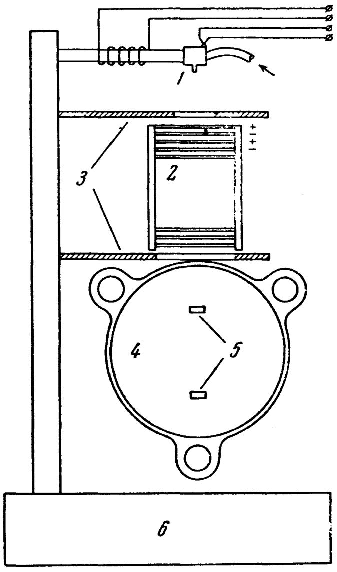

FIG. 1. Diagram of the working apparatus. One half of the separator and one of the disks of the resonator are removed. 1—source of the beam, with a thermocouple for regulating the cooling, 2—the state separator, which gives a flat, wide beam of active molecules, 3—the cold diaphragms, 4—the Fabry-Perot resonator, 5—the coupling holes, 6—dewar with liquid nitrogen.

which was an assembly of electrodes arranged perpendicular to the beam direction, charged alternately. The beam of molecules was directed into the gap between the plates. The separating system carried a voltage up to 15 kV. This system gave more than twice the number of active molecules than the usual quadrupolar system. Cold diaphragms with slits in them were located on both sides of the separator. A single beam source was used with a diameter of 0.6 mm. In order to increase the intensity of the line, the source was cooled to approximately −70°C, as recommended in [3] and also done previously in [2]. Contrary to the results in [4] a normal increase in the amplification factor to about 30 was observed before the establishment of oscillations. The spectral line in the resonator was observed to be a singlet with a width of the order of 15 kcs, as in the case of an ordinary resonator in the E_{010} mode. Unlike [5], the generation proceeded at one frequency. The signal-to-noise ratio during generation was not less than 20.

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[1]Resonators of this type for millimeter and submillimeter regions were suggested by A. M. Prokhorov.[6]

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SEARCH FOR THE DECAY $\omega \to e^+ + e^-$

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In theoretical papers, Zhizhin and Solov'ev [1] and Nambu and Sakurai [2] estimated the probability of ω decay via the scheme $\omega \to e^+ + e^-$. It was shown that the ratio $R = w(\omega \to e^+ + e^-)/w(\omega \to \pi^+ + \pi^- + \pi^0)$ should be of the order $\sim 10^{-2}$. In the present work, we attempted to detect the decay $\omega \to e^+ + e^-$ experimentally.

For this purpose, we studied the reaction

$$\pi^- + p \to n + X^0 \qquad (X^0 \to e^+ + e^-), \tag{1}$$

where X^0 is some neutral particle decaying via the scheme $X^0 \to e^+ + e^-$. For the study we used film obtained by us earlier [3] in a 17-liter xenon-propane bubble chamber exposed to 1.55 and 2.8 BeV/c π^--meson beams from the proton synchrotron at the Institute of Theoretical and Experimental Physics. The chamber was operated without a magnetic field.

The pictures were scanned for two-prong stars satisfying the following selection criteria: 1) both tracks should have a relativistic ionization; 2) at least one track should be characteristic of an electron track, i.e., produce a shower; 3) the angle of each track relative to the direction of the primary π^- meson should be sufficiently large to be detected in the scanning; 4) the angle between the two tracks should be $\geq 15°$; 5) no electron-positron conversion pairs pointing to the star should be present in the picture (no γ quanta).

We carried out two independent scannings of 20,000 pictures at 1.55 BeV/c and 40,000 pictures at 2.8 BeV/c. We found four two-prong stars completely satisfying all the selection criteria and three doubtful cases which could not be excluded from the statistics for any justifiable reason. Hence the number of events which we attributed to reaction (1) was $7^{+2.7}_{-5.0}$ (including possible background).

