Table 2

The results of experimental investigation of the $M\bar{M}$–conversion process in the PNPI–JINR experiment

Accelerator run	N_μ	$W(\Delta E)$	W_M	$N_{M\bar{M}}$	$W_{M\bar{M}}$	$G_{M\bar{M}}$
I [4]	$4.5 \cdot 10^{10}$	$1.05 \cdot 10^{-3}$	0.027	0	$< 3.6 \cdot 10^{-6}$	$< 0.38 G_F$
II+III [5]	$3.44 \cdot 10^{11}$	$1.51 \cdot 10^{-3}$	0.029	1	$\leq 5.1 \cdot 10^{-7}$	$\leq 0.14 G_F$
I+II+III	$3.89 \cdot 10^{11}$			1	$\leq 4.7 \cdot 10^{-7}$	$\leq 0.14 G_F$

N_μ – total number of muons passing through the target; W(ΔE) – the probability of registration of electron in the energy range ΔE [7]: W_M – the probability of muon yield out of the SiO_2 – target to vacuum [7]; $N_{M\bar{M}}$ – total number of events registrated; $W_{M\bar{M}}$ – the experimental probability of the $M \to \bar{M}$ – conversion process; $G_{M\bar{M}}$ – the estimation of the upper limit of coupling constant in the process under consideration.

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MEASUREMENT OF THE SPIN ROTATION PARAMETERS A AND R IN $\pi^{\pm}p$ ELASTIC SCATTERING IN THE MOMENTUM RANGE 1.4 – 2.1 GeV/c

V. V. Abaev, N. A. Bazhanov, V. S. Bekrenev, Yu. A. Beloglazov, A. I. Kovalev, N. G. Kozlenko, S. P. Kruglov, A. A. Kulbardis, L. V. Lapochkina, I. V. Lopatin , V. V. Sumachev, V. Yu. Trautman, E. A. Filimonov, V. A. Shchedrov, I. G. Alekseev[1)], B. M. Bobchenko[1)], P. E. Budkovsky[1)], V. V. Zhurkin[1)], V. P. Kanavets[1)], L. I. Koroleva[1)], V. I. Martynov[1)], B. V. Morozov[1)], V. M. Nesterov[1)], V. V. Platonov[1)], V. V. Ryltsov[1)], V. A. Sakharov[1)], D. N. Svirida[1)], A. D. Sulimov[1)]

[1)] *Institute for Theoretical and Experimental Physics, Moscow*

Measurement of the spin rotation parameters A and R in πp elastic scattering in the momentum range from 1.4 to 2.1 GeV/c was started by the PNPI–ITEP collaboration in the framework of general program "Baryon spectroscopy". In the second πN resonance region such measurement is being performed for the first time in the world. The main goal of these experiments is to resolve existing uncertainties of nonstrange baryon resonance spectrum

which arise in turn from ambiguities of partial-wave analyses (PWAs). In the momentum range chosen for the measurement, a discrepancy between the predictions of PWAs KH [1] and CMB [2], on the one hand, and PWA SM90 [3], on the other hand, manifests itself especially distinctly.

Experiments are carried out on a pion channel of the ITEP synchrotron. The experimental layout is shown in Fig.1. The basic elements of the apparatus [4] are the polarized proton target with the vector of polarization collinear to the beam direction (pure A-experiment) and the carbon multiplate polarimeter with automatic television read-out. The polarimeter

