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ASTROPHYSICAL S-FACTOR AND REACTION RATE OF THE RADIATIVE $^3H(p,\gamma)^4He$ CAPTURE

Abstract. Calculations of the astrophysical S-factor of the proton radiative capture on ^3H at energies from 1 keV to 10 MeV in the frame of Modified Potential Cluster Model with classification of orbital states of nuclear particles according to Young tableaux and isospin were carried out and the possibility of description of available experimental data in the energy range from 50 keV to 5 MeV is shown. We calculated rate of this reaction from 0.05 to 2 T_9, because it can play certain role in the primordial nucleosynthesis of the Universe.

Key words: Nuclear astrophysics; primordial nucleosynthesis; light atomic nuclei; astrophysical energies; radiative capture; thermonuclear processes; potential cluster model; forbidden states, p^3H system.

1. Introduction

The proton capture on ^3H reaction is of interest from both theoretical and experimental points of view for understanding the dynamics of photonuclear processes involving the lightest atomic nuclei at low and ultralow, i.e., astrophysical energies [1]. It also plays a role in the nucleosynthesis of primordial elements in the early Universe [1-3] leading to the pre-stellar formation of ^4He nuclei. Therefore, experimental studies of this reaction continue. New data for the total cross section of proton radiative capture on ^3H and the astrophysical *S*-factor in the energy range from 50 keV to 5 MeV [4] and at 12 and 39 keV [5] in the center of mass system (c.m.) have been obtained. These data will be used by us for further comparison with the calculation results. In addition, we ought to note other experimental studies of the photodisintegration of ^4He carried out, for example, in works [6]. Also, interesting theoretical results for photodisintegration of this nucleus into the p^3H channel were published in [7], including, on the basis of *ab initio* studies (see, for example, [8]).

Upon cooling to a temperature of ~0.8 MeV, the processes of the primordial nucleosynthesis became possible [9,10] with the formation of stable ^2H, ^3He and ^4He nuclei and, also stable in the first minutes of the Universe, the ^3H nucleus. These reactions are shown in Table 1 – the processes of the radiative capture are marked by italic. In table also the data of the *S*-factors and total cross sections at low energies in the energy range 10 – 20 keV were given with references to original works with these results. Table 1 shows that only one of these reactions, No.4, results in energy absorption Q<0. All of the others lead to energy release Q>0. Some inverse nuclear reactions, for example, photodisintegration of $^{3,4}He$ and $^{2,3}H$ by gamma-quantum cannot occur because of their extremely low energies at which weak processes cannot keep the balance [10]. Therefore the constant synthesis of stable nuclei without their further disintegration to lighter nuclei becomes possible.

