Identification of a maximum in the angular distribution of protons emitted during the interaction of relativistic alpha-particles with lead nuclei

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Results are presented of measurement of the velocity spectra and angular distributions of secondary particles emitted during the collision of alpha-particles with energies of 3.6 GeV/nucleon with lead nuclei. A maximum in the angular distribution for velocities ~0.5 sec may be explained by a model of a shock wave propagating in the nuclear material.

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We report here the results of experimental studies of the velocity spectra of secondary particles emitted as a result of interaction between alpha-particles with energies of 3.6 GeV/nucleon with lead nuclei for a large number of scattering angles in the range from 30 to 150°. The measurements were carried out on the external beam of the Dubna synchrocyclotron, using the same methodology as employed earlier.[1,2]

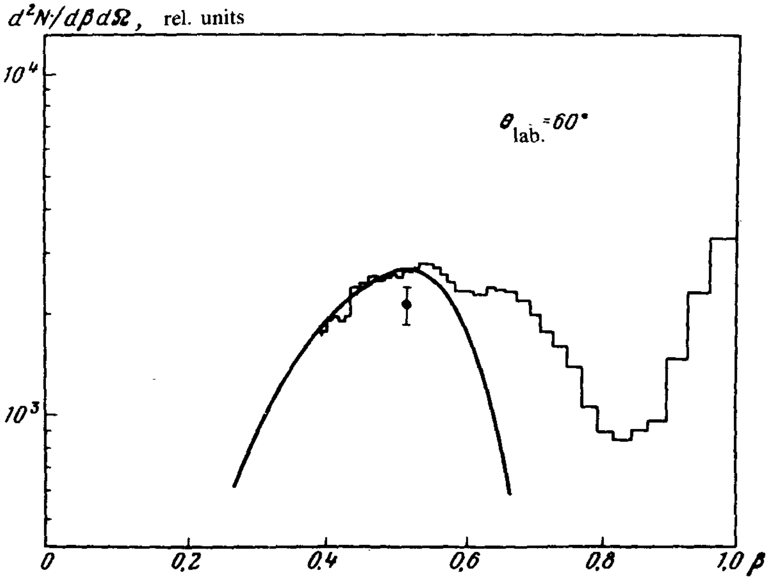

FIG. 1. Experimental velocity spectrum of single-charged particles emitted at 60° in the laboratory frame due to collision of alpha-particles with energies of 3.6 GeV/nucleon with lead nuclei (histogram). Continuous line—results of calculations using a propagating shock wave model with $\mu = 60°$ and $E_{CT} = 81$ MeV.

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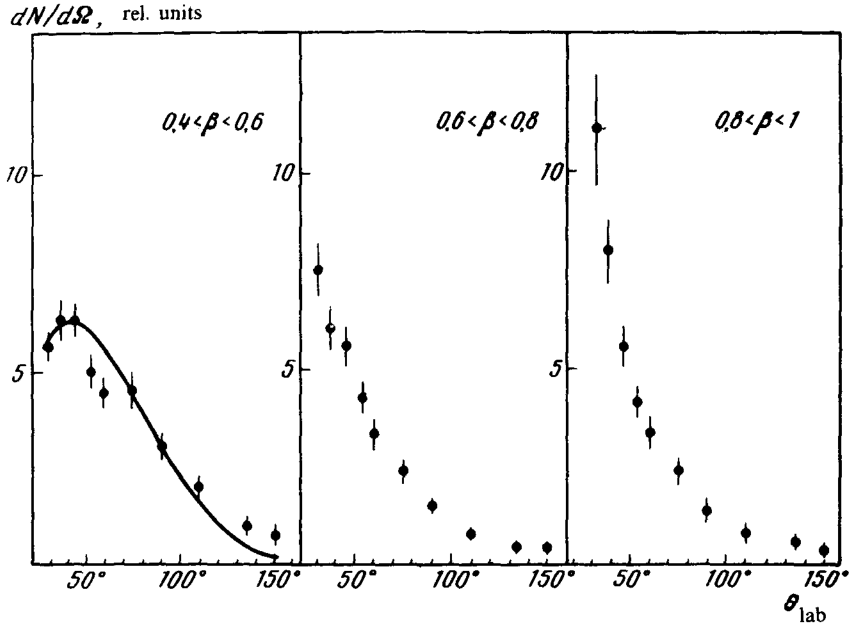

