$$P = \text{const}\cdot\Delta t_2\theta_0^2\exp\{-2(t_2-t_1)/\tau\}. \quad (2)$$

From formula (2) the possibility is evident of directly determining the relaxation time τ within the framework of the experiment described. Actually, a change of ν_2 by adjustment of resonator 3 is equivalent to a change of t_2. If meanwhile Δt_2 is constant [$H(t)$ a linear function and $\Delta\nu_2$ a constant], then

$$\ln(P'/P'') = 2(t_2''-t_2')/\tau, \quad \tau = 2(t_2''-t_2')/\ln(P'/P''). \quad (3)$$

All the quantities in the right member of (3) are found from the experiment.

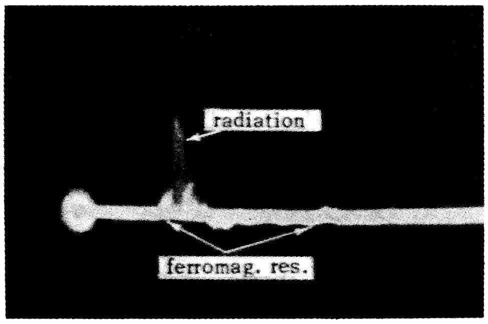

FIG. 3. Signals due to radiation and to ferromagnetic resonance on the oscillograph screen.

Figure 3 shows a photograph of the picture on the oscillograph screen. The large pulse is caused by the radiation at $H = H_2$, and the two small ones by ferromagnetic resonance at $H = H_1$. The correctness of this interpertation was confirmed by special checks. In the first place, it was established that the carrier frequency of the large pulse coincided with ν_2 and of the smaller with ν_1. For this purpose, there was connected in the line, in front of the detector, the adjustable resonator-filter 10. In the second place, it was shown that the radiation pulse was absent in all cases in which the magnetic field did not reach the value H_2. In the third place, the dependence of the size of the radiated pulse on Δt_2 was verified qualitatively. The fact is that the slope of the pulse front of the magnetic field was slightly oscillatory, as is shown by the dashed curve in Fig. 2. Consequently the interval Δt_2 should also oscillate with change of t_2, and the dependence $P(t)$ expressed by formula (2) ceases to be purely exponential. On the experimentally obtained graphs of $P(t)$, the corresponding fluctuations are clearly indicated; this, unfortunately, greatly complicates the determination of the relaxation time.

The specimens used in this research were of yttrium iron garnet, of diameter from 0.5 to 1.0 mm, with polished surface of spherical form.

In closing, we wish to express our deep gratitude to A. G. Gurevich, G. A. Smolenskiĭ, and K. P. Belov, who kindly provided the ferrite specimens; to A. M. Leonov, who took an active part in the construction of the apparatus; and to V. M. Faĭn for valuable advice.

*A similar idea was used in the work of Hoskins,[6] where an experiment with ruby is described.

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FORMATION OF PIONS IN πN COLLISIONS

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THE model of Lindenbaum and Sternheimer[3] offers only a qualitative explanation for the observed momentum distribution of π mesons from the reaction $\pi + N \rightarrow 2\pi + N$ at kinetic energies 1.0 and 1.4 Bev (in the laboratory frame of reference). According to this model, the meson arises from the formation of an isobaric state ($T = 3/2$, $J = 3/2$, $l = 1$) with finite width. On the other hand, Fermi's statistical theory does not explain these distributions, while within the framework of this theory a calculation of the isobars, as particles of mass M = 1.32 nucleon masses, also leads to only qualitative agreement with experiment. Rus'kin[5] has attempted to improve the agreement by taking into account a resonance $\pi\pi$ interaction, a new particle Π being introduced, with mass $M = 0.47$ nucleon masses, which decays into two π mesons. We have made analogous calculations, which do in-