Table 1 - Basic reaction of the primordial nucleosynthesis with light nuclei

No.	Process	Released energy in MeV	Astrophysical *S*-factor in keV b at 10 – 20 keV in center of mass – the accurate energy is stated in square brackets	The total cross section σ_t in μb for the given energy	Reference
1.	$p+n \rightarrow {}^{2}H+\gamma$	2.225	$3.18(25)\cdot10^{-3}$ [10.0]	$3.18(25)\cdot10^{2}$ [10.0]	[11]
2.	${}^{2}H+p \rightarrow {}^{3}He+\gamma$	5.494	$3.0(6)\cdot10^{-4}$ [10.4]	$1.0(2)\cdot10^{-2}$ [10.4]	[12]
3.	${}^{2}H+n \rightarrow {}^{3}H+\gamma$	6.257	$1.2\cdot10^{-5}$ [10.5]*	1.1 [10.5]*	[13]
4.	^{3}H+p → ^{3}He+n	–0.763 (see [14])	2536 [12]***	81537 [roughly at 12 keV above the threshold or 1.03354 MeV in l.s.]	[15]
5.	^{3}He+n → ^{3}H+p	0.764	63.2 [10.3]	$6.14(16)\cdot10^{6}$ [10.3]	[16]
6.	${}^{3}H+p \rightarrow {}^{4}He+\gamma$	19.814	$2.2\cdot10^{-3}$ [10.0]	$4.0\cdot10^{-2}$ [10.0]	[5]
7.	${}^{3}He+n \rightarrow {}^{4}He+\gamma$	20.578	$1.7\cdot10^{-4}$ [18.4]	9.2(2.0) [18.4]	[17]
8.	^{2}H+^{2}H → ^{3}He+n	3.269	51.4(2.0) [9.94]	241.3(9.4) [9.94]**	[18]
			53.05(0.55) [10.0]***	255.1(2.9) [10.0]	[19]
9.	^{2}H+^{2}H → ^{3}H+p	4.033	56.1(1.6) [9.97]	270.4(7.6) [9.97]	[20]
10.	^{2}H+^{3}He→^{4}He+p	18.353	7480(200) [10.7]	0.5(1) [10.7]**	[21]
11.	^{2}H+^{3}H→^{4}He+n	17.589	12328.4 [9]***	14200 [9]	[22]
12.	${}^{2}H+{}^{2}H\rightarrow{}^{4}He+\gamma$	23.847	$5.7(2.4)\cdot10^{-6}$ [10.0]	$2.9(1.2)\cdot10^{-5}$ [10.0]	[23]
13.	${}^{2}H+{}^{3}He\rightarrow{}^{5}Li+\gamma$	16.66	0.41 [111]***	5.3 [111]	[24]
14.	${}^{2}H+{}^{3}H\rightarrow{}^{5}He+\gamma$	16.792	0.17 [90]***	50 [90]	[24]

* - theoretical value calculated on the basis of the Modified Potential Cluster Model

** - the value calculated on the basis of the *S*-factor

*** - the value calculated on the basis of the total cross section

This was the situation when the Universe was about 100 sec old and the number of protons and neutrons was comparable – approximately 0.2 neutrons to each proton. The epoch of primordial nucleosynthesis finished at approximately 200 sec [9] by which time practically all neutrons are bound into ^{4}He nuclei and the number of ^{4}He is about 25% of the number of ^{1}H nuclei. At that point the content of ^{2}H and ^{3}He relative to ^{1}H was about 10^{-4}–10^{-6} [1–3,10].

Thus ^{4}He was the last nucleus to emerge at the initial stage of nucleosynthesis because heavier nuclei such as C and O could only be synthesized in the process of nuclear reactions in stars. The reason for this is the existence of some an instability gap for light nuclei (A = 5), which, apparently, cannot be bridged in the process of initial nucleosynthesis. In principle, ^{4}He could have given rise to heavier nuclei (A = 7) in the ${}^{4}\mathrm{He} + {}^{3}\mathrm{H} \rightarrow {}^{7}\mathrm{Li} + \gamma$ and ${}^{4}\mathrm{He} + {}^{3}\mathrm{He} \rightarrow {}^{7}\mathrm{Be} + \gamma$ reactions. However the Coulomb barrier for these reactions is about 1 MeV while the kinetic energy of the nuclei at temperatures of ~1 T_9 is of the order of 0.1 MeV and probability of such reactions will be negligible [25]. The mechanism of synthesis of ^{4}He explains its abundance in the Universe confirms its origin at the pre-stellar stage and corroborates the Big Bang theory.

It is important to estimate the *S*-factors of reactions 1–14. For example, as will be seen further, the astrophysical *S*-factor of proton capture on ^{2}H at an energy of 1 keV is in 5–10 times lower than the *S*-factor of the proton capture on ^{3}H at the same energy [13]. This means that the latter process, which contributes to the formation of ^{4}He in primordial nucleosynthesis, is much more likely, in spite of the lower abundance of ^{3}H relative to ^{2}H [9,10,26]. Most data available in the literature [1–4,13,25] relate to the abundance of elements such as ^{3}He at present time. This is generally confirmed by modern astrophysical observations [9,26]. However, the abundance of ^{3}H for the first 100–200 s after the Big Bang cannot be much smaller than that of ^{2}H since the neutron capture reaction, in spite of the reduction of neutron numbers down to 0.2 of the proton numbers, can go on deuteron at any energy. In addition, the half-life of ^{3}H is 4500(8) days [27] and do not make a real contribution to the decrease of the number of ^{3}H at the first few minutes after the Big Bang.

