PROTONS FROM THREE-BODY AND FOUR-BODY BREAK-UP IN THE DD-COLLISIONS

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Formation of protons in three-body and four-body break-up reactions: $D + D \rightarrow p + n + d$ and $D + D \rightarrow p + n + p + n$ were considered. Inclusive spectra of protons in the proton energy ranges of $5 \leq E_p \leq 40$ MeV at initial deuteron energy E_d=36.9 MeV were studied experimentally. The experiment was carried out at U-240 cyclotron of the Institute for Nuclear Research of NAS of Ukraine. Measurements were carried out on CD_2 and ^{12}C targets – for determination of background, created by carbon target in spectrum from CD_2 target. Energy and angular distributions of protons in the angle range $15° \leq \theta \leq 55°$ were obtained. Absolute values of the cross-sections are detected with accuracy of ~15%. Energy spectra of protons are broad, practically symmetrical maximums, and their shape is similar to energy spectra of protons and neutrons from reactions D(d,n), available in literature for energies of $10 \leq E_d \leq 60$ MeV.

In this paper, for analysis of inclusive spectra of protons from D(d,p)nd reactions, there is used microscopic diffraction model that allow to determine quantitatively contributions of quasi-free scattering cross-sections and distinguish the part of cross-section that is caused by other interaction processes in the output reaction channel. Analysis has shown that three-particles breakup reactions make significant contribution to cross-section of proton generation in all range of exit angles; and, for angles $\theta_p \geq 30°$, contribution of protons from D(d,p)nd reactions is a definitive one.

Among four-particle reactions, following were selected: $D(d,d^*)d^* \rightarrow p+n+p+n$ – decay of two deuterons with generation of two unbound couples neutron-proton in triplet spin state; exchange reactions with generation of dineutron and diproton couple – D(d,2p)2n. For satisfactory matching of energy and angular distributions of protons, it is necessary to take into account mainly the contribution of cross-sections for generation of np couples in singlet and triplet spin states. For proton exit angle θ_p=15°, total contribution of cross-sections for generation of *n*p couples in singlet and triplet spin states is ~40%., and for angle θ_p= 3° respective contribution decreases to 20–25%.