Radiative ^{3}He(^{2}H,γ)^{5}Li capture at astrophysical energy and its possible role in accumulation of ^{6}Li at the BBN

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We see the interest to the radiative capture reactions in the isobar-analogue channels ^{3}He(^{2}H, γ)^{5}Li and ^{3}H(^{2}H, γ)^{5}He is due to following two main reasons. The new data may be found in [1] on their application in the diagnostics of nuclear fusion efficiencies of ^{2}H(^{3}H, n)^{4}He and ^{2}H(^{3}He, p)^{4}He reactions used for study of tokamak plasmas in experiments on JET and ITER. The latest data on plasma diagnostics are presented in [2].

These reactions are also parts of nucleosynthesis chain of the processes occurring on the early stage of stable stars formation, as well as possible candidates for the overcoming of the well-known problem of the $A = 5$ gap in the synthesis of light elements in the primordial Universe [3].

There is an "unambiguous" opinion: due to the smallness of the cross section of the ^{3}He(^{2}H, γ)^{5}Li reaction, it does not contribute to the astrophysical processes [4]. However, this statement is not entirely true, since the rate of this reaction is not negligible. In addition, we consider a possible scenario for astrophysical processes of ^{6}Li formation involving a short-lived ^{5}Li isotope.

The radiative ^{3}He(^{2}H, γ)^{5}Li capture is considered on the basis of the modified potential cluster model (MPCM) [5] and new results are obtained for dipole $E1$ and $M1$ transitions, taking into account the mixing of the doublet and quartet spin channels, both in scattering states and for the bound ground state. The potentials of the intercluster interaction were constructed on the basis of the description of the known scattering phase shifts and the main characteristics of the ground state (GS) of ^{5}Li. The total cross sections of the ^{3}He(^{2}H, γ)^{5}Li capture at energies from 5 keV to 5 MeV in c.m. are calculated on the GS of ^{5}Li. For the astrophysical S-factor and the rate of this reaction, obtained in these calculations, simple analytic parametrizations are proposed.

The parametrization of the cross sections for the ^{3}H(^{3}He, γ)^{6}Li and ^{5}Li(n, γ)^{6}Li processes of radiative capture is carried out. Corresponding the rates of these processes were calculated, their parametrization was performed, and a comparison with the ^{3}He(^{2}H, γ)^{5}Li and ^{4}He(^{2}H, γ)^{6}Li capture reactions rate was made.

On the basis of comparisons of the rates of these reactions and the prevalence of light elements, it is assumed that the two-step process ^{2}H + ^{3}He $\rightarrow$ ^{5}Li + γ and n + ^{5}Li +γ $\rightarrow$ ^{6}Li + γ can make a definite contribution to the production of ^{6}Li at the BBN at least at temperatures T_9 of the order of unity. In this temperature range the number of neutrons has not yet begun to decrease, and the number of ^{2}H and ^{3}He nuclei is already reaching its maximum, which leads to increase in the reaction yield ^{2}H + ^{3}He $\rightarrow$ ^{5}Li + γ.

References

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