The quantity of tritium, additionally to process No.3, also increases due to reactions No.5 and No.9, but can decrease due to processes No.6 and 11. At energies lower than 0.8 MeV reaction No.4 makes virtually no contribution to reductions in tritium. Meanwhile, the total cross section of reaction No.11 is about 14.2 mb at 9 keV [22] and of the reaction No.6 is about $4\cdot10^{-2}$ □b at 10 keV [5] show their small relative contributions to the formation of ^{4}He. However the number of deuterons available for reaction No.11 is approximately 4–5 orders of magnitude less than the number of protons taking part in reaction No.6. Therefore the overall contribution of the two reactions in pre-stellar formation of ^{4}He will be similar.

Reaction No.12 proceeds with comparatively low probability, since the $E1$ process is forbidden by the isospin selection rules. This leads to the factor $\left(Z_1/m_1^J+(-1)^J Z_2/m_2^J\right)$ at multipolarity of γ-quantum of $J = 1$ [13]. This product defines the value of the total cross sections of the radiative capture and $E1$ processes with the same Z/m ratio, for particles of the initial channel leads to zero cross sections. The probability of the allowed $E2$ transitions in such processes is usually nearly 1.5 to 2.0 orders of magnitude less [28] that was noted earlier in reviews [9,10].

Let us show furthermore the reaction rates given in work [29] in the form of parametrizations. Shape of these rates for first reactions, leading to the formation of ^{4}He or nuclei with mass of 3, is shown in Fig. 1. One can see that considered in this work reaction is at the third level for rate of forming ^{4}He and its rate in some times lower, for example, that the reaction rates of ^{3}H(d,n)^{4}He or ^{3}He(d,p)^{4}He. However, at the energy about 10 T_6 the rate of the last reaction equals the reaction rate of the proton radiative capture on ^{3}H.

All these results and more new data from works [30,31] show that the contribution of the ^{3}H(p,γ)^{4}He capture reaction into the processes of primordial nucleosynthesis is relatively small. However, it makes sense to consider this process for making the picture complete of the formation of prestellar ^{4}He and clearing of mechanisms of this reaction. In addition, as it was shown furthermore, our calculations of this reaction rate, based on the modern data of the astrophysical S-factors [5], lays slightly lower from the results of works [29,32-34]. The latest works do not take into account new data [4,5], which were taken into account by us in this work, and our results can be considered as an improved data on the rate of the considered reaction.

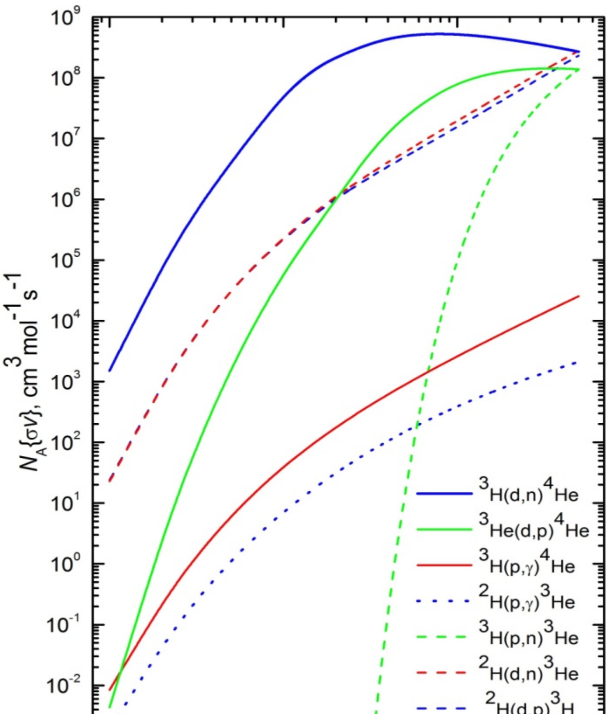

Figure 1 - Reaction rates from [29]

