

Observation of $\psi(3686) \rightarrow e^+ e^- \chi_{cJ}$ and $\chi_{cJ} \rightarrow$
 $e^+ e^- J/\psi$

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Motivation

- The study of electromagnetic Dalitz decays, in which a virtual photon is internally converted into an e^+e^- pair, plays an important role in revealing the structure of hadrons and the interactions between photons and hadrons.
- Recently the BESIII experiment confirms that the contributions from the higher-order multipole amplitudes in $\psi(3686) \rightarrow \gamma\chi_{cJ}$ are small, the E1 contribution is dominant. Therefore, it is of great interest to measure the EM transition $\psi(3686) \rightarrow e^+e^-\chi_{cJ}$ and $\chi_{cJ} \rightarrow e^+e^-J/\psi$.

Reconstruction

In this Letter, we report the observation of the EM Dalitz decays $\psi(3686) \rightarrow e^+e^-\chi_{cJ}$ and $\chi_{cJ} \rightarrow e^+e^-J/\psi$ by analyzing the cascade decays $\psi(3686) \rightarrow e^+e^-\chi_{cJ}$, $\chi_{cJ} \rightarrow \gamma J/\psi$ and $\psi(3686) \rightarrow \gamma\chi_{cJ}$, $\chi_{cJ} \rightarrow e^+e^-J/\psi$, respectively.

Candidate events are required to have four charged tracks, with a sum of charges equal to zero, and at least one photon

$$\begin{array}{lcl} \psi(3686) \rightarrow & \chi_{cJ} & e^+e^- \\ & \downarrow & \\ & J/\varphi & \Upsilon \\ & \downarrow & \\ & e^+e^- \text{ or } \mu^+\mu^- & \end{array}$$

$$\begin{array}{lcl} \psi(3686) \rightarrow & \chi_{cJ} & \Upsilon \\ & \downarrow & \\ & J/\varphi & e^+e^- \\ & \downarrow & \\ & e^+e^- \text{ or } \mu^+\mu^- & \end{array}$$

Fit

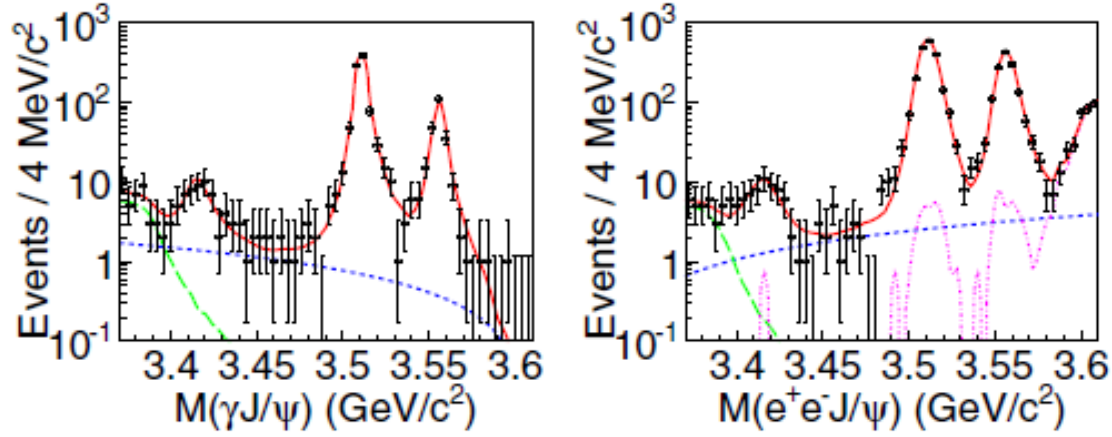


FIG. 2. Data (points with error bars) distributions of (left) $M(\gamma J/\psi)$ and (right) $M(e^+e^-J/\psi)$. The red solid curve is the overall fit result, the green long-dashed curve is for the background (left) $\psi(3686) \rightarrow \gamma\chi_{c0}$, $\chi_{c0} \rightarrow e^+e^-J/\psi$ and (right) $\psi(3686) \rightarrow e^+e^-\chi_{c0}$, $\chi_{c0} \rightarrow \gamma J/\psi$, the blue dashed curve is for QED background, and the pink dashed-dotted curve in right plot is for the backgrounds from $\psi(3686)$ decays.

Fig. 2. Clear χ_{cJ} signals are observed in the $M(\gamma J/\psi)$ and $M(e^+e^-J/\psi)$ distributions, corresponding to the decays $\psi(3686) \rightarrow e^+e^-\chi_{cJ}$ and $\chi_{cJ} \rightarrow e^+e^-J/\psi$, respectively.

We use the signal MC-determined shape, convoluted with a common Gaussian function, to describe the shape of χ_{cJ} signals.

Results

TABLE I. Signal yields, detection efficiencies, the branching fractions, and the ratios of the branching fractions. Here, the first uncertainty is statistical and the second systematic.

Mode	Yields	Efficiency(%)	Branching fraction	$\mathcal{B}(\psi(3686) \rightarrow e^+ e^- \chi_{cJ}) / \mathcal{B}(\psi(3686) \rightarrow \gamma \chi_{cJ})$	$\mathcal{B}(\chi_{cJ} \rightarrow e^+ e^- J/\psi) / \mathcal{B}(\chi_{cJ} \rightarrow \gamma J/\psi)$
$\psi(3686) \rightarrow e^+ e^- \chi_{c0}$	48 ± 10	6.06	$(11.7 \pm 2.5 \pm 1.0) \times 10^{-4}$	$(9.4 \pm 1.9 \pm 0.6) \times 10^{-3}$...
$\psi(3686) \rightarrow e^+ e^- \chi_{c1}$	873 ± 30	5.61	$(8.6 \pm 0.3 \pm 0.6) \times 10^{-4}$	$(8.3 \pm 0.3 \pm 0.4) \times 10^{-3}$...
$\psi(3686) \rightarrow e^+ e^- \chi_{c2}$	227 ± 16	3.19	$(6.9 \pm 0.5 \pm 0.6) \times 10^{-4}$	$(6.6 \pm 0.5 \pm 0.4) \times 10^{-3}$...
$\chi_{c0} \rightarrow e^+ e^- J/\psi$	56 ± 11	6.95	$(1.51 \pm 0.30 \pm 0.13) \times 10^{-4}$...	$(9.5 \pm 1.9 \pm 0.7) \times 10^{-3}$
$\chi_{c1} \rightarrow e^+ e^- J/\psi$	1969 ± 46	10.35	$(3.73 \pm 0.09 \pm 0.25) \times 10^{-3}$...	$(10.1 \pm 0.3 \pm 0.5) \times 10^{-3}$
$\chi_{c2} \rightarrow e^+ e^- J/\psi$	1354 ± 39	11.23	$(2.48 \pm 0.08 \pm 0.16) \times 10^{-3}$...	$(11.3 \pm 0.4 \pm 0.5) \times 10^{-3}$

Summary

We search for the decays $\psi(3686) \rightarrow e^+e^-\chi_{cJ}$ and $\chi_{cJ} \rightarrow e^+e^-J/\psi$, where $J = 0,1,2$.
The decays $\psi(3686) \rightarrow e^+e^-\chi_{cJ}$ and $\chi_{cJ} \rightarrow e^+e^-J/\psi$ are observed for the first time.