HOW ARE PARTICLE PRODUCTION, NUCLEON EMISSION, AND TARGET FRAGMENT EVAPORATION PROCESSES INTERRELATED IN HADRON-NUCLEUS COLLISIONS ?

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ABSTRACT

Relations between particle production, nucleon emission, and fragment evaporation processes were searched for in hadron-nucleus collisions. It has been stated that: 1. The nucleon emission and target fragment evaporation proceed independently of the particle production process. 2. Relation between multiplicities of the emitted protons and of the evaporated charged fragments is expressed by simple formula.

1. Introduction

When high energy hadrons - with energies larger than the pion production threshold - collide with atomic nuclei, nucleons are emitted always, target fragment evaporated, and particles may be generated, as it has been stated experimentally.

The emission of nucleons with kinetic energies of about 20 - 400 MeV, or of the so called g-track leaving particles, and the evaporation of the target nucleus fragments may occur without particle production. The question arises therefore: "How are the particle production, nucleon emission, and target fragment evaporation processes interrelated ?"

The answer to this question should be found experimentally. In this paper, results obtained in our searches for the relations in question are presented.

2. Method

In investigations we have used the 26 and 180 litre xenon bubble chambers, Kanarek T.I. et al. (1959), Kuznetsov E.V. et al. (1970), exposed to pion beams from the synchrophasotron of the Joint Institute for Nuclear Research at Dubna and from the accelerator of the Institute of Experimental and Theoretical Physics in Moscow.

General information about pion-xenon nucleus collisions is contained in a set of Communications of the Joint Institute for Nuclear Research at Dubna, Strugalski Z. et al. (1982, 1983); we applied for the analysis in this work the DST used in them. Additional appropriate information at higher energies we have found in various emulsion works : Andersson B. et al. (1978), Babecki J. and Nowak G. (1978), Bannik B. P. et al. (1980), Gurtu A. et al. (1974), Meyer H. et al. (1963), Otterlund I. et al. (1978), Tsai-Chü et al. (1977), Winzelel H. (1965); the accelerator data there are up to 400 GeV of the incident hadron energy in the laboratory system, some data from cosmic rays, Meyer H. et al. (1963) are up to about 3 500 GeV.

The method of investigation is based on the fact that at energies much larger than the pion production threshold hadron-nucleus collision events occur in which intensive emission of nucleons proceeds without particle production, without pion production in particular. It consists in preparation of various characteristics of the emitted nucleons - of the emitted protons in particular - in dependence on the multiplicity $n_{\pi} = 0, 1, 2, 3, \ldots$ of produced pions of any electric charge. Clearly : 1. We prepare firstly a set of various dependences of the characteristics of the emitted protons on the multiplicities n_{π} of produced pions , at 2 - 9 GeV/c momentum, and we discover general features of these dependences. It should be mentioned here that in the xenon chambers we register practically all the emitted protons and all the produced pions of any electric charge. 2. Secondly, we compare available characteristics of the proton emission process at higher energies, up to about 3 500 GeV, with corresponding characteristics in pion-xenon nucleus collisions at 2 - 9 GeV. Results of such a comparison allow to conclude about the behaviour of the nucleon emission process with the incident hadron energy increase, in other words - with increase of the multiplicity of produced particles. 3. Thirdly, we investigate the dependences of characteristics of the fragment evaporation process on the multiplicity n_p of the emitted protons at various hadron energy.

This way, the effects of the particle production process on the nucleon emission and fragment evaporation processes, and the relation between the nucleon emission process and fragment evaporation process may be discovered.

3. Results

In result of the analysis of various characteristics in question, Strugalski Z. (1984), it can be concluded that:

a) The particle production process in hadron-nucleus collisions does not effect on the nucleon emission process in them at any energy of the incident hadron.

b) The evaporation process of the fragments from the target nuclei in hadron-nucleus collisions is not influenced by the particle production process at any projectile energy.

The analysis in details of the sequence of the three processes - particle production, nucleon emission, and target fragment evaporation allows to conclude that: Any hadron with energy higher than the pion production threshold causes emission of nucleons with kinetic energies from about 20 up to about 400 MeV from the target nucleus, in passing through it; the nucleon emission may, in many cases, go in advance of the particle-producing collision of the incident hadron inside the target nucleus; the fragment evaporation process appears in result of the target nucleus damage due to the nucleon emission; the multiplicity n_p of protons emitted and the multiplicity $\langle n_b \rangle$ of the charged fragments evaporated are connected by simple formula

$$\langle n_b \rangle = 1.25\left(n_p + \frac{A-Z}{Z} \right)$$

where A and Z are the mass and charge numbers of the target nucleus, Strugalski Z. (1984).

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