Moreover it should be noted that our understanding of the different stages in the formation of the Universe, of the processes of nucleosynthesis occurring in it and of the properties of new stars, is still developing. Therefore there is a pressing need to acquire new information on primordial nucleosynthesis and on the mechanisms of the Universe's formation and this is one of the main tasks for the construction of a unified cosmological model. All of this directly applies to the detailed study of the ^{3}H(p,γ)^{4}He capture reaction in the astrophysical energy region on the basis of the modern nuclear model. This model, as shown below, has already demonstrated its efficiency in the description of the characteristics of almost 30 such reactions [13,35-41].

2. Used model

Earlier in our works [13,35-37,40-42] the possibility of description of astrophysical *S*-factors or total cross-sections of the radioactive capture for three dozens of processes on the basis of two-body potential cluster model (PCM) was shown and also the preliminary results [43] for p^{3}H-capture at astrophysical energies have been obtained. The calculations of these reactions are carried out on the basis of the modified variant of PCM with forbidden states (FSs) [44] and classification of states according to Young tableaux (MPCM).

The well-defined success of the MPCM in the description of the total cross sections of this type can be explained by the fact that the potentials of the intercluster interaction in the continuous spectrum are constructed on the basis of the known elastic scattering phase shifts or structure of the resonance spectrum levels of the final nucleus, and for the discrete spectrum – on the basis of the main characteristics of the bound states (BSs) of such nuclei: the excited (ES) or the ground (GS) states. These intercluster potentials are based also on the classification of the cluster states according to Young tableaux [45], which enables one to determine the presence and quantity of the FSs in each partial wave. This means finding the number of wave function (WF) nodes in such cluster systems [35].

Furthermore, such potentials permit us to carry out the calculations of some basic characteristics of the considered particles interaction in the elastic scattering processes and reactions. For instance, these can be the astrophysical *S*-factors of the radiative capture reactions [46] or the total cross sections of these reactions [47]. Including radiative capture cross sections at the astrophysical and thermal energy range which has been considered in our previous papers [13,35-37,40-42]. On the basis of such conception we succeeded in the correct description of the total cross sections of the radiative capture processes of almost thirty reactions for light nuclei at thermal and astrophysical energies [13,35-37,40-42].

Therefore, continuing studying the thermonuclear reactions [13,35-37,40-42] on the basis of the MPCM [13,35] with separation of orbital states according to Young tableaux let us consider description of the astrophysical *S*-factor of the radiative proton capture on ^{3}H at energies of 1 keV–10 MeV and rate of this reaction from $T_9 = 0.05$ to $T_9 = 2$. Preliminary results on *S*-factor of this reaction at astrophysical energies in the frame of the MPCM were given in our previous work [43]. New results for the rate of the proton capture on ^{3}H were obtained here and comparison of our results from [43], published in 1995, and the newest experimental data also published in 1995 year too, given further and do not take into account in our work [43]. For carrying out of the present calculations the potentials of the scattering processes and bound p^{3}H states were improved and detailed classification orbital states of p^{3}H system according to Young tableaux and isospin is given. Basic methods and principles of the MPCM used here recently were partially given in [40], and more detailed in book [35].

