K^{\pm}\pi^{\mp}$ is studied and the following results are got (upper limits on 90% confidence level):

$$B(\psi(2S) \to K\bar{K}\pi) = (1.20 \pm 0.30 \pm 0.25) \times 10^{-4}$$
$$B(\psi(2S) \to K^0\bar{K}^*(892)^0 + c.c.) = (8.4 \pm 2.4 \pm 1.6) \times 10^{-5}$$
$$B(\psi(2S) \to K^+\bar{K}^*(892)^- + c.c.) < 3.2 \times 10^{-5}$$

The difference of the branching fractions between the charged and the neutral modes decay of $\psi(2S) \to K\bar{K}^*(892) + c.c.)$ is interpreted as the effect of the suppression of the strong decay of $\psi(2S)$ compared with that of J/ψ.

CONTENTS:

1 Introduction

- Experiments[1] show that the Vector-pseudoscalar mode of $\psi(2S)$ decay is suppressed compared with J/ψ decay, besides $\psi(2S) \to \rho\pi$, $\psi(2S) \to K^+\bar{K}^*(892)^- + c.c.$ was studied in detail with $K^+K^-\pi^0$ final state. $\psi(2S) \to K^0K^\pm\pi^\mp$ final state can also be used to study this channel, as a check to the results listed in PDG[1].

- SU(3) symmetry predicts $\psi(2S) \to K^0\bar{K}^*(892)^0 + c.c. = \psi(2S) \to K^+\bar{K}^*(892)^- + c.c.$, so we expect the same suppression in the neutral channel, which was not studied before.

- $\psi(2S) \to K\bar{K}^*(892) + c.c$ is part of $\psi(2S) \to K\bar{K}\pi$. One may wonder whether the suppression of $\psi(2S) \to VP$ is caused by the more general dynametics. PDG[1] lists $B(\psi(2S) \to K^+K^-\pi^0) < 2.96 \times 10^{-5}$ which leads to an upper limit of $B(\psi(2S) \to K\bar{K}\pi) < 1.78 \times 10^{-4}$. With $\psi(2S) \to K^0K^\pm\pi^\mp$ final state study, we can see whether this suppression is real.

- The analysis described here is based on 3.5 million produced $\psi(2S)$ taken by BES (BEijing Spectrometer)[2] at BEPC (Beijing Electron Positron Collider)[2] in 1993/94 and 1995 running.

2 K^0 finding and general selection criteria

Of every two charged tracks with net charge zero and effective mass lies between $M_{K^0} - 0.100$ and $M_{K^0} + 0.100$ when they are assumed to be π, the combination with mass most near K^0 nominal energy is considered to be K_s candidate. K_s vertex is got by crossing these two tracks and the primary vertex is estimated with the cross point of another two charged tracks assuming one of them is kaon and another pion. Two parameters are defined to identify the K_s: the distance between primary vertex and secondary vertex in $R - \phi$ plain L_{xy} and the angle between the K_s momentum and its vertex direction CSKS which is expected to be very near zero for a real K_s event.

The following criteria are used for all the decay modes:

1. The number of charged tracks is required to be four with net charge zero and each track with high quality in track fitting;
2. Transverse momentum of each track $P_{xy} > 0.10GeV/c$ to remove the possible circling track in Main Drift Chamber(MDC).
3. $|\cos\theta| < 0.8$
   where θ is the polar angle relatives to the beam axis, $|\cos\theta_\pi| = 0.8$ corresponds to the coverage of the seventh MDC layer;
4. Total momentum of each two different charged tracks is required to be greater than $0.6GeV/c$ to remove all $\psi(2S) \to \pi^+\pi^- J/\psi$ events.
5. K_s candidate mass lies in a three standard deviations region around K_s nominal mass, where the mass resolution of different channel is fitted out from Monte Carlo simulation and is different.
6. $CSKS < 10^0$!
7. The probability of 4C-fit to $\psi(2S) \to \pi^+\pi^+ K^\pm\pi^\mp$ is required to be $P_{\chi^2} > 0.01$.

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$\psi(2S) \to K\bar{K}\pi \to K^0K^\pm\pi^\mp \to \pi^+\pi^- K^\pm\pi^\mp$ is tagged with the following criteria besides those listed in section 2.

1. $P_{K^\pm} + P_{\pi^\mp} > 1.60GeV/c$;
2. $L_{xy} > 1cm$;
3. TOF and dE/dx information is used for particle identification of the kaon and pion from $\psi(2S)$ directly. The probability of π candidate to be identified as π and kaon candidate as kaon is required to be greater than 1%. $K_sK^+\pi^-$ and $K_sK^-\pi^+$ is separated by comparing total probability of partical ID to $K^\pm\pi^\mp$ and kinematics fit.