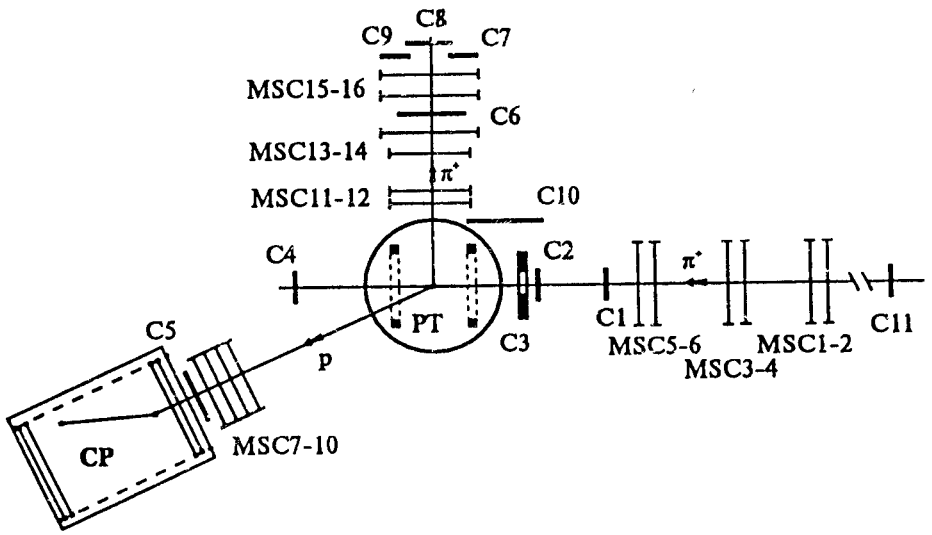

Fig.1. The experimental layout. PT – polarized target; CP – carbon multiplate polarimeter; MSC1-16 – magnetostrictive spark chambers; C1 ..1 – scintillation counters

consists of twenty optical spark chambers, twelve of them (in the middle) have carbon electrodes each of 30 mm thick. The polarimeter allows to measure asymmerties of the secondary (proton-carbon) scattering in both the vertical and horizontal planes and, hence, to measure all the three polarization parameters P, A and R simultaneously. Sets of magnetostrictive spark chambers serve for the detection of the incident particle and two charged particles produced in the reaction. A system of scintillation counters is used for triggering and identification of the incident pions by time–of–flight technique.

The first experiment was carried out at the momentum of the incident pions 1.43 GeV/c. Data obtained in four runs with total of 7.1×10^5 raw events of $\pi^+ p$–interactions were written on magnetic tapes during the experiment.

The processing of the obtained data was performed in three steps:

- The second scattering was analyzed and its vertex and other parameters were determined. The events with a proton–carbon scattering angle 6° – 20° were selected for further processing.
- The first scattering was reconstructed and the events of elastic scattering on free protons of the target were selected. The kinematical criteria of complanarity and of correlation between polar angles of the scattered pions and the recoil protons were used for this selection.

The background due to quasielastic scattering on bound protons of the target nuclei was less than 30% and it was taken into account in the data processing.

- The selected 5562 events were divided into two angular intervals over θ^{cm} and the values of A^+ , P^+, R^+ were calculated in each angular interval. For the parameter R^+ the experiment gives only absolute values according to the equation $\mid R \mid = \sqrt{1 - A^2 - P^2}$.

Results of this experiment [5] are shown in Fig.2 along with the predictions of the three above mentioned PWAs. The distinction between different PWAs in the region $\theta^{cm} = 120°$–$136°$ appears in the momentum range from 1.1 to 1.8 GeV/c. One can see that the experiment confirms the predictions of PWA SM90 and contradicts obviously to the predictions of PWAs KH and CMB. It can be shown (see below) that the discrepancies between different PWAs are attributed to the Barrelet ambiguities [6] in the selection of the PWA solution branch.

