Radiative decay of $J/\psi$ into $\gamma \pi^+ \pi^-$
DM2 Collaboration

Laboratoire de l’Accélérateur Linéaire, Université de Paris-Sud, F-91405 Orsay, France

Z. Ajaltouni, A. Falvard, J. Jousset, B. Michel, J.C. Montret
Laboratoire de Physique Corpusculaire, Université de Clermont II, BP 45, F-63170 Aubière, France

R. Baldini, S. Calcaterra, G. Capon
Laboratori Nazionali di Frascati dell’INFN, CP 13, I-00044 Frascati, Italy

D. Bisello, G. Busetto, S. Limentani, M. Nigro, L. Pescara, M. Posocco, P. Sartori, L. Stanco
Dipartimento di Fisica dell’Università di Padova, e INFN, Sezione di Padova, I-35131 Padua, Italy

Received 14 July 1987

Abstract. The radiative decay $J/\psi \rightarrow \gamma \pi^+ \pi^-$ has been studied using the 8.6 million $J/\psi$ produced in the DM2 experiment at the DCF e$^+e^-$ storage rings at Orsay. The $\pi^+\pi^-$ mass spectrum shows a clean $f_2(1270)$ signal, and the possible presence of two other states at the $f_2(1720)$ and $f_4(2030)$ masses. For the $f_2(1270)$, the branching ratio $BR(J/\psi \rightarrow \gamma f) \times BR(f \rightarrow \pi^+\pi^-)$ is measured to be $(7.50 \pm 0.30 \pm 0.12) \times 10^{-4}$, and the spin analysis prefers the $J=2$ assignment, with helicity parameters $x=0.83 \pm 0.06$ and $y=0.01 \pm 0.06$. The existence of higher mass states is discussed.

Introduction

The $f_2(1270)$, which is produced with a very large rate in radiative $J/\psi$ decays, has been observed in its decay into $\pi\pi$ by the PLUTO [1], CRYSTAL BALL [2], MARK II [3] and MARK III [4] experiments. Some QCD calculations predict [5], in the spin 2 hypothesis, a large contribution of the helicity 1 and 2 amplitudes, relatively to the helicity 0. Experiments [2] and [4] contradict this prediction by excluding the presence of helicity 2.

Radiative $J/\psi$ decays are expected also to copiously produce gluonium states [6]; the $f_2(1720)$ is a glueball candidate: observed in its decay into $KK$ by the collaborations [3], [4] and [7] with a branching ratio of about $10^{-3}$, its spin analysis shows, as compared to the $f_2(1525)$ in the same $KK$ decay mode and the $f_2(1270)$ in the $\pi\pi$ decay mode, a very different behavior, with comparable helicity 0, 1 and 2 contributions. First observed decaying into $\eta\eta$ by experiment [2] with $BR \approx 2 \times 10^{-4}$, the $f_2(1720)$, if it has a glueball component, should also decay into $\pi\pi$ with a significant rate due to the flavour-independent coupling of the glue to the quarks [8]; experiments [2] and [4] have measured the corresponding branching ratio but the presence of a large background and possible interference effects reduce the significance of the signals and exclude the possibility of a spin analysis.

The DM2 collaboration has achieved an accurate measurement of the production branching ratio of the $f_2(1270)$ in its decay into $\pi^+\pi^-$, and a precise determination of the spin and helicity parameters of this particle; for the $f_2(1720)$ the branching ratio is measured, with the same limitations than experiment [4]. The high statistics DM2 results fully agree with previous ones.
Experimental set-up

The DM2 detector shown on Fig. 1 and described in detail elsewhere [9] is a large solid angle magnetic spectrometer: a 2 m diameter and 3 m long solenoid with a 1 $X_0$ aluminium coil produces a 5 kG magnetic field. Inside, 2 proportional and 13 drift chambers allow the detection of charged particles over a solid angle of $0.87 \times 4\pi$ sr, with a momentum resolution of 3.5% at 1000 MeV/c. A set of 2 cm thick 36 scintillators provides a time-of-flight measurement with a total resolution of 540 ps, including 440 ps from the beam spread, allowing a $3 \sigma \pi/K$ separation up to 450 MeV/c. Outside the coil, a photon detector divided into 8 octants of 14 planes of streamer tubes, sandwiched with $5X_0$ lead and scintillator planes, covers a solid angle of $0.7 \times 4\pi$ sr, with a detection efficiency greater than 96% above 110 MeV; the spatial resolution for the photon is 10 mrad in azimuth and 7 mrad in polar angle. Two end-cap photon detectors, consisting of wire plane chambers interleaved with $5X_0$ lead allow the rejection of events with an extra-photon emitted over a solid angle of $0.12 \times 4\pi$ sr.

Event selection

After geometrical reconstruction, 88000 events with two oppositely charged tracks and one photon remain.

A first set of kinematical cuts is applied, on the total energy $E$ of the final state under $\gamma\pi^+\pi^-$ assumption ($2900 < E < 3300$ MeV), and on the missing mass $M$ of the $\pi^+\pi^-$ system ($\Delta M^2 < 5 \times 10^3 (\text{MeV/c})^2$).

Radiative Bhabhas (and also $\gamma\gamma$ events) are mainly discarded by imposing that the angle $\delta_i$ ($i = 1, 2$) be-

![Fig. 1. Axial and transverse views of the DM2 detector](image)

![Fig. 2a, b. $\pi^+\pi^-$ mass distribution for experimental events a, and for simulated events ($J/\psi \rightarrow \rho \pi$ and $\gamma(p^+)K^+K^-$ b](image)