POSSIBLE EXISTENCE OF $\pi^-\gamma$ RESONANCE WITH MASS 270 MeV

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We have obtained an experimental indication of the possible existence of a new meson resonance: a narrow peak at M = 270 MeV was observed in the effective-mass spectrum of the $\pi^-\gamma$ system produced in the reaction $\pi^-p \to \pi^-p + (2, 3)\gamma$ at 5 GeV/c.[2)] The experiment is based on an analysis of about 6000 two-prong stars with two and more γ quanta, obtained by scanning 230,000 photographs obtained with the JINR propane bubble chamber [2].

The system for reducing the events was described earlier [3, 4]. By way of an example demonstrating that it gives unbiased values of the kinematic parameters of the pions and gamma quanta, Figure 1 shows the effective-mass distribution of two γ quanta produced in the reactions $\pi^-p \to \pi^-p + 2\gamma$ and $\pi^-p \to n\pi^+\pi^- + 2\gamma$, and the effective-mass distribution of the $\pi^+\pi^-$ system for V^0 particles identified as K^0 mesons.

We retained for study events of type $\pi^-p \to \pi^-p + (2, 3)\gamma$ satisfying the following requirements: 1) the protons are identified by the ionization and stopping in the chamber; the proton momenta do not exceed 900 MeV/c; 2) the length of the tracks of the secondary charged particles of the star is not less than 2 cm, and the momenta of these particles are measured with accurary not worse than 30%; 3) the γ quanta have momenta higher than 30 MeV/c, measured with accuracy not worse than 25%; 4) the angles between the two γ quanta do not exceed 2°.

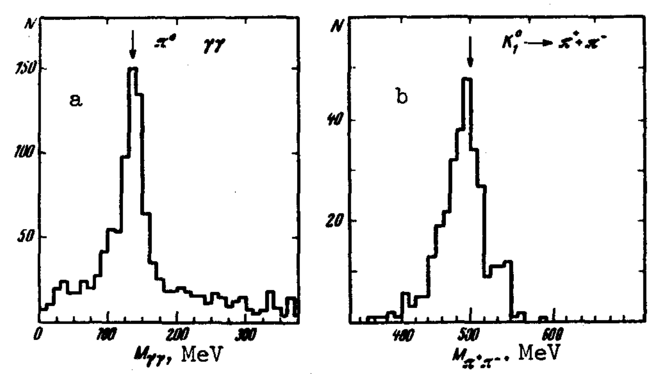

Fig. 1. a - Distribution with respect to the effective mass of two γ quanta produced in the reactions $\pi^-p \to \pi^-p + 2\gamma$ and $\pi^-p \to n\pi^+\pi^- + 2\gamma$; b - distribution with respect to the effective mass of the $\pi^+\pi^-$ system for V^0 events identified as K^0 mesons.

Application of these criteria left 238 events of type $\pi^-p \to \pi^-p + 2\gamma$ and 36 events of type $\pi^-p \to \pi^-p + 3\gamma$. Figure 2 shows the distribution with respect to the effective mass $M(\pi^-\gamma)$ for these events (584 combinations). A noticeable increase in the number of events above the background curve is observed in the mass region 240 - 290 MeV.

The background curve is the sum of the $M_i(\pi^-\gamma)$ distributions calculated for the reactions making the

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[2)] Preliminary results of this experiment were reported at the Fifteenth International Conference on High-energy Physics (Kiev, 1970) and are cited in Astier's rapporteur's paper [1].

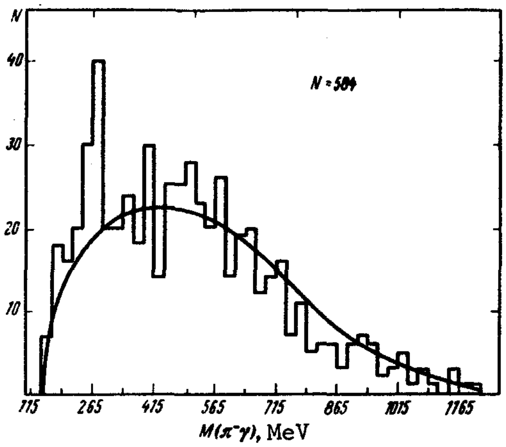

Fig. 2. Distribution with respect to the effective mass of the $\pi^-\gamma$ system produced in the reaction $\pi^-p \to \pi^-p + (2, 3)\gamma$.

main contribution to the total cross section of the process $\pi^-p \to \pi^-p$ + "neutral particles":

$$\pi^-p \to \pi^-p + (1, 2, 3, 4)\pi^0, \quad (1)$$

$$\pi^-p \to p\rho^- + (0, 1, 2)\pi^0, \quad (2)$$

$$\pi^-p \to \Delta^+(1236)\pi^- + (0,1)\pi^0. \quad (3)$$

The $M_i(\pi^-\gamma)$ distributions and the efficiencies of the registration of the reactions (1) and (2) were calculated by the Monte Carlo method with allowance for the angular distribution of the baryons in the c.m.s. of the primary interaction, the probability of registering the γ quanta in the chamber, and the selection criteria, in analogy with [5]. The $M_i(\pi\gamma)$ distributions were included in the summary background curve with a weight proportional to the cross section and to the efficiency of registration of the i-th channel.