19.4$\pm$4.9 events pass these criteria and fitted out from K_s mass spectrum. For detection efficiency determination, a generator considering the phase space of $\psi(2S) \to K^0 K^{\pm}\pi^{\mp} \to \pi^+\pi^- K^{\pm}\pi^{\mp}$, and the contribution of $\psi(2S) \to K^0 \bar{K}^*(892)^0 + c.c.$ is taken into account. One get

$$\epsilon = 13.8\%$$

so the branching fraction of $\psi(2S) \to K\bar{K}\pi$ is estimated:

$$\begin{aligned} B(\psi(2S) \to K\bar{K}\pi) &= \frac{n^{obs}/\epsilon}{\frac{1}{3}N_{\psi(2S)}} \\ &= (1.20 \pm 0.30 \pm 0.25) \times 10^{-4} \end{aligned}$$

4 $\psi(2S) \to K^0\bar{K}^*(892)^0 + c.c.$

14 ± 4 events in the $\psi(2S) \to K\bar{K}\pi$ sample satisfy an additional condition $P_{K_{s\pi^+}} + P_{K_{s\pi^-}} > 1.60 GeV/c$, and the invariant mass of kaon and pion lies in the $K^*(892)^0$ region. Monte Carlo shows the acceptance for $\psi(2S) \to K^0\bar{K}^*(892)^0 + c.c. \to K^0 K^- \pi^+ + c.c$ is

$$\epsilon = 14.4\%$$

so the branching fraction of $\psi(2S) \to K^0\bar{K}^*(892)^0 + c.c.$ is estimated:

$$\begin{aligned} B(\psi(2S) \to K^0\bar{K}^*(892)^0 + c.c.) &= \frac{n^{obs}/\epsilon}{\frac{1}{3}N_{\psi(2S)}} \\ &= (8.4 \pm 2.4 \pm 1.6) \times 10^{-5} \end{aligned}$$

5 $\psi(2S) \to K^+\bar{K}^*(892)^- + c.c.$

Besides those criteria listed in section 2, after a requirement of the momentum of kaon greater than 1.6 GeV/c, one event was found in the vicinity of $K^*(892)^{\pm}$ for $\psi(2S) \to K^+\bar{K}^*(892)^- + c.c. \to K^+\bar{K}^0\pi^- + c.c \to K^+\pi^+\pi^-\pi^- + c.c$.

Monte Carlo shows the detection efficiency of $\psi(2S) \to K^+\bar{K}^*(892)^- + c.c. \to K^+\bar{K}^0\pi^- + c.c$ is

$$\epsilon = 10.6\%$$

so the 90% CL upper limit of the branching fraction of $\psi(2S) \to K^+\bar{K}^*(892)^- + c.c.$ is estimated:

$$\begin{aligned} B(\psi(2S) \to K^+\bar{K}^*(892)^- + c.c.) &< \frac{3.89/\epsilon}{\frac{1}{3}N_{\psi(2S)}} \\ &= 3.2 \times 10^{-5} \end{aligned}$$

6 Conclusion and Discussion

$\psi(2S) \to K\bar{K}\pi \to K^0K^\pm\pi^\mp \to \pi^+\pi^-K^\pm\pi^\mp$ is studied and the branching fractions of three $\psi(2S)$ decay channels were given below(upper limit on 90% confidence level):

$$B(\psi(2S) \to K\bar{K}\pi) = (1.20 \pm 0.30 \pm 0.25) \times 10^{-4}$$
$$B(\psi(2S) \to K^0\bar{K}^*(892)^0 + c.c.) = (8.4 \pm 2.4 \pm 1.6) \times 10^{-5}$$
$$B(\psi(2S) \to K^+\bar{K}^*(892)^- + c.c.) < 3.2 \times 10^{-5}$$

The first error quoted is statistical error, and the second one systematic which is estimated from varying selection criteria and from the uncertainty of $\psi(2S)$ number.

Conclusion:

- Both $K^0\bar{K}^*(892)^0 + c.c.$ and $K^+\bar{K}^*(892)^- + c.c.$ decay channels of $\psi(2S)$ are suppressed compared with J/ψ decays.
- $\psi(2S) \to K\bar{K}\pi$ is suppressed too.
- The difference between the branching fractions of $\psi(2S) \to K^0\bar{K}^*(892)^0 + c.c.$ and the branching fractions of $\psi(2S) \to K^+\bar{K}^*(892)^- + c.c.$ is due to the different electromagnetic interaction of the two channels, charged and neutral K and $K^*(892)$ have different quark constitution.

References

[1] Particle Data Group, Phys.Rev. **D50** part I (1994)

[2] J.Z. Bai et al., (BES Collab.), Nucl. Inst. Meth. **A344** (1994) 319