The resonance structure of $\Lambda\bar{\Lambda}$-spectrum with spin 0 and 1 in $\pi^- p$ interactions at 40 GeV *

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$\Lambda\bar{\Lambda}$ effective mass distributions of 2300 events from reaction $\pi^- p \to \Lambda\bar{\Lambda}n$ at 40 GeV measured at 6-meter spectrometer ITEP are presented. Bumps near 2.3, 2.5 and 2.8 GeV/c^2 are clearly seen. Singlet state dominates at 2.3 GeV/c^2, while state at 2.8 GeV/c^2 is mainly triplet.

1. INTRODUCTION

Relatively high mass of the $\Lambda\bar{\Lambda}$ system and the presence of strange quarks are the main reasons for experimental study of meson decay modes into this system [1–3]. Like the ordinary $(q\bar{q})$ states, quantum numbers of such mesons are: P=$(-1)^{l+1}$, C=$(-1)^{l+s}$. Isospin of the system I=0. For singlet states $s = 0$, J^{PC} = 0^{-+}, 1^{+-}, ..., for triplet P=C. The system $\Lambda\bar{\Lambda}$ have been studied in [4–6] with statistics about 100 events and consequently without detailed analysis. Some experiments with larger statistics near the threshold [7,8] showed polarization properties, but could not observe resonance behavior. Some evidence of $\Lambda\bar{\Lambda}$ resonance states was reported in our previous papers [9–11].

Here we present 2300 events of reactions

$$\pi^- p \to \Lambda\bar{\Lambda}n, \tag{1}$$

$$\pi^- p \to \Lambda\bar{\Lambda}X^0 \tag{2}$$

at 40 GeV measured at 6-meter spectrometer ITEP [12] in experiment SERP-E-173.

Dozens of resonances are expected in the region 2.23–3.0 GeV/c^2. Our 2300 events of reactions (1) and (2) which are considerable part ($\sim$ 70 ev/nb) of fixed target world statistics, is still not enough for PWA.

2. EXPERIMENTAL CUTS

High precision of coordinate detector of the spectrometer makes it possible to identify $K_S, \Lambda, \bar{\Lambda}$ and γ by kinematical properties of their decays into charged particles (Fig. 1) without identification of charged particle type.

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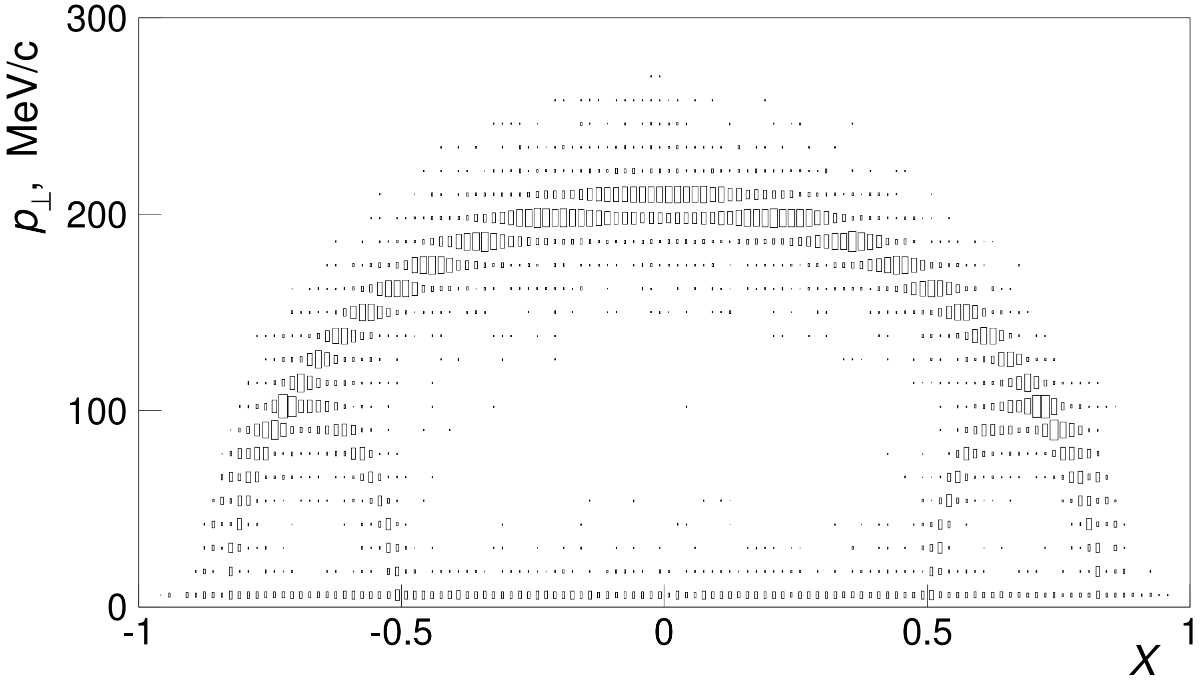