3. Astrophysical S-factor of the proton capture on ^{3}H

Earlier in [43], based on the modified potential cluster model, the total cross sections and the astrophysical *S*-factor of the proton radiative capture process on ^{3}H were calculated. Meanwhile, it was assumed that the main contribution into the cross sections of *E*1 photodisintegration of ^{4}He in p^{3}H channel, or into the proton radiative capture on ^{3}H, was due to the isospin-flip transitions for which $\Delta T = 1$ [48]. Therefore, the $^1P_1$ potential for p^{3}He scattering in the pure with respect to isospin ($T = 1$) singlet state of this system and the ^1S potential for the ground pure with respect to the isospin $T = 0$ bound state of ^{4}He nucleus in p^{3}H channel [43] should be used in calculations.

Using these conceptions, the calculations of the *E*1 transition with refined potential of the ground state of ^{4}He (see Table 2) were carried out from the start, in comparison with [43]. The results of these calculations of the astrophysical *S*-factor at energies from 1 keV up to 10 MeV are shown in Figs. 2a and

2b by the green solid lines. In the energy region specifically from 10 keV, considered earlier in [43], and up to 10 MeV here the new results were obtained and they practically do not differ from our previous results given in [43].

Table 2 Pure with respect to isospin of $T = 0$ potentials of the Gaussian form for p^{3}H interactions in the singlet channel. Here, E_{GS} is the calculated bound ground state energy and E_{exp} is the experimental value of this energy [14]

System	^{2S+1}L	V_0 (MeV)	α (fm^{-2})	E_{GS} (MeV)	E_{exp} (MeV)
p^{3}H	^1S	-62.906841138	0.17	-19.81381000	-19.813810
	^1P	+8.0	0.03	–	–

New experimental data was taken from [4,5], and additional data from [49] not known to us earlier were also used. It can be seen from these figures that the calculations performed about 20 years ago [43] well reproduce the data on the *S*-factor obtained in [4] at energies of p^{3}H capture from 50 keV to 5 MeV (center of mass system). These data were published after the publication of our article [43] and have noticeably lower ambiguity at energies lower 1 MeV than do earlier results [50-53] and they more accurately determine the general behavior of the *S*-factor at low energies, practically coinciding with early data [49] in an energy range of 80–600 keV. The energy region above 1–2 MeV has been studied in many papers; therefore, for comparison, we are shown these earlier results in Fig. 2b, that demonstrate a large ambiguity of experimental measurements done in different time and works: circles [51], open squares [52], crosses (×) [53], and downward open triangles [50].

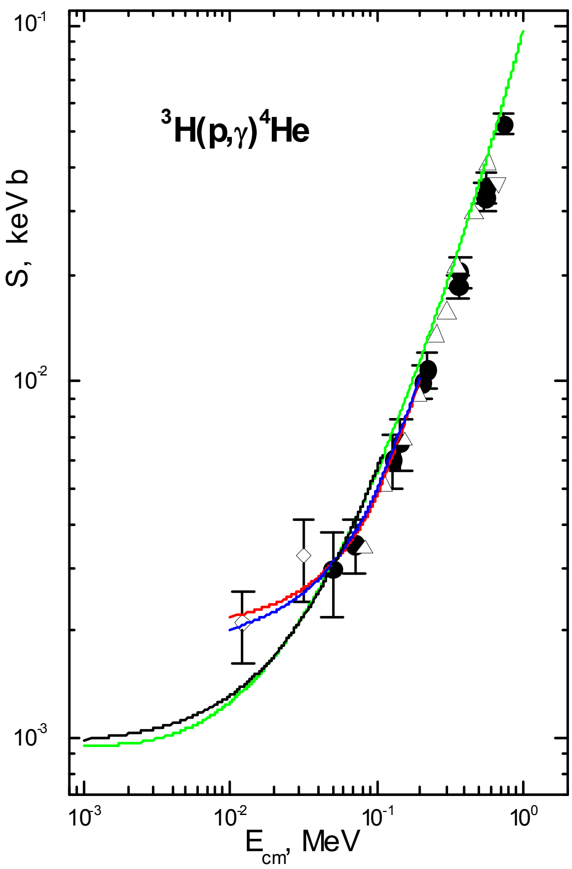

Figure 2a - Astrophysical *S*-factor of the proton radiative capture on ^{3}H in a range of 1 keV–1 MeV. Green line shows calculation with the GS ^1S potential given in Table 3, red line shows the results of approximation from [5], blue line shows results of approximation from [4], black line shows our approximation. Points show recalculation of total capture cross sections [4], given in [5], upward open triangles [49], rhombs [5], downward open triangles [50]