To establish the nature of the X^0 particles, we proceeded as follows. For reaction (1), the momentum of the X^0 particle in the center of mass of the π^-p system has a constant value which can be calculated from the known momentum of the π^- in the laboratory system. Using this value and the fact that in the decay of a heavy particle X^0 via the scheme $X^0 \rightarrow e^+ + e^-$ the opening angle between the electron and the positron has a minimum value θ_{min} determined by the relation $\sin(\theta_{min}/2) = m/E$ (m is the mass of the X^0 particle and E is its total energy), we determined the opening angle θ between the electron and positron in the c.m.s. of the π^-p system for the seven events attributed to reaction (1). For each case, we measured on a stereo reprojector the emission angles of the electron and positron relative to the direction of the π^- meson and the angle between them. These data were used to calculate the angle θ. The distribution of the angle θ for the events is shown in Fig. 1; the arrows indicate the values of the angle θ_{min} calculated for a particle of mass 782 MeV, i.e., for the ω meson (119° at 1.55 BeV/c and 82°31′ at 2.8 BeV/c); the doubtful events are shown dotted. As is seen from Fig. 1, the events are grouped close to the angles θ_{min} corresponding to the ω meson. For comparison, Fig. 2 shows the distribution of the angle θ for events which are known not to be cases of reaction (1), but could, under unfavorable conditions, simulate this reaction, i.e., serve as a source of background. It is seen that the distributions in Fig. 2 are more isotropic and differ from the distributions in Fig. 1. This analysis of the angle θ is, in our opinion, an important argument in favor of the suggestion that most of the seven two-prong stars satisfying the foregoing selection criteria are cases of the re-

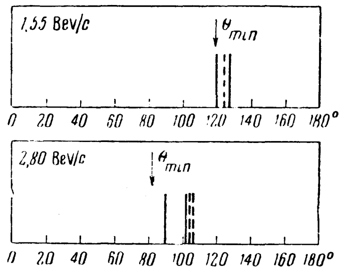

FIG. 1

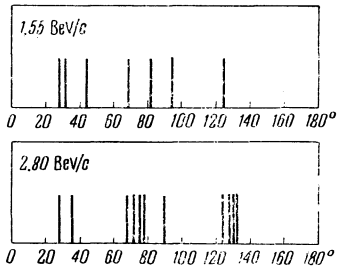

FIG. 2

action $\pi^- + p \rightarrow n + \omega$ with the subsequent decay of the ω via the scheme $\omega \rightarrow e^+ + e^-$.

The most likely sources of background are as follows:

1) The charge-exchange reaction $\pi^- + p \rightarrow n + \pi^0$ with the subsequent decay of the π^0 through a Dalitz pair $\pi^0 \rightarrow e^+ + e^- + \gamma$, where the γ quantum is not recorded in the chamber. The background from such events was considerably reduced by the selection criterion that the angle between the prongs be $\geq 15°$. To estimate the size of this background, we looked for cases of the reaction $\pi^- + p \rightarrow n + \pi^0$ ($\pi^0 \rightarrow e^+ + e^- + \gamma$), where the γ quantum from the Dalitz decay gave rise to an electron-positron pair in the chamber. Only three such cases were found, and all had values of the angle θ in the region < 50°. Using these results and the known efficiency for recording γ quanta in the chamber,[3] we estimated that the background from the Dalitz decays in the reaction

$$\pi^- + p \rightarrow n + \omega \qquad (\omega \rightarrow e^+ + e^-) \tag{2}$$

should be ~ 0.7 event.

2) The reaction $\pi^- + p \rightarrow n + \pi^- + \pi^+ + \pi^0$, where one of the gamma rays from the decay $\pi^0 \rightarrow 2\gamma$ lies along the line of flight of the π^+ or π^- and converts in the chamber so as to imitate an electron shower. Ten cases of this reaction in which one of the γ converted close to the direction of one of the charged pions were found. Estimates indicated that this source of background gave a contribution of about 0.2 event to reaction (2).