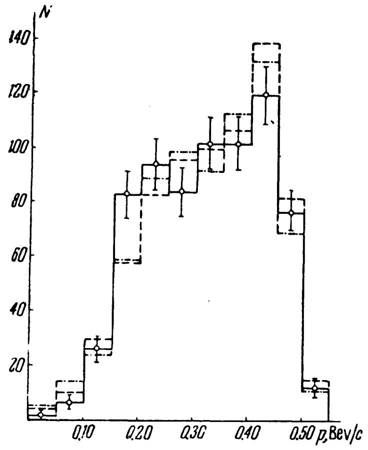

FIG. 1. Momentum distribution of all π mesons (π^+, π^-, π^0) from the reactions $\pi^- + p \to \pi^- + \pi^+ + n$, $\pi^- + \pi^0 + p$ at an energy of 1 Bev (number of mesons N as a function of momentum p in the center-of-mass system). The solid histogram is drawn through the experimental points of reference 1, while the dot-dash one was calculated from the statistical theory, taking into account the isobar with M = 1.32 and a Π particle (M = 0.47). The dashed histogram was calculated taking into account the finite width of the isobaric state (3/2, 3/2, 1).

deed improve agreement with experiment but not to the extent quoted in reference 5. We wish to point out that it is possible to describe the experimental data just as well without taking into account the meson-meson interaction, but including instead in the statistical theory the effect of the finite width of the isobar which decays to give π mesons.

To do this we take into account the interaction in the final state;[6] in our case the final state is $\pi + \pi + N$ and we consider only the interaction between the meson and the nucleon. We then have for the part of the cross section which corresponds to the formation of a π meson through the isobaric state

$$d\sigma_1 = (p^{-2}\sin\delta_{33})^2\, d\mathbf{p}_1\, d\mathbf{p}_2\, d\mathbf{p}_3\, \delta\Big(\sum_{i=1}^{3} E_i - E_0\Big)\,\delta\Big(\sum_{i=1}^{3} \mathbf{p}_i\Big),$$

where the phase δ_{33} describes the resonance scattering of mesons by nucleons and p is the modulus of the relative meson-nucleon momentum. Integration of this formula leads to the result of Lindenbaum and Sternheimer. The total cross section for the reaction $\pi + N \to 2\pi + N$ has the form

$$d\sigma = C_1\, d\sigma_1 + C_2\, d\sigma_2,$$

where $d\sigma_2$ is the cross section for the formation of three particles without interaction, while C_1 and C_2 are determined by the statistical weights for the formation of a π meson plus the isobar (M = 1.32) and two π mesons plus a nucleon. $d\sigma_1$ and $d\sigma_2$ are normalized to the same number of mesons.

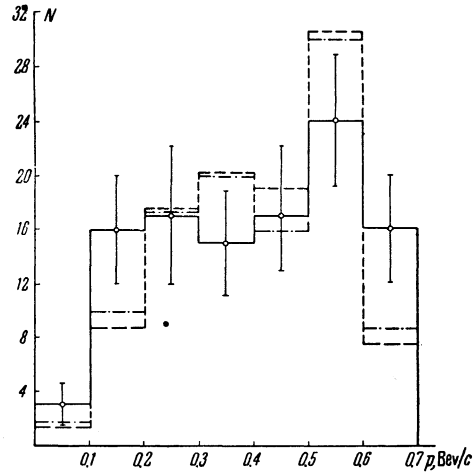

FIG. 2. Same as Fig. 1, but at 1.4 Bev. The experimental points were taken from reference 2.

Figures 1 and 2 show the results of integrating this formula over all variables (except the momentum of one particle), namely the momentum distribution of the mesons in the center-of-mass system for incident-meson energies 1.0 and 1.4 Bev. It is clear that the calculated histograms agree with the experimental data just as well as the results of statistical-theory calculations with account of $\pi\pi$ interaction. Thus the experimental data can be described without invoking the particle Π (M = 0.47), particularly since the existence of such a particle implies a peak in the momentum distribution of the recoil nucleons, a peak which is not observed in the new, more comprehensive data at 1 Bev.[1]

If we take into account the second resonance state ($T = 1/2$, $J = 3/2$, $l = 2$) in the πN system[7] as a second isobar with mass M = 1.52, then agreement between theory and experiment becomes worse. (Such a second resonance state would correspond to a π meson with kinetic energy ~ 600 Mev in the laboratory frame of reference.) This is because both the π meson from the decay of this isobar and the recoil meson contribute to the momentum spectrum just where the observed spectrum has a plateau or even a dip.