At the energy 1 keV the calculated value of the *S*-factor is equal to 0.95 eV b, and calculation results at energies less than 50 keV are slightly lower than data of [5], where for S_0 from the parametrization of the form

$$S(E_{c.m.}) = S_0 + E_{c.m}S_1 + E^2_{c.m}S_2, \quad (1)$$

the value 2.0(2) keV mb was obtained, for the S_1 parameter the value $1.6(4)\cdot10^{-2}$ mb in [5], and for the S_2 $1.1(3)\cdot10^{-4}$ mb keV^{-1} is given. The results of approximation by expression (1) with the given above parameters of experimental data [5] being in a good agreement with these data are shown in Fig. 2a by the red solid line.

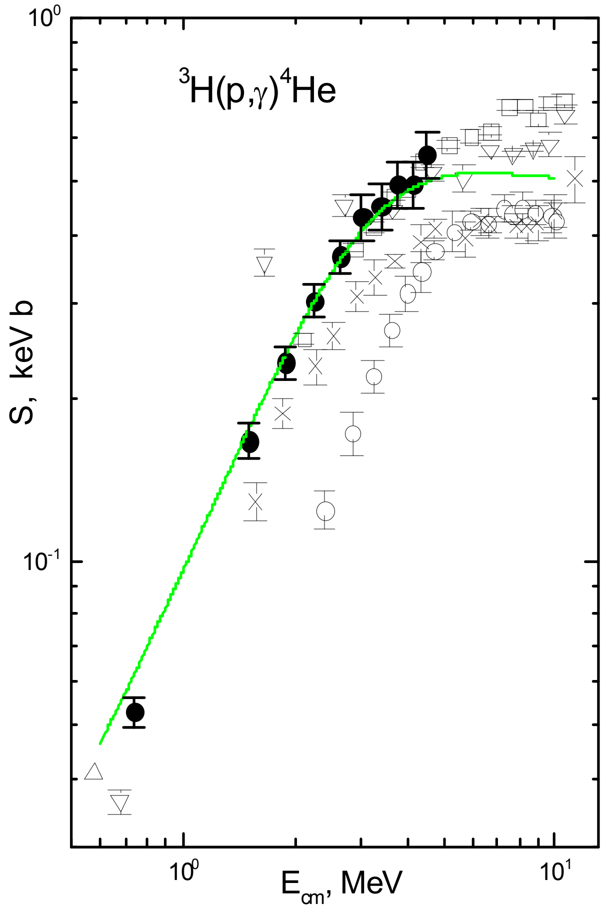

Figure 2b - Astrophysical S-factor of the proton radiative capture on ^{3}H in a range of 1÷10 MeV. Green line shows calculation with the GS potential given in Table 3. Points show recalculation of total capture cross sections [4] given in [5], upward open triangles [49], circles [51], open squares [52], crosses [53], and downward open triangles [50]

In [4] for the same values we found $S_0 = 1.8(1.5)$ keV mb, $S_1 = 2.0(3.4)\cdot10^{-2}$ mb and $S_2 = 1.1(1.4)\cdot10^{-4}$ mb·keV^{-1}. Results of such extrapolation are given in Fig. 2a by the blue solid line. However, the linear extrapolation of the available experimental data according to three latest points of works [4,49] to 1 keV leads to its value about 0.6(4) eV b, i.e., is three times less than it was in [5]. In addition, the data of [5] have relatively large error and, notably, are needed to be refined in future. In order to get rid of the existent data ambiguity of the S-factor of the proton capture on ^{3}H, we need its new measurements, even though in 2–3 points in the energy range approximately from 5–10 up to 30–50 keV.