3) The production of a fast δ electron at a point

where the primary π^- track experiences a deflection or nuclear interaction. Two events with a δ electron close to a kink in the primary track were found. Estimates showed that the contribution from this source of background was negligible. Summarizing these results, we can say that among the seven events found which we can ascribe to the decay $\omega \rightarrow e^+ + e^-$, no more than one case should be due to background.

To calculate the probability for the $\omega \rightarrow e^+ + e^-$ decay, it is necessary to know the efficiency for recording electrons in the chamber and the number of $\omega \rightarrow \pi^+ + \pi^- + \pi^0$ decays in the scanned pictures. To estimate the efficiency for recording the $X^0 \rightarrow e^+ + e^-$ events, we determined experimentally a "recognition length" for an electron l_e related to the probability for recording an electron w by the formula $w = 1 - \exp(-l/l_e)$, where l is the length of the electron track in the chamber. The track lengths were measured on a stereo reprojector. The quantity l_e measured for electrons of energy ~ 1 BeV proved to be 26 ± 5 cm and the mean probability of recording one electron in the chamber was $\bar{w} = 0.3$. Thus the mean probability for recording two electrons simultaneously was 0.09 and the probability of recording at least one of the two electrons was $2\bar{w}(1 - \bar{w}) = 0.42$. The number of $\omega \rightarrow \pi^+ + \pi^- + \pi^0$ decays was calculated with the aid of our results on the cross sections for the reaction $\pi^- + p \rightarrow n + \omega$ ($\omega \rightarrow \pi^0 + \gamma$).[3] The number was 5×10^3. In this way we found that $R = (0.40^{+0.15}_{-0.30}) \times 10^{-2}$, assuming that the $7^{+2.7}_{-5.0}$ cases found by us are due to reaction (2). This result is in agreement with the theoretical estimates for the quantity R [1,2] and with the preliminary data of [4] in which it is reported that $R \lesssim 10^{-2}$ on the basis of five cases of the $\omega \rightarrow e^+ + e^-$ decay observed in the reaction $K^- + p \rightarrow \Lambda + \omega$ in a hydrogen bubble chamber.

In conclusion, we consider other possible sources of the observed $X^0 \rightarrow e^+ + e^-$ decays apart from reaction (2). One of the competing reactions could be the production of a ρ^0 meson, whose mass is close to the ω, and its decay $\rho^0 \rightarrow e^+ + e^-$. However, the cross sections for the reactions $\pi^- + p \rightarrow n + \omega$ and $\pi^- + p \rightarrow n + \rho^0$ are approximately the same in our energy region, while the width of the ρ^0 is at least an order of magnitude greater than the width of the ω, so that the $\rho^0 \rightarrow e^+ + e^-$ decay can be neglected here. A more likely source can be the production of a φ meson of mass 1020 MeV in the reaction $\pi^- + p \rightarrow n + \varphi$ and its decay $\varphi \rightarrow e^+ + e^-$, since it was recently established that the quantum numbers of the φ are evidently the same as those of the ω.[5,6] However, the threshold for the reaction $\pi^- + p \rightarrow n + \varphi$ is 1.56 BeV/c, so that the decay $\varphi \rightarrow e^+ + e^-$ could be significant only in the case of our results at 2.8 BeV/c. At this momentum the minimum angle for the φ is 106° 30′. As follows from Fig. 1, all the cases of $X^0 \rightarrow e^+ + e^-$ found at 2.8 BeV/c are at smaller angles, but if we take into account the measurement errors, then it is possible to explain the events in the region close to 106° by the $\varphi \rightarrow e^+ + e^-$ decay if the cross sections for the reactions $\pi^- + p \rightarrow n + \omega$ and $\pi^- + p \rightarrow n + \varphi$ are comparable.

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