Figure 1. 2-D plot of $(x, p_\perp)$, $x = (p_{1||} - p_{2||})/(p_{1||} + p_{2||})$, where p_1, p_2 are the momenta of positive and negative V_0-components. Points near large arc with $p_{\perp max} = 206$ MeV/c are $K_S \to \pi^+\pi^-$ decays. Points from the right small arc are $\Lambda \to p\pi^-$ decays, left — $\bar{\Lambda} \to \pi^+\bar{p}$. Events near x-axis correspond to $\gamma \to e^+e^-$. Small regions of higher density near $p_\perp = 100$ Mev/c corresponding to $K_S - \Lambda$ and $K_S - \bar{\Lambda}$ ambiguity are clearly seen.

Λ candidates are considered if

$$|M_{p\pi^-} - M_\Lambda| < 10 \text{ MeV/c}^2 \qquad \text{and} \qquad |M_{\pi^+\pi^-} - M_{K^0}| > 10 \text{ MeV/c}^2$$

$\bar{\Lambda}$ candidates are considered if

$$|M_{\bar{p}\pi^+} - M_{\bar{\Lambda}}| < 10 \text{ MeV/c}^2 \qquad \text{and} \qquad |M_{\pi^+\pi^-} - M_{K^0}| > 10 \text{ MeV/c}^2$$

The main part of background from $K_S \to \pi^+\pi^-$ decays is rejected by these cuts. By combining these cuts, $\Lambda\bar{\Lambda}$ sample is selected with purity 88%. The selection efficiency is estimated as 92%. Geometrical and track selection cuts were described in our previous papers [13,14].

3. EXPERIMENTAL RESULTS

Weak decays $\Lambda \to p\pi^-$ and $\bar{\Lambda} \to \bar{p}\pi^+$ give information on polarization and spin of the $\Lambda\bar{\Lambda}$ system. Parameter

$$C = -\frac{9}{\alpha^2}\left(\overline{\cos\theta_{p\bar{p}}}\right) \qquad (3)$$