It is seen from Fig. 2a that the calculated S-factor at the lowest energies, approximately at the region 1–3 keV, practically does not depend on energy. It affords ground for assumption that its value at zero energy practically does not differ from the value at 1 keV. Therefore, the difference of the S-factor at 0 and 1 keV, evidently will be equal not more than 0.05 eV b and this value one can consider as an error of determination of the calculated S-factor at zero energy, i.e., represent it in the form $S(0) = 0.95(5)$ eV b. If for parametrization of the calculated S-factor at the energy range 1–100 кэВ it is necessary to use quadratic form (1), so for its parameters it is possible to obtain the next values: $S_0 = 0.9530$ eV b, $S_1 = 3.497\ 10^{-2}$ eV b keV^{-1}, $S_2 = 1.216\ 10^{-4}$ eV b keV^{-2} at the value of $\chi^2 = 0.049$ at 10% errors of S-factor.

The results of such interpolation are shown in Fig. 2a by the black solid line. It is clear that expression (1) doesn't fit very well for interpolation of the calculated *S*-factor, especially lower 10–12 keV, since leads to the other shape of the line at low energies.

4. Reaction rate of the $^3H(p, \gamma)^4He$ radiative capture

Furthermore, in Fig. 3, the reaction rate $N_A<\sigma v>$ of the proton capture on ^3H is shown by the solid green line, which corresponds to the solid green line in Figs. 2a and 2b and is presented in the form [46]

$$N_A\langle\sigma v\rangle = 3.7313\cdot 10^4 \mu^{-1/2} T_9^{-3/2} \int_0^\infty \sigma(E) E \exp(-11.605 E / T_9) dE\,, \tag{2}$$

where $N_A\langle\sigma v\rangle$ is the reaction rate in cm^{3}mole^{-1}sec^{-1}, E is in MeV, the cross section σ (E) is measured in μb, μ is the reduced mass in amu, T_9 is the temperature in 10^9 K [46], which specifies in our calculations in the range from 0.05 to 2.0 T_9. Integration of the cross sections was carried out in the range 1 keV–2 MeV for 2000 steps with the step value of 1 keV. The expansion of this interval into the large side, for example, up to 3 MeV from 3000 steps at the same step led to a change of the reaction rate of about 1%.

We can see in Fig. 3 the sharp increase of the reaction rate value at low T_9 in the range 0.05–0.5. However, at larger T_9, approximately 1.5–2.0, $N_A\langle\sigma v\rangle$ almost reaches its saturation, tending to the value on the order of 10^4 cm^{3}mole^{-1}sec^{-1}. Finally note that we do not succeed to find other results on the rate of this reaction, obtained by using other methods, in order to make a comparison with our calculations.

