

ENERGY-RANGE RELATIONS FOR HADRONS IN NUCLEAR MATTER

Strugalski Z.

Institute of Physics of the Warsaw Technical University

ul. Koszykowa 75

00-662 Warsaw, Poland

and

Joint Institute for Nuclear Research, High Energy Labor.

at Dubna, USSR

ABSTRACT

Range-energy relations for hadrons in nuclear matter exists, similarly to the range-energy relations for charged particles in materials.

1. Introduction

When hadrons of GeV kinetic energies collide with atomic nuclei massive enough, events occur in which incident hadron is stopped completely inside the target nucleus without causing particle production - without pion production in particular. The "stoppings" are always accompanied by intensive emission of nucleons with kinetic energy from about 20 up to about 400 MeV, Strugalski Z., Pluta J. (1974), Strugalski Z., Pawlak T., Pluta J. (1982). We showed experimentally that the mean number $\langle n_N \rangle$ of the emitted nucleons is a measure of the mean path $\langle \lambda \rangle$ in nuclear matter in nucleons/S on which the incident hadrons are stopped, where $S = \pi D_0^2 \approx 10 \text{ fm}^2$ and D_0 is the nucleon diameter, Strugalski Z. (1978, 1979, 1984):

$$\langle n_N \rangle \approx \langle \lambda \rangle S \quad (1)$$

Similar relation can be written for the mean multiplicity $\langle n_p \rangle$ of emitted protons only, usually observed in experiments:

$$\langle n_p \rangle \approx \langle \lambda \rangle S \frac{Z}{A}, \quad (2)$$

where Z and A are the charge and mass numbers of the target nucleus.

It is known as well, from our experiments, that the mean number $\langle n_p \rangle$ of protons emitted in the "stopped" events decreases with the incident hadron energy E_h decrease.

The question arises: Is the mean path $\langle \lambda \rangle$, in nucleons/S, of the incident hadron in nuclear matter related definitely to its kinetic energy E_h or not? The answer to the question should be found primarily in experiments, and we would like to find it.

2. Experimental Determination of the Range-Energy Relation

The method of determination of the relation between the hadron range R_h and the incident hadron energy E_h is simple - it consists in a determining of the mean multiplicities $\langle n_N \rangle$ or $\langle n \rangle$ in the "stopped" collision events of a definite hadron with a definite massive target nucleus at various energies E_h . Such measurements have been performed at two values of E_h : $E_h = E_\pi = 2.12$ GeV and $E_h = E_\pi = 3.2$ GeV, using pion-xenon nucleus collisions. For both the values of E_h the ratio

$$\epsilon_h = \frac{E_h}{\langle n \rangle} = \frac{E_h}{R_h} \quad (3)$$

is practically the same: $\epsilon_h = \epsilon_\pi = 180$ MeV/(nucleon/S). It enables us to suppose that the relation exists

$$E_h = R_h \epsilon_h, \quad (4)$$

where E_h is in MeV, R_h is in nucleons/S, and ϵ_h is in MeV/(nucleons/S).

Using data on the "stopped" events in proton-AgBr collisions, Sumbera M. and Vokal S. (1982), we determined the quantity $\epsilon_h = \epsilon_p = 360$ MeV/(nucleon/S), for incident protons.

The results obtained are based only on a few experimental points, at two values of E_h for the pion-xenon nucleus collisions and on one value of E_h for the proton-AgBr collisions. It would be not needless to test relation (4) in some other way. We have done it. Namely, we have made an expectation for the probability for the occurrence of the "stopped" events in dependence on the incident hadron energy E_h in pion-xenon nucleus collisions at values of E_h : 2.1, 3.2, 5, 9 GeV. Predictions are based on the relation (4), they are in agreement with corresponding experimental data, fig. ; more details concerning the calculations one can find in one of my works, Strugalski Z. (1983).

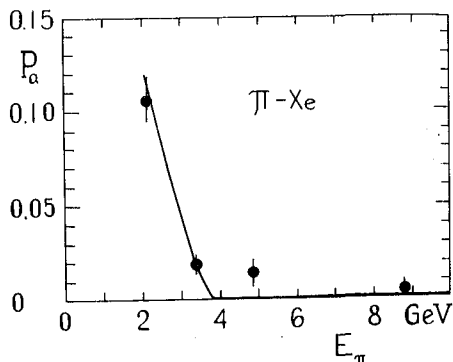


Fig. Probability P of the appearance of the pion-xenon nucleus collision events in which incident pion is stopped inside the target nucleus, in dependence on the incident pion momentum P_π . ● - experimental data, — - calculations, using formula (4) and data on the xenon nucleus, Strugalski (1983).

3. Conclusions

In result of the measurements, we obtained that definite relation exists in nuclear matter between the hadron range R_h and the kinetic energy E_h of this hadron. This relation is an analog to similar range-energy relation in materials, for electrically charged particles.

Relation (4), together with relations (1) and (2), allows to understand the energy-dependences of the mean multiplicity of the emitted nucleons in hadron-nucleus collisions at energies smaller than a few GeV, Strugalski Z. (1984), Abdurakhimov E.O. et al. (1978).

Relation (4) helps to determine the hadron energy loss in nuclear matter, from the energy-dependence of the mean multiplicity $\langle n_p \rangle$ of emitted protons in any-type hadron-nucleus collision reactions, as well, Strugalski Z. (1985).

References

- Abdurakhimov E.O. et al., 1978, Sov. Journ. of Nuclear Physics, 27, 1020.
 Strugalski Z., Pluta J., 1974, Sov. Journ. of Nuclear Physics, 20, 504.
 Strugalski Z., Pawlak T., Pluta J., 1982, Communications JINR, Dubna: E1-82-234, E1-82-718, E1-82-719, E1-82-841.
 Strugalski Z., 1978, Communications JINR, Dubna, E1-11976.
 Strugalski Z., 1979, Communications JINR, Dubna, E1-12086.
 Strugalski Z., 1983, Communications JINR, Dubna, E1-83-850.
 Strugalski Z., 1984, Communications JINR, Dubna: E1-84-268, E1-84-853, E1-84-194.
 Strugalski Z., 1985, Communications JINR, Dubna, E1-85-231.
 Sumbera M., Vokal S., 1982, Acta Physica Slov. 32, 265.