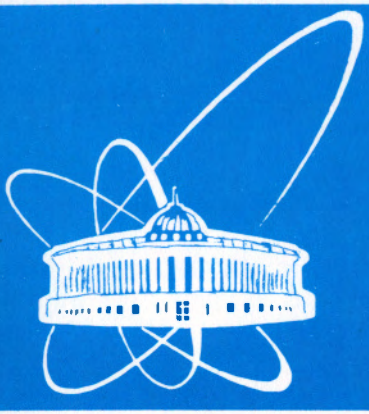

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E.Strugalska-Gola*, Z.Strugalski*

TRANSMUTATIONS OF ATOMIC NUCLEI IN HADRON-NUCLEI NUCLEAR COLLISIONS AT GeV ENERGIES

*Institute of Atomic Energy, 05-400 Otwock-Świerk, Poland
e-mail: elasg@hp2.cyf.gov.pl; zstrug@hp2.cyf.gov.pl

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1. INTRODUCTION

The subject matter of this work is a presentation of the results of hadron-nucleus and nucleus-nucleus collisions experimental studies. The mechanisms of these collision processes [1,2] are used as a basis for studies of the nuclei transmutations in the nuclear collisions.

The studies are based on our experimental materials and on experimental data collected by several other authors in investigations performed for many years with the use of photographic emulsions and heavy liquid bubble chambers [3—6].

The changes of one element into another (base metals into gold, especially) were principal objective, medieval chemical arts of alchemy — an early form of chemistry with philosophical and magical associations. With a development of the knowledge on radioactivity the attention of physicists to the problems of element transmutations was reconstituted because of real possibility of heavy atomic nuclei to break up into light fragments. The discovery of Otto Hahn with Fritz Strassman in 1939 showed that it was possible to split a Uranium 235 nucleus into two massive parts. But in 1939, E.Rutherford published the article «The Transmutations of Heavy Elements» [7] and the book «The Newer Alchemy» [8].

In this work, after the Introduction, the following topics are subjects of considerations: a) the mechanism of nuclei transmutations — as prompted experimentally; b) conclusions and remarks on applicability of the results obtained.

2. THE MECHANISM OF NUCLEI TRANSMUTATION PROCESS — AS PROMPTED EXPERIMENTALLY

Atomic nuclei change their mass- and charge-numbers A and Z if bombarded by fast hadrons or nuclei; the transmutation appears as a complicated process. It proceeds in a definite way — through a few stages or phases of the hadron-nucleus and nucleus-nucleus collision processes.

Adequate total and accurate identification of any of the emitted and evaporated nucleons and charged light target fragments in any of the nuclear collision events provides a possibility of determining quantitatively the transmutation products at any of the stages or phases of the collision and correspondingly of the transmutation process.

The mechanism of the transmutation of the target nucleus was prompted experimentally. In the first stage of the collision lasting nearly $10^{-24} - 10^{-23}$s the target nucleus is pierced by the projectile. The projectile involved the intranuclear matter into strong interaction within the channel centred on its course; the diameter D of the channel is roughly as large as two strong interaction ranges $R_s, D \approx 2R_s; R_s \approx D_0$, where D_0 is the nucleon diameter. The fast nucleons (20–500 MeV of kinetic energy) are emitted from the intranuclear region involved in the collision. The target nucleus is left by the projectile as locally damaged and excited. In the next stage, the target nucleus is transmuted in a definite way: $Z' \rightarrow Z - n_p$ and $A' \rightarrow A - (n_p + n_n)$, where n_p and n_n are the numbers of the emitted fast protons and neutrons. The number of the emitted nucleons $n_N = (n_p + n_n)$ may be estimated simply enough, the emitted protons and their emission intensity n_p are observable quantities. The residual target nucleus (A', Z') is unstable although. It must emit (evaporate) some number of the light nuclear fragments (known as the black tracks) if registered in nuclear photoemulsion.

The mean number $\langle n_b \rangle$ of such black tracks depends on the number n_p of the fast protons emitted in the fast stage of the collision:

$$\langle n_b \rangle = 1.25 \{n_p + ([A - Z]/Z)\}.$$

The number n_N of the emitted fast nucleons is defined always by the hadron-nucleus collision impact parameter in a hadron-nucleus nuclear collision.

In our opinion, the experimentally based knowledge about the mechanism of nuclei, transmutation by fast hadrons and nuclei is substantial. It may form a physical foundation of a method of radioactive waste transmutation in power energetics and in nuclear chemistry.

3. CONCLUSIONS

The above shortly presented data on the mechanism of hadron-nucleus collision processes and the mechanisms of target-nuclei transmutations in them provide a basis for working out a practical quantitative method for realization of the nuclei transmutation in beams of nucleons and various nuclei.

Practically, all the quantitative data in question can be found in references for the publications cited in this work.

The testing of such method may be done at the LHE accelerators.

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