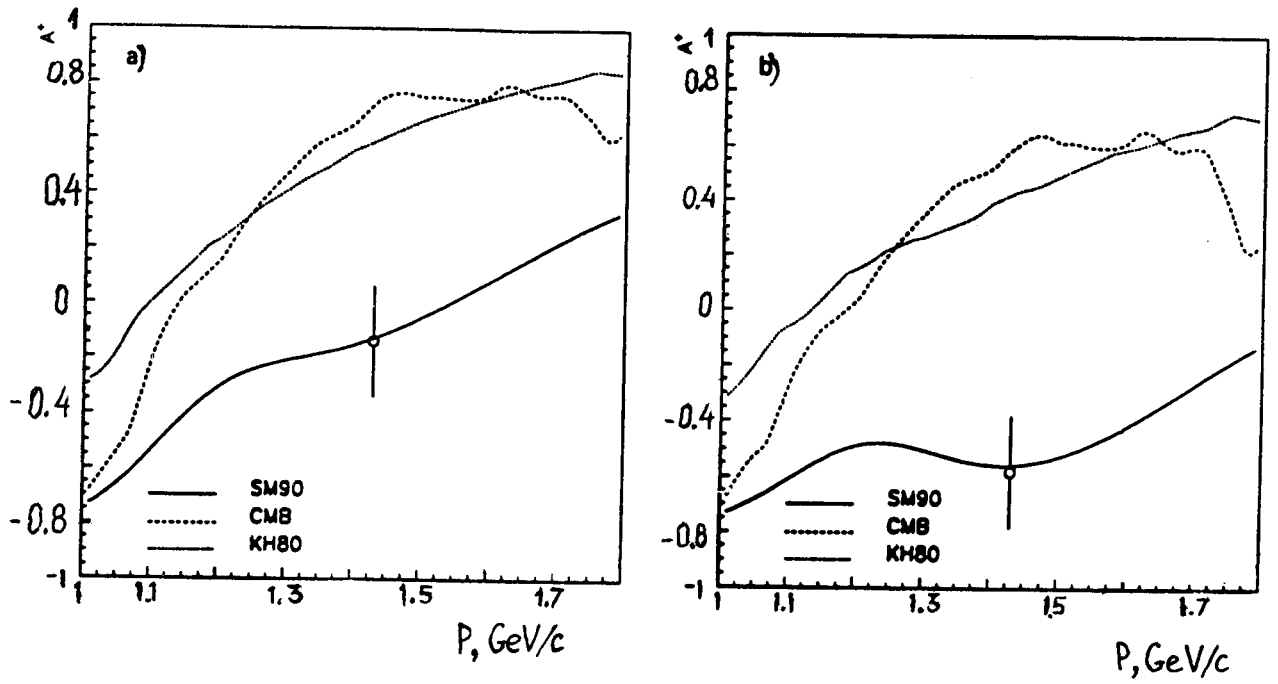

Fig.2. Results of this experiment for $\theta^{cm} = 127°$ (a) and $\theta^{cm} = 133°$(b) in comparison with the predictions of different PWAs

In order to compare the predictions of different PWAs in a wide range of the incident pion momentum it is convenient to use the method of Barrelet zero trajectories [6,7]. At fixed energy the transversity amplitudes $F(\pm)$ are usually considered as functions of either $z = cos\theta$ or a variable ω which is connected with z by a conformal mapping $\omega = e^{i\theta} = z \pm \sqrt{z^2 - 1}$. When θ is real, it corresponds to the centre-of-mass scattering angle. The