FIG. 2. Experimental angular distributions of single-charged particles emitted due to collision of alpha-particles with energies of 3.6 GeV/nucleon with lead nuclei for three velocity regions. Solid curve—results of calculations (see Fig. 1).

The characteristic features of these spectra—one of which is shown in Fig. 1—were described earlier.[2]

The measurements also enabled us to find the angular distribution of secondary, single-charged particles for the following velocity ranges: $0.4\leqslant\beta<0.6$; $0.6\leqslant\beta<0.8$, and $0.8\leqslant\beta<1$. The first range corresponds to a broad maximum in the velocity spectrum identified earlier,[2] which was observed for all angles up to 90°. The bulk of the secondary particles consist of protons ($\sim 90\%$) with a small number of deuterium and tritium nuclei. The range $0.8\leqslant\beta<1$ consists predominantly of π-mesons. Figure 2 shows the angular distributions we obtained. If in the last two ranges—which correspond to high velocities—we observed cross sections that decreased sharply with increasing angles. In the velocity range $0.4\leqslant\beta<0.6$ the angular distribution exhibited a broad ($\sim 50°$) maximum at a 45° angle in a laboratory frame. This result differs sharply from the structureless angular distributions reported earlier.[3]

It could be assumed that the special features identified in the angular distributions of secondary products are associated with the collective motion of the nuclear material. In this connection, we calculated the velocity spectra and angular distributions using a simple model of a conical shock wave.[4] The model does not consider the mechanism of generation of the shock wave and the following parameters which characterize it are phenomenologically introduced: the Mach angle μ and the mean energy of random motion of a particle behind the front E_{CT}. The results of calculations are weakly dependent on the choice of the equation of state of the nuclear material which in our case was the same as in Refs. 5 and 6. These results for values of $\mu = 60°$ and $E_{CT} = 81$ MeV are shown as continuous curves. A comparison of these shows good agreement with the experimental data for this simple model.

Thus, the maxima which we identified provide an explanation based on the excitation of the nuclear shock wave.

[1]K.V. Karadzhev, E.A. Kuz'min, A.A. Kurashov, V.I. Man'ko, A.A. Ogloblin, V.V. Paramonov, A.A. Tsvetkov, and G.B. Yan'kov, Tezisy dokladov XXVIII Soveshcheniya po yadernoĭ spektroskopii i strukture atomnogo yadra (Proceedings of the 28th Conference on Nuclear Spectroscopy and Atomic Nuclear Structure). L., Nauka, 1978, 213 p.

[2]V.G. Antonenko, V.M. Galitskis, Yu. I. Grigor'yan, M.S. Ippolitov, K.V. Karadzhev, E.A. Kuz'min, V.I. Man'ko, A.A. Ogloblin, and G.B. Yan'kov, Pis'ma Zh. Eksp. Teor. Fiz. **28**, 609 (1978) [JETP Lett. **28**, 561 (1978)].

[3]J. Gosset, H.H. Gutbrod, W.G. Meyer, A.M. Poscanzer, A. Sandoval, R. Stock, and G.D. Westfall, Phys. Rev. C **16**, 619 (1977).

[4]V.G. Antonenko and V.I. Man'ko, Preprint IAE-2740, 1976.

[5]A.A. Amsden, G.F. Bertsch, F.A. Harlow, and J.R. Nix, Phys. Rev. Lett. **35**, 905 (1975).

[6]W. Scheid, H. Muller, and W. Greiner, Phys. Rev. Lett. **32**, 741 (1974).