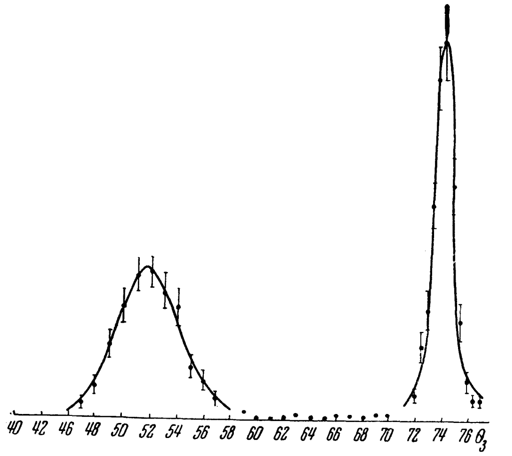

FIG. I.

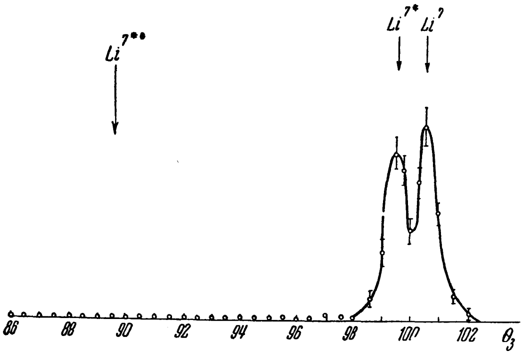

FIG. 2.

express my gratitude to S. S. Vasil'ev for his attention to this work and for a number of valuable comments, also to the engineers V. S. Zazulin, A. I. Akishin, Iu. A. Vorob'ev, A. N. Boiarkina and to the co-workers maintaining the cyclotron for their help in carrying out the various stages of this investigation.

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138

Mean Excitation Energy of Fissioning Uranium Nuclei on Absorption of Slow π^-–Mesons

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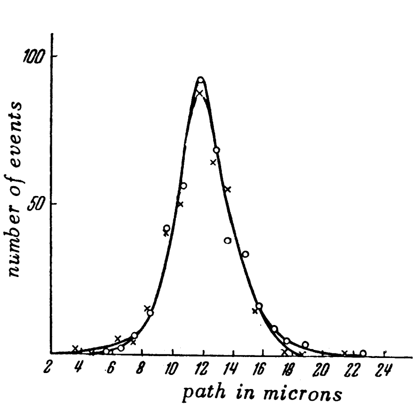
FISSIONING of uranium nuclei upon absorption of slow π^-–mesons[1] may be considered as a fission induced by fast nucleons resulting from the interaction between a π^-–meson and a pair of nucleons of the nucleus (n, p) or (p, p).* The fast nucleons produced may, in passing through a uranium nucleus, undergo collisions with the nucleus, giving rise to a nuclear-cascade process, and leave the nucleus in an excited state. The excited nucleus may lose energy by the evaporation of nucleons, undergoing fissioning at any of the stages of excitation. Thus, the fissioning on capture of slow π^-–mesons in reality can be reduced to the fission of nuclei induced by fast nucleons, and a comaprison of the data characterizing the fission of U^{238} nuclei byslow π^-–mesons and by protons of 140 mev energy represents great interest. Furthermore, the comparison provides a possibility of obtaining an evaluation for the mean excitation energy of the fissioning uranium nuclei on capture of slow π^-–mesons.

In the Figure the distribution curves are given as a function of the paths of the single fragments for the fission induced by π^-–mesons (crosses) and by protons with $E = 140$ mev (circles). There is good agreement between the two curves and they have one clearly expressed maximum. The coincidence of these curves, however, does not yet permit us to draw the conclusion that the mean excitation energies of the fissioning nuclei are equal in both cases, since in the region of comparatively larger mean excitation energies (from 80 to 160 mev) the shape of these curves does not change greatly.[4] It is significant that in fission by π^-–mesons there is a single clearly expressed maximum, indicating that the mean excitation energy in this case is definitely higher than 50 mev. (It is known that for the energy of a falling nucleon 45 mev, the distribution curve of the single fragments for uranium has two additional clearly expressed maxima[5]).

An evaluation of the upper limit of the mean excitation energy for π^-–mesons can be obtained by comparing the average number of charged evaporation particles per single fission: for slow π^-–mesons [1] and for protons with $E = 140$ mev[4] these are 0.04 and 0.14, respectively; the probabilities of fission are, respectively, 0.42[1] and 0.77[6] ($Z^2 A$ = 35.0 and 34.4). If, in accordance with our evaluation[4], the mean excitation energy is equal to 80 mev in the fission by protons of 140 mev, then for uranium nuclei fissioned by π^--mesons this value should be less than 80 mev, since in this case the average number of charged evaporation particles (0.04) is less than the corresponding value (0.14) in fission by protons of E = 140 mev. Therefore we may assign the following limits to the mean excitation energy in the fission of uranium on absorption of slow π^--mesons:

$$50 \text{ mev} \ll E_{\text{exc}} < 80 \text{ mev}.$$



This value differs somewhat from those given in the literature data. Thus, in investigation[7], the mean excitation energy of heavy nuclei in emulsion (Ag, Br) on absorption of slow π^--mesons was evaluated as $\sim$ 100 mev. However, a conclusion may be drawn that the mean excitation energy of the Ag, Br nuclei is considerably less than 100 mev, on comparison of some available experimental data. Thus, in the interaction of protons with E = 400 mev with the heavy nuclei of emulsion[8,9], the average number of charged evaporation particles is equal to approximately two (1.86 and 2.1). The mean excitation energy for these nuclei, calculated by the Monte Carlo method, for the interaction of protons of this energy is equal to 50 mev[10]; however, the average number of evaporation particles on capture of π^--mesons in the Ag, Br nuclei is considerably smaller and is equal to 1.1.[7] Even if we consider that in the interaction with protons many of the events without the ejection of ionized particles were missed, and if, accordingly, we take into account this possibility and recalculate the data for the π^--mesons, we obtain for the upper limit of the average number of charged particles the value of 1.72. From this it follows that the mean excitation energy of the Ag, Br nuclei from π^--mesons does not exceed 50 mev, which does nor contradict the evaluation of the mean excitation energy for uranium which we have obtained. In conclusion, we should draw attention to the considerable difference in the probabilities of uranium 0.42[1] and 0.75[6] on capture of slow π^-- mesons and on interaction with protons of E = 140 mev. This difference can be explained to some degree by the difference in the values of the paramter Z^2/A, characterizing the probability of fissioning in both cases.

The above-described peculiarities in the fission of uranium nuclei on capture of π^--mesons may be qualitatively explained if we assume that on absorption of a π^--meson by a heavy nucleus the most probable interaction is that between a meson and a pair of nucleons of the outer shell of the nucleus. Then it is most probable that only one of the produced fast nucleons will pass through the nucleus, undergoing collisions, while the other will leave the nucleus without interacting with the nucleons. From this it follows directly that the mean excitation energy of the nucleus cannot exceed 70 mev, since each of the interacted nucleons will receive an energy of $\sim$ 70 mev.

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*From the data of the investigations,[2,3] the interaction of a π^--meson is most probable with the (n, p) pair.

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135