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Search for the rare decays $J/\psi \to D_s^- e^+ \nu_e$, $J/\psi \to D^- e^+ \nu_e$, and $J/\psi \to \overline{D^0} e^+ e^-$

BES Collaboration

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Abstract

We report on a search for the decays $J/\psi \to D_s^- e^+ \nu_e + \text{c.c.}$, $J/\psi \to D^- e^+ \nu_e + \text{c.c.}$, and $J/\psi \to \overline{D^0} e^+ e^- + \text{c.c.}$ in a sample of 5.8×10^7 J/ψ events collected with the BESII detector at the BEPC. No excess of signal above background is observed, and 90% confidence level upper limits on the branching fractions are set: $B(J/\psi \to D_s^- e^+ \nu_e + \text{c.c.}) < 4.9 \times 10^{-5}$, $B(J/\psi \to D^- e^+ \nu_e + \text{c.c.}) < 1.2 \times 10^{-5}$, and $B(J/\psi \to \overline{D^0} e^+ e^- + \text{c.c.}) < 1.1 \times 10^{-5}$.

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1. Introduction

Hadronic, electromagnetic, and radiative decays of the J/ψ have been widely studied. However there have been few searches for rare weak J/ψ decay processes. Kinematically, the J/ψ cannot decay to a pair of charmed D mesons, but can decay to a single D meson. Searches for weak decays of J/ψ to single D or D_s mesons provide tests of standard model (SM) theory and serve as a probe of new physics [1], such as TopColor model, the minimal supersymmetric standard model with or without R-parity, and the two Higgs doublet model [2].

The branching fractions of J/ψ decays to single D or D_s mesons are predicted to be about 10^{-8} or smaller [3] in the SM. The flavor changing neutral current (FCNC) process $c \to u$ occurs in the standard model only at the loop level where it is suppressed by the GIM mechanism. Fig. 1 shows the dominant Feynman diagrams within the standard model for the decays $J/\psi \to D_s^- e^+ \nu_e$, $J/\psi \to D^- e^+ \nu_e$, and $J/\psi \to \overline{D^0} e^+ e^-$. No decay of this type has been observed so far. In this Letter, we perform a search for the decays $J/\psi \to D_s^- e^+ \nu_e$, $J/\psi \to D^- e^+ \nu_e$, and $J/\psi \to \overline{D^0} e^+ e^-$ in a sample of 5.8×10^7 J/ψ events collected with the Beijing Spectrometer (BESII) [4] detector at the Beijing Electron–Positron Collider (BEPC) [5]. Throughout this Letter the charge conjugate states are implicitly included.

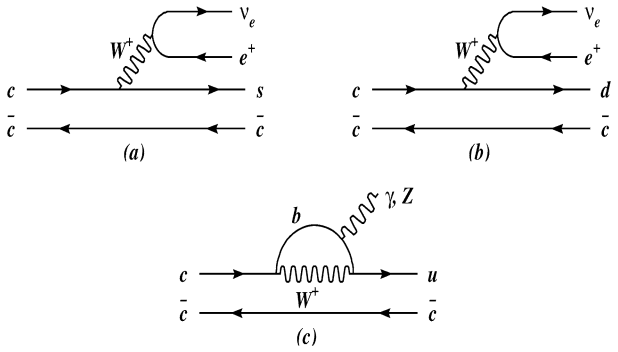

Fig. 1. Typical Feynman diagrams for (a) $J/\psi \to D_s^- e^+ \nu_e$, (b) $J/\psi \to r D^- e^+ \nu_e$, and (c) $J/\psi \to \overline{D^0} e^+ e^-$.

2. BESII detector

BES is a conventional solenoidal magnetic detector that is described in detail in Ref. [6]. BESII is the upgraded version of the BES detector [4]. A 12-layer vertex chamber (VC) surrounds the beryllium beam pipe and provides track and trigger information. A forty-layer main drift chamber (MDC) located just outside the VC provides measurements of charged particle trajectories over 85% of the total solid angle; it also provides ionization energy loss (dE/dx) measurements which are used for particle identification (PID). A momentum resolution of $1.78\%\sqrt{1+p^2}$ (p in GeV/c) and a dE/dx resolution for Bhabha electrons of $\sim 8\%$ are obtained. An array of 48 scintillation counters surrounding the MDC measures the time of flight (TOF) of charged particles with a resolution of about 200 ps for hadrons. Outside the TOF counters, a 12 radiation length, lead-gas barrel shower counter (BSC), operating in self quenching streamer mode, measures the energies and positions of electrons and photons over 80% of the total solid angle with resolutions of $\sigma_E/E = 0.21/\sqrt{E}$ (E in GeV), $\sigma_\phi = 7.9$ mrad,

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