Study of the ω meson in the VÉPP-2M storage ring

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The reaction $e^+e^-\to\pi^+\pi^-\pi^0$ has been studied at c.m. energies from 760 to 800 MeV in the VÉPP-2M storage ring. The following parameters were found for the ω resonance: $M_\omega = 782.2 \pm 0.4$ MeV, $\Gamma_\omega = 9.8 \pm 0.9$ MeV, $\sigma_{\max}(\omega\to\pi^+\pi^-\pi^0) = 1.39 \pm 0.10\,\mu$b, and $\Gamma(\omega\to e^+e^-) = 0.63 \pm 0.05$ keV.

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The only previous study of the reaction $e^+e^-\to\pi^+\pi^-\pi^0$ in colliding electron-positron beams in the ω-meson region was carried out at the Orsay storage ring.[1-3] (A. C. O.) The results found by Benaksas *et al.*[2] agree satisfactorily with those found by Cordier *et al.*,[3] although the ω mass found in Ref. 3 differs from the tabulated value by two standard deviations. In this letter we report a study of the reaction $e^+e^-\to\pi^+\pi^-\pi^0$ with the help of the OLYa detector in the VÉPP-2M storage ring.

The detector, which has been described in detail elsewhere,[5] consists of four identical quadrants which surround the beam collision region. The useful solid angle of this detector is $0.64\times 4\pi$ sr. Each quadrant contains scintillation counters, which used to trigger the detector; coordinate chambers for determining the geometric characteristics of the charged particles; a shower detector consisting of a scintillation sandwich and shower chambers; and range chambers. The detector is triggered by two charged particles in opposite quadrants or by two charged particles in adjacent quadrants accompanied by operation of the sandwich in the quadrants without charged particles.

In this paper we are using data from the interval of beam energies from 760 to 800 MeV in the c. m. frame, part of the experimental information acquired in a scan of the entire energy range accessible to the VÉPP-2M. The ω-meson region was scanned at steps of 0.5 MeV. The luminosity taken at each point was about 1 nb^{-1}. The total luminosity integral in this energy interval is 70 nb^{-1}.

The $e^+e^-\to\pi^+\pi^-\pi^0$ events were distinguished by two charged particles in the coordinate chambers and one or two γ rays (from π^0 decay) in the scintillation sandwich. The events had to satisfy the following criteria: a) The two tracks must emerge from a common point in the beam interaction volume. b) The azimuthal angle of the deviation from collinearity, $\Delta\phi$, must exceed 6° in absolute value. c) The amplitude in the sandwich of at least one quadrant without charged particles must exceed 0.75 of the amplitude of the minimum-ionization particle in the sandwich.

The events selected were divided into two groups on the basis of the type of trigger: events with tracks in opposite quadrants and events with tracks in adjacent quadrants. To reduce the background for the events of the first of these groups, we imposed the further requirement that the shower chamber must detect a γ ray from π^0

decay. We found 723 such events. For the events of the second group, the presence of a signal in the sandwich proved sufficient; there were 765 such events.

The luminosity taken at each point along the energy scale was determined from the number of large-angle e^+e^- elastic-scattering events. The Monte Carlo method[6] was used to simulate the reaction $e^+e^-\to\pi^+\pi^-\pi^0$ to find the detection efficiency. This simulation incorporated the kinematics of the process, the interaction of the final particles with the detector material, and the emission of photons by the initial particles (radiative corrections). Over the energy range under consideration, the efficiency of the $\pi^+\pi^-\pi^0$ detection was $4.3 \pm 0.2\%$, independent of the energy, for these event-selection criteria. The accuracy with which the efficiency is calculated is determined primarily by the systematic error resulting from the uncertainty in our understanding of the nuclear interaction of π mesons with the detector material. The absolute beam energy was found by a conversion of the energy scale from the region of the Φ meson, where an absolute energy calibration had been carried out previously by the method of resonant beam depolarization.[7,8] In these calculations we used the results of magnetic measurements and experimental data on the long-term stability of the absolute energy.

The amplitude for the reaction $e^+e^-\to\pi^+\pi^-\pi^0$ was approximated by the Breit-Wigner resonance formula with radiative corrections in the double logarithmic approximation.[9,10] In the energy interval studied the ω-ϕ interference is negligible, and we ignored it. The adjustable parameters for this optimization were the mass and width of the ω resonance, the cross section at the maximum, $\sigma_{\max}(\omega\to\pi^+\pi^-\pi^0)$, and the uniform background level. The two groups of events were analyzed independently to determine the parameters of the ω meson; the results turned out to be statistically consistent. A final analysis was carried out on the basis of all events. The maximum-likelihood method yields the following parameters for the ω meson:

$$M_\omega = 782.2 \pm 0.4\ \text{MeV},$$
$$\Gamma_\omega = 9.8 \pm 0.9\ \text{MeV},$$
$$\sigma_{max}(\omega \to \pi^+\pi^-\pi^0) = 1.39 \pm 0.10\ \mu\text{b}\ .$$

Using

$$\Gamma(\omega \to e^+e^-) = 4\pi\alpha^2 M_\omega/(3g_\omega^2)$$

$$\sigma_{max}(e^+e^- \to \pi^+\pi^-\pi^0) = \frac{12\pi}{M_\omega^2}\,\frac{\Gamma(\omega \to e^+e^-)\Gamma(\omega \to \pi^+\pi^-\pi^0)}{\Gamma_\omega^2}$$

we find

$$B(\omega \to e^+e^-) = (6.4 \pm 0.4)\times 10^{-5},$$
$$\Gamma(\omega \to e^+e^-) = 0.63 \pm 0.05\ \text{keV},$$
$$g_\omega/(4\pi) = 22.2 \pm 1.7.$$

Figure 1 shows the experimental cross sections for the reaction $e^+e^-\to\pi^+\pi^-\pi^0$ and an approximating theoretical curve. The agreement between experiment and cal-

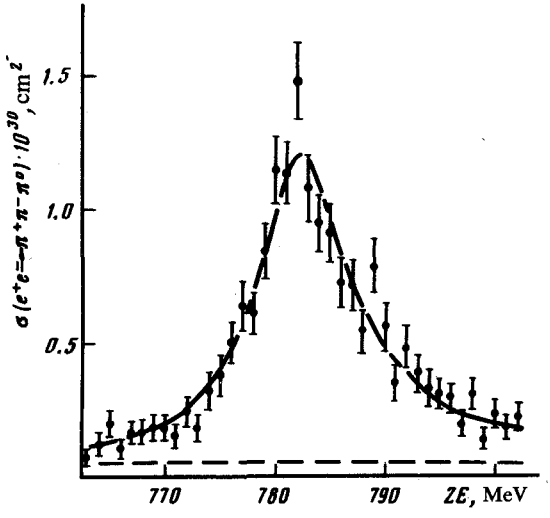

FIG. 1. Experimental cross sections for the reaction $e^+e^-\to\pi^+\pi^-\pi^0$. Solid curve—theoretical; dashed line—nonresonance background.

culation is, according to the $P(\chi^2)$ test, 14%. The parameters found for the ω meson agree with the tabulated values.[4]

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