The background curve was normalized to the total number of events outside the peak. The excess of number of events over the background curve in the mass region 240 - 290 MeV corresponds to (5.2 - 0.4) standard deviations (70 events as against the expected 38). The error in this quantity reflects the uncertainty in the position of the background curve, due to the errors in the values of the cross sections of the reactions (1) - (3).

A least-squares approximation of the experimental $M(\pi^-\gamma)$ spectrum by a sum of a Gaussian curve and the background curve yielded a mean value M = 270 ± 5 MeV and a width Γ = 13 ± 5 MeV. The obtained value of Γ coincides with the calculated value of the experimental resoltuion in the given mass region (≈12 MeV).

Simulation of the reactions with formation of the known resonances η, ω, and f has shown that the narrow peak observed by us at M = 270 MeV cannot be their "kinematic reflection".

It can therefore be assumed that the effect observed by us is due to the existence of a new meson resonance[3)].

We are grateful to the High-energy Laboratory for collaborating in the operation of the chamber in the proton synchrotron, to the Computation and Automation Laboratory for measurement of the events, and to our laboratory group for scanning the photographs and for processing the events.

[1] A. Astier, Report on the Bosonic Resonances. Proc. 15th Internat. Conf. on High-energy Physics, Kiev, 1970. JINR Publication 5454, 1970.
[2] A.V. Bogomolov et al. PTE No. 1, 61 (1964).

[3)] In [6, 7] there was discussed the possible existence of mesons for which decays in strong interactions are forbidden, and it was shown that if these mesons have masses in the interval 140 - 560 MeV and quantum numbers S = 0, I = 1, and $J \leq 1$, then they decay mainly in an electromagnetic interaction with participation of γ quanta.

[3] V.M. Bondarenko et al. JINR Preprint 10-3246, 1967.
[4] N.A. Buzdavina et al. JINR Publication B1-10-3572, 1967.
[5] V.B. Vinogradov et al. JINR Communication 13-5516, 1970.
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[7] V.G. Grishin and G.I. Kopylov, Nuovo Cimento 37, 962 (1965).

NUCLEON DISTRIBUTION IN THE NUCLEI $Cr^{50, 52, 54}$, $Fe^{54, 56}$, and $Ni^{58, 60, 62, 64}$

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The recently published reformulated optical model of Greenlees et al. [1] relates the real part of the central potential with the distribution of nuclear matter and the potential of the nucleon-nucleon interaction. Assuming functional forms of the nucleon-density distribution in the nucleus and the potential of the two-particle interaction, it is possible to obtain from an analysis of the experimental differential cross sections for elastic scattering of the protons the values of the rms density-distribution radius of the nuclear matter and of the volume integral of the real part of the central potential. It has been shown [1 - 2] that these quantities provide definite radial and dynamic information that does not depend on individual values of the model parameters within a range of reasonable values of the rms deviation of the calculated curve from the experimental dependence.

Using the proton-density parameters that are obtained with good accuracy in experiments on the scattering of electrons and on the spectra of transitions in mesic atoms, it is possible to obtain information on the distribution of the neutrons in the investigated nuclei.

We measured the differential cross sections for elastic scattering of 9.6-MeV protons by $Cr^{50, 52, 54}$, $Fe^{54, 56}$, and $Ni^{58, 60, 62, 64}$ in the angle range 15 - 170°. The experimental and analysis procedures are described in [3]. Figures 1 and 2 show the rms radii of the distribution of nuclear matter $\langle r^2\rangle_m^{1/2}$ and of the neutrons $\langle r^2\rangle_n^{1/2}$ obtained as a result of an analysis based on the reformulated optical model. Figure 2 shows also the rms charge-distribution radii obtained by investigating the scattering of 225-MeV electrons by $Ni^{58, 60, 62, 64}$ [4, 5]. It is of interest to compare the change of the charge and nuclear-matter distribution parameters obtained in the present case for isotope nuclei.

Khvastunov et al. [4] relate the change of the rms radii of the charge distribution with the values of the angular momenta of the added neutrons, but with account taken in this case of the influence of the residual interactions. Since the investigated nuclei Fe and Ni are deformed, the process of filling the nucleon shells should lead to a charge in the residual interactions due to the pair interactions.

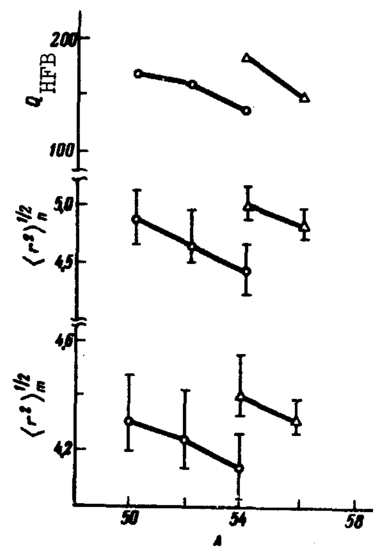

Fig. 1. Change of rms distribution radii of the density of nuclear matter $\langle r^2\rangle_m^{1/2}$, of the neutrons $\langle r^2\rangle_n^{1/2}$, and of the internal quadrupole moments, calculated by the HFB method, of axially deformed states of the nuclei $Cr^{50, 52, 54}$ and $Fe^{54, 56}$ with filling of the neutron shells. The lengths are in Fermi units and the quadrupole moments in Fermi units squared.