PHYSICS

1961

SovietRxiv

Fig. 1. Angular distribution of fragments at proton energies of 100 MeV (solid line) and 200 MeV (dashed line)

Figure 1: Fig. 1. Angular distribution of fragments at proton energies of 100 MeV (solid line) and 200 MeV (dashed line)

Abstract

Full Text

PHYSICS

M. M. MAKAROV and N. A. PERFILOV

ON FRAGMENTATION ON LIGHT NUCLEI

(Presented by Academician B. P. Konstantinov, 3 II 1961)

To clarify the mechanism by which multiply charged particles appear in nuclear disintegrations, we previously noted ([1]) the need to study fragmentation at proton energies below and near the threshold for meson production. In the present note brief results of such an investigation are given.

P-9 (g) nuclear photoemulsions were irradiated with an extracted beam of protons at the synchrocyclotron of the Joint Institute for Nuclear Research. The proton energies were 100, 200, and 350 MeV. Stars containing tracks of multiply charged particles were studied in the photographic plates. The measurement results are given below.

1) The cross sections for the formation of fragments with charge $Z \geq 4$ and with range $l > 15\,\mu$ on C, N, O nuclei are 0.50 ± 0.34, 0.92 ± 0.54, and 1.60 ± 0.38 mb for proton energies of 100, 200, and 300 MeV, respectively.

2) The most probable range, within the experimental errors, is the same for proton energies of 100 and 200 MeV.

3) All fragments are directed into the forward hemisphere with respect to the direction of the proton beam. The lower the proton energy, the more pronounced the forward directionality (see Fig. 1).

Fig. 1. Angular distribution of fragments at proton energies of 100 MeV (solid line) and 200 MeV (dashed line)

4) Table 1 gives the angular distribution of cascade protons ($E_p > 20 \div 30$ MeV) in stars with fragments, relative to the beam. Also given there are the angular distributions of cascade nucleons calculated by the Monte Carlo method ([2]) and experimentally determined for ordinary (without fragments) stars on light nuclei, which coincide.

Table 1

Angle in deg.	0–20	20–40	40–60	60–80	80–100	100–120	>120
Number of protons, expt. (2)	11	22	7	8	3	1	1
Number of protons, calc. (2)	12	24	8	2	–	2	2
Number of protons, expt., present work	2	8	13	10	8	7	14

As can be seen from Table 1, the distribution observed by us differs sharply from that given in work (2), mainly because of the considerable contribution of angles $> 120°$. This fact may be interpreted as a consequence of the fact that the nuclear cascade does not always proceed through purely nucleon–nucleon collisions, but also through collisions of the nucleon–substructure type. In this case the appearance of fragments is the result of quasi-elastic scattering of protons—incident ones or those arising in the course of cascade development—on substructures of the nucleus.

It should be noted that this point of view does not contradict the experimental facts of work (3), in which it was found that the scattering cross section of protons with energies of 350-600 MeV through an angle of $180 \pm 15°$, after collision with a substructure of 8-12 nucleons, is no greater than $3 \cdot 10^{-33}$ cm^2/sterad. Indeed, there are grounds to suppose (4) that, as the proton energy increases (above 100 MeV), the probability of their interaction with substructures will decrease. Therefore the quasielastic scattering cross section measured in work (3) proved to be so small. This also follows from the fact (5) that the differential cross section of elastic ($p\alpha$) interaction, $d\sigma/d\Omega$, at proton scattering angles of 165–180° decreases by approximately a factor of 20 when going from a proton energy of 95 MeV to an energy of 147 MeV (for the angle 165°, $d\sigma/d\Omega$ is $6.9 \cdot 10^{-30}$ and $1.24 \cdot 10^{-28}$ cm^2/sterad at proton energies of 147 and 95 MeV, respectively).

In conclusion, it may be added that our results do not completely rule out other probable mechanisms of fragmentation, such as pick up or nuclear breakup; however, they are more consistent with the possibility of formation of fragments in quasielastic scattering of nucleons by nuclear substructures.

V. G. Khlopin Radium Institute
Academy of Sciences of the USSR

Received
24 I 1961

CITED LITERATURE

1. U. R. Arifkhanov, M. M. Makarov, N. A. Perfilov, V. P. Shamov, ZhETF, **38**, 115 (1960).
2. H. Muirhead, W. Roser, Phil. Mag., **46**, 652 (1955).
3. G. A. Leksin, Yu. P. Kumekin, ZhETF, **33**, 1147 (1957).
4. V. I. Ostroumov, R. A. Filov, ZhETF, **37**, 643 (1959).
5. A. M. Cormack, J. N. Palmieri, N. F. Ramsey, R. W. Wilson, Phys. Rev., **115**, 599 (1959); W. Selove, J. M. Teem, Phys. Rev., **112**, 1658 (1958).

Note: Figure translations are in progress. See original paper for figures.