In conclusion, the authors would like to express their gratitude to I. A. Egorova for doing the laborious numerical computations.

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GAMMA RADIATION PRODUCED IN THE INTERACTION BETWEEN ACCELERATED C^{12} IONS AND TIN NUCLEI

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COMPOUND nuclei with large excitation energy and angular momentum are produced in nuclear reactions caused by accelerated heavy ions. Strutinskiĭ[1] assumes that during the decay of such a compound nucleus the main part of the angular momentum is carried off by gamma radiation, i.e., the emission of nucleons is accompanied by a gamma-ray cascade.

The present paper is devoted to the study of the gamma-ray energy spectrum appearing during the irradiation of Sn with C^{12} ions, accelerated to about 78 Mev. According to estimates, the maximum excitation energy of the compound nucleus in this case amounts to ~ 66 Mev, and the maximum angular momentum amounts to $\sim 45\ \hbar$. The experiments were carried out with the extracted beam of the 150-cm cyclotron of the Atomic Energy Institute of the U.S.S.R. Academy of Sciences. The intensity of the beam was $\sim 5 \times 10^6$ particles/sec. The 24 mg/cm^2 tin target was set at 45° to the incident beam. The gamma rays in the 0.4- to 4-Mev energy range were registered with a scintillation gamma spectrometer, consisting of a CsI crystal (3 cm diameter, 3 cm height), an S-993 photomultiplier and an ÉLA-2 multichannel analyzer.[2] The channel width was 0.075 Mev. The energy resolution of the Cs^{137} photopeak (0.661 Mev) was $\sim 11\%$. A miniature proportional counter, mounted on the entrance diaphragm, was used to monitor the beam. To absorb the soft x rays appearing when the carbon ions pass through the target, a lead foil $\sim 150\,\mu$ thick was placed in front of the crystal. The distance between the target and the spectrometer crystal could be varied from 0.2 to 5 cm. In the experiments for determining the background, the ion energy was decreased below the Coulomb barrier of tin nuclei for C^{12} ions by inserting a $60\,\mu$ aluminum foil at a distance of 15 cm from the crystal. In processing the spectra, the spectral sensitivity of the instrument and the line shape, obtained during the registration of monochromatic gamma rays,[3] were taken into account.

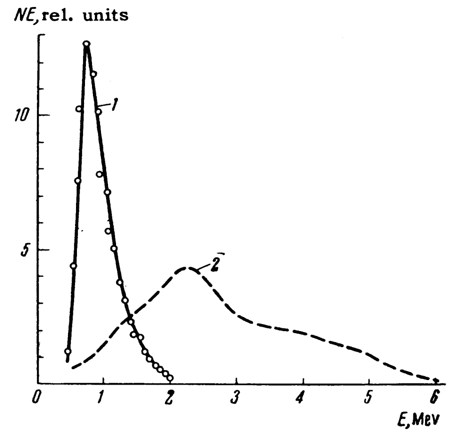

FIG. 1

Figure 1 (curve 1) shows the corrected gamma spectrum in the form $NE = f(E)$ [N is the number of gamma quanta in the channel with an energy E]. The distance R between the crystal and the target was 5 cm. The spectrum has the form of a continuous distribution with a maximum at $E = 0.8$ Mev. Figure 1 (curve 2) also shows the gamma-ray spectrum from the reaction $Sm^{150}(n, \gamma)$ with thermal neutrons (unresolved portion[4]), which is typical of the case of a compound nucleus with an angular momentum practically the same as in the ground state. This spectrum has a peak energy of about 2 Mev.

Comparison of these two spectra indicates that in our case the transition of the nucleus to the ground state takes place overwhelmingly with emission of softer gamma quanta than emitted in radiative neutron capture.

An attempt was also made to estimate experimentally the mean number of gamma quanta emitted during the disintegration of the compound nucleus. For this purpose the distance between the crystal and the target was decreased to its minimum; this increased the probability of simultaneous registration of successively emitted gamma quanta.

Figure 2 shows corrected gamma-ray spectra obtained for $R = 5$ cm (a) and $R = 0.2$ cm (b) normalized to make the areas under the respective curves, plotted in NE and E coordinates, equal.