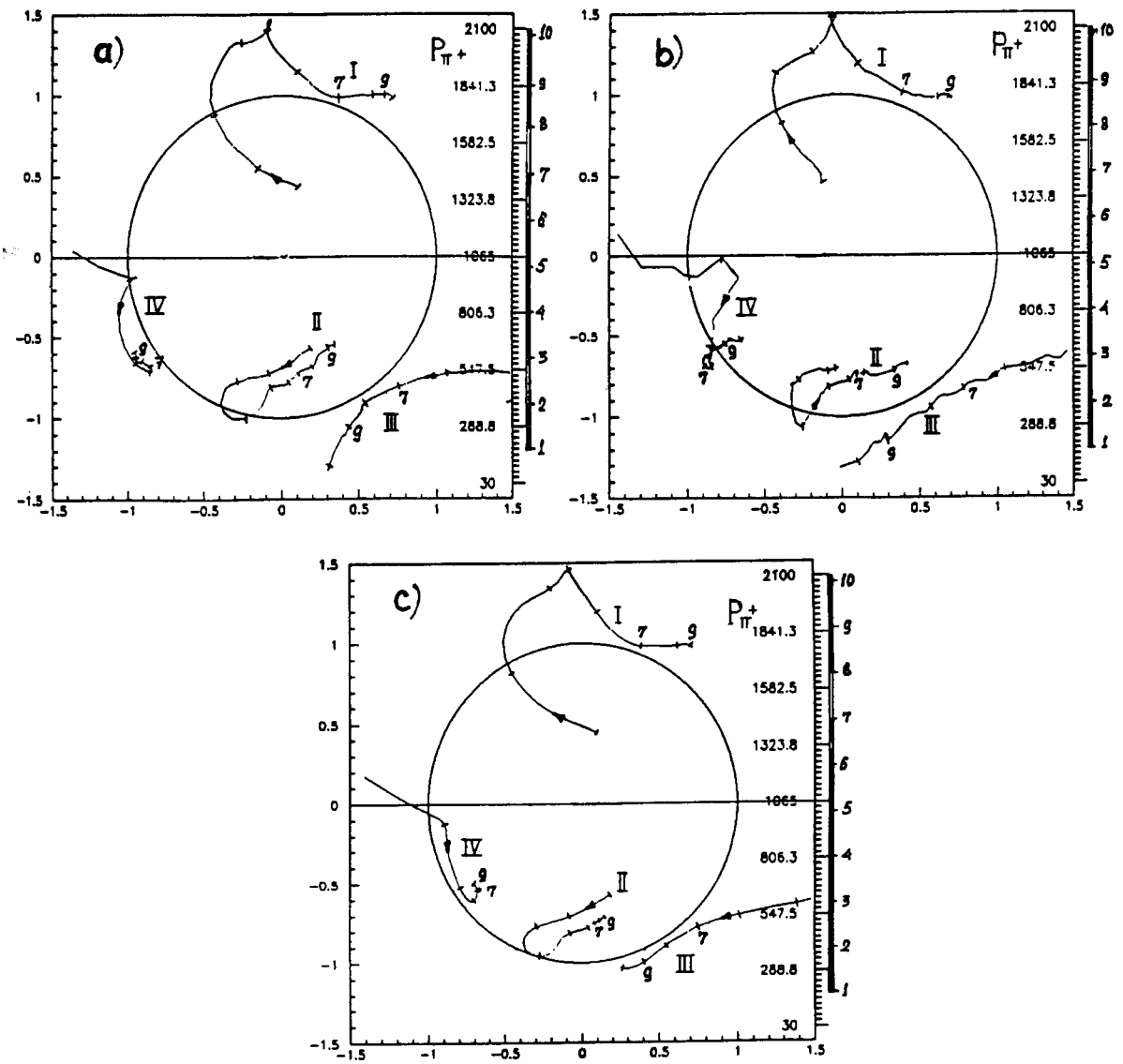

Fig.3. a–c. Four zero trajectories for PWAs KH, SM90 and CMB, respectively. The scale on the right of each picture shows to what incident momentum does each point of the trajectory correspond. For example, point 7 corresponds to $P_{\pi+} = 1.44$ GeV/c

transversity amplitudes have the advantage that their moduli can be determined from $d\sigma/d\Omega$ and P data alone $\mid F(\pm) \mid^2 = d\sigma/d\Omega \times (1 \pm P)$. This equation shows that the zeros of the amplitude can be derived from the zeros of $d\sigma/d\Omega$ and P data but, unfortunately, there is a 2^{2N} fold ambiguity [1] because, for each pair of zeros z_i and z_i^* (or ω_i and $1/\omega_i^*$), one has the choice whether z_i or z_i^* belongs to the amplitude F. Measurements of the spin rotation parameters A and R can help to make the correct choice.

The positions of the zeros of $F(\pm)$ depend, of course, on the momentum of the incident pions. This allows one to solve problems of unknown PWA ambiguities simply by looking at the zero trajectories in the ω–plane which are located near the physical region. Four such trajectories are plotted in Fig.3a–c for PWAs KH, CMB and SM90, respectively, in the range of the incident pions momentum from 0.18 to 2.08 GeV/c. They are marked as I, II, III and IV. It can be seen that although the behaviour of these trajectories is similar in general for all three PWAs, there exists distinct difference between KH, CMB and SM90 in the region 0.80–2.08 GeV/c for the trajectories IV – the point 7 corresponding to $P_{\pi+} = 1.44$ GeV/c lies outside the unit circle for KH and CMB but inside this circle for SM90. Just this inversion of the zeros with respect to the unit circle is the source of the above mentioned discrepancies between different PWAs; an unproper choice of the trajectory caused by such inversion can lead to the observed contradiction between the predictions of PWAs KH and CMB and the experimental results.

The results of this experiment have demonstrated clearly how measurement of the spin rotation parameters only for one momentum had allowed to remove ambiguities and select the correct solution (SM90) among all existing ones. These results show that characteristics of the nonstrange baryon resonances given in Tables of the Particle Data Group [8] needs to be revised since these characteristics are obtained on the base of two another solutions KH and CMB which appeared to be incorrect in the light of the present results.

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[1] N is the number of the zeros which is equal to the maximal number of partial waves in a partial-wave expansion of the amplitude