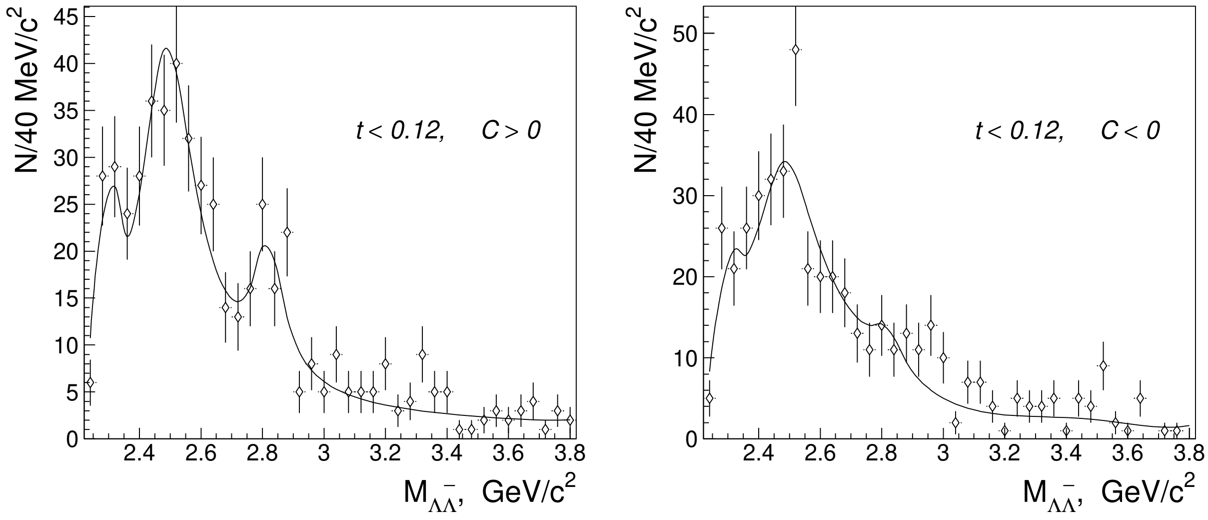

Figure 2. $\Lambda\bar{\Lambda}$ effective mass distributions for mainly triplet (left, $C > 0$) and singlet (right, $C < 0$) states.

equals $C = 1$ for triplet state of $\Lambda\bar{\Lambda}$, $C = -3$ for singlet. In the definition (3) α is the polarization parameter $\alpha = \pm 0.647$, the angle $\theta_{p\bar{p}}$ is the angle between the directions of p and $\bar{p}$ momenta.

Table 1
Polarization parameters of the $\Lambda\bar{\Lambda}$ system.

	$M_{\Lambda\bar{\Lambda}}$ range	C	S
1	2.28÷2.38	-1.23 ± 0.65	0
2	2.43÷2.55	0.98 ± 0.59	0,1
3	2.75÷2.85	2.02 ± 0.84	1

The $\Lambda\bar{\Lambda}$ effective mass M distribution has three bumps near 2.3, 2.5 and 2.8 GeV/c^2. Figure 2 shows the same mass distribution, but for $C < 0$ and $C > 0$ samples separately. These distributions may be described by the sum of the phase space term W

$$W = a_1 \frac{\pi}{2} \sqrt{(1 - 2\frac{m}{M})} exp(-a_2 M), \tag{4}$$

where m is Λ mass, and possible Breit-Wigner resonances contribution. Parameters a_1, a_2 and amplitude, mass and width for bumps near 2.3, 2.5 and 2.8 GeV/c^2 were fitted.

4. CONCLUSION

Like $(q\bar{q})$ states the $\Lambda\bar{\Lambda}$ system has the following quantum numbers: P=$(-1)^{l+1}$, C=$(-1)^{l+s}$, but isospin of the $\Lambda\bar{\Lambda}$ I=0. Bumps reported here can be considered as ordi-

Table 2
Resonance parameters.

Mass (MeV)	Width (MeV)	Cut	A_p(norm.)	σ^* (nbn)
2320 ± 20	65 ± 20	1	42 ± 15	1.8 ± 0.4
		2	21 ± 8	
2500 ± 10	205 ± 50	1	71 ± 12	2.9 ± 0.5
		2	41 ± 10	
2805 ± 15	90 ± 25	1	31 ± 10	1.0 ± 0.4
		2	6 ± 4	

* The cross section value not corrected for acceptance.
Cut 1: $t' < 0.12$ and $C > 0$.
Cut 2: $t' < 0.12$ and $C < 0$.

nary $(q\bar{q})$ meson states or exotic one with $(q\bar{q})$ admixture. We report here the preferable spin of $\Lambda\bar{\Lambda}$ only, but other quantum numbers remain unknown.

- Bumps near 2.3, 2.5 and 2.8 GeV/c^2 $\Lambda\bar{\Lambda}$ mass are clearly seen in the sample of 2300 events. Isospin I=0.
- State at 2.3 GeV/c^2 is mainly singlet. J^{PC} = 0^{-+}, 1^{+-}, ...
- State at 2.8 GeV/c^2 is mainly triplet.

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