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The effect of the electron screening in the D(3He, p)4He reaction in deuterated metals

In recent decades, the issue of increasing cross sections of the thermonuclear reactions in the low-energy region has become relevant. This phenomenon is associated with the effect of the electron screening, which consists in reducing the Coulomb energy between interacting nuclei by the electrons of the surrounding substance. The study of this phenomenon is important in the astrophysics, since research in this area can shed light on the issues of the Big Bang Nucleosynthesis [1], as well as resolves a number of questions in the field of a stellar dynamics. At the same time, the application of this effect can be found in the design and material science of the thermonuclear reactors.

A specific feature of light nuclei synthesis reactions in the astrophysical energy region is that the electron screening potentials obtained in the experiments are higher than those calculated in the adiabatic limit. This has not been explained in theoretical studies so far [2]. The situation is even more dramatic in the study of reactions to solid targets [3,4]. In this work we present the results of the study of D(3He, p)4He reactions using deuterated Ti and Zr targets.

The D(3He, p)4He reaction was investigated at the pulsed plasma Hall accelerator (Tomsk) in the 3He+ energy range EHe = 16÷34 keV (E = 6.41÷13.61 keV in the center-of-mass system) with a step of 2 keV. The aim of this work was to experimentally determine the enhancement factor of the D(3He, p)4He reaction and the electron screening potential of Ue using TiD and ZrD targets. In this work, two types of targets with different crystal structures were used: channeling and screening with Miller indices [100] and [111], respectively. Targets were placed on a stainless steel substrate 50 μm thick. The registration of protons from the D(3He, p)4He reaction (Ep = 14.7 MeV) was carried out by the detector based on a plastic scintillator BC-404 (d = 115 mm, thickness 4 mm). The pulse operation mode of the accelerator and the background events measurement in the intervals between pulses of the accelerator made it possible to suppress the background events registration.

The measured screening potentials of the D(3He, p)4He reaction in deuterated Ti and Zr metals are almost an order of magnitude higher than for gas targets and reach values of the order of Ue = 1255 eV for the conditions of the present experiment. The enhancement factor obtained on a TiD target with a Miller index [100] reaches 8.1 for E = 6.51 keV, which is ˜ 2 times greater than the value obtained for the ZrD target [100]. At the same time, the values of the enhancement factors obtained for ZrD and TiD targets with the Miller index [111] differ by only 20% and amount to ˜ 3, which is 3 times more than for the calculated curve. These results clearly indicate of the channeling effect on the reaction yield. In this case, energy behavior of the enhancement factor of the D(3He, p)4He reaction is not described by the classical exponential formula.

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Primary authors: Mr NURKIN, Azamat (National Research Tomsk Polytechnic University); Mr BYSTRITSKY, V. (Joint Institute for Nuclear Research); Mr DUDKIN, G. (National Research Tomsk Polytechnic University); Mr CHUMAKOV, D. (National Research Tomsk Polytechnic University); Mr FILIPOWICZ, M. (Faculty of Energy and Fuels, University of Science and Technologies); Mr PHILIPPOV, A. (Joint Institute for Nuclear Research); Mr NECHAEV, B. (National Research Tomsk Polytechnic University); Mr PADALKO, V. (National Research Tomsk Polytechnic University); Mr PEN'KOV, F. (Institute of Nuclear Physics, Ministry of Energy, al-Farabi Kazakh National University); Mr TULEUSHEV, Yu. (Institute of Nuclear Physics, Ministry of Energy); Mr VARLACHEV, V. (National Research Tomsk Polytechnic University); Mr ZHAKANBAEV, E. (Institute of Nuclear Physics, Ministry of Energy)

Presenter: Mr NURKIN, Azamat (National Research Tomsk Polytechnic University)

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