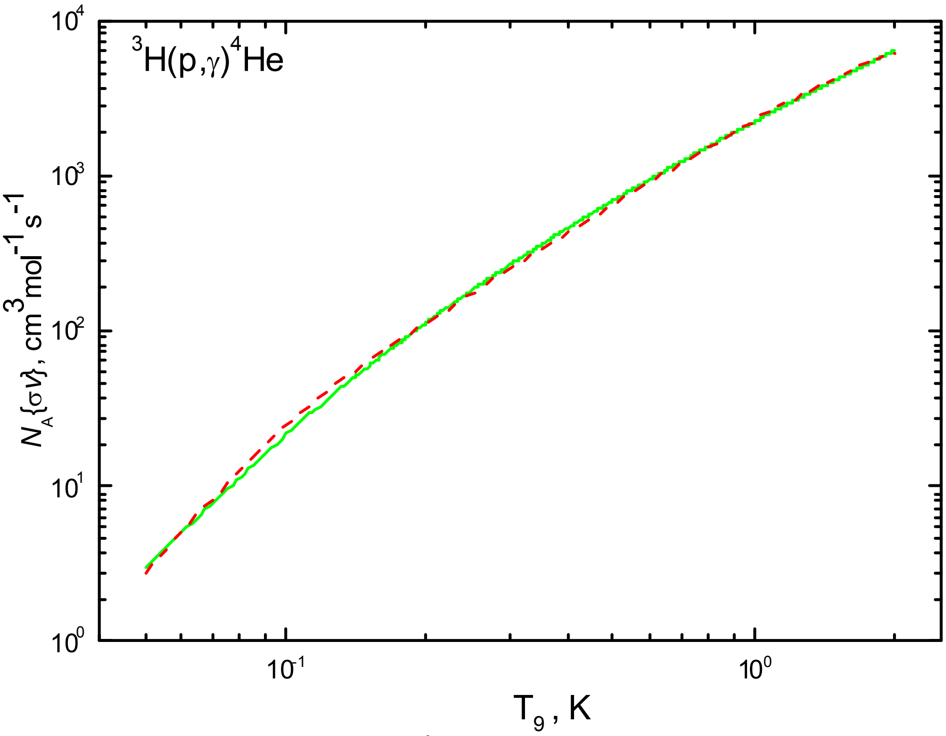

Figure 3 - Reaction rate of the proton radiative capture on ^3H. Green line is the calculation results for the GS potential from the Table 2, which correspond to cross sections shown in Fig. 2 by the green solid line. Dashed red line is reaction rate approximation by (3)

The resulting shape of the reaction rate in the range of 0.05–2.0 T_9 can be approximated by a general polynomial

$$N_A\langle\sigma v\rangle = \sum_{k=1}^{5} a_k T_9^{k-1} \tag{3}$$

with parameters given in Table 3.

Table 3 - Expansion parameters for the reaction rate of the form (3)

k	1	2	3	4	5
a_k	-9.0	105.5	2628.0	-313.0	-130.0

The result of the rate calculation with such parameters is shown in Figure 3 by dashed red line at the average value $\chi^2 = 1.33$ at 1% errors of the reaction rate. The increasing of the series dimension up to 7 leads to unessential improvement in the description of the theoretical curve. However, the reduction of dimension up to 4 leads to a sharp increasing of χ^2 up to a value of about 100.

5. Conclusion

Thereby, in the frame of considered modified potential cluster model based on the intercluster potentials describing elastic scattering phase shifts and characteristics of the binding state with the potential parameters suggested about 20 years ago [43], on the basis of only the $E1$ transition we succeeded in description of the general behavior of the *S*-factor of the proton capture on ^{3}H at energies from 50 to 700 keV. Really, on the basis of analysis of the experimental data above 700 keV [50] about 20 years ago we have done calculations of the *S*-factor for energies down to 10 keV [43]. As we can see it now, the results of these calculations reproduce well new data on the *S*-factor, obtained in [4] (points in Figs. 2a and 2b) at energies in the range 50 keV to 5 MeV.

However, the available experimental data on the *S*-factor at 50 keV and lower energies have a low enough accuracy and significant ambiguity, as it seen from Figure 2a. To avoid these ambiguities, it needs new additional and independent measurements of *S*-factor in the energy range from about 5–10 to 30–50 keV with minimal errors. The experimenters did not return to this problem for more than 10 years [5], while reliable measurements of *S*-factor at energies of 50 keV–5.0 MeV have been made more than 20 years ago [4]. Evidently, modern measurement techniques could reduce error value and obtain more reliable data, especially at the lowest energies. And this, in turn, will get rid of the existing ambiguities in determining the reaction rate.

The magnitude of p^{3}H capture reaction rate calculated in this paper at temperatures from 0.01 T_9 up to 5 T_9 leads to the conclusion that this reaction might make some contribution to the formation of ^{4}He nuclei in the primordial nucleosynthesis of elements in the Universe, especially at higher temperatures of order 3–5 T_9. The results obtained for the reaction rate due to their simple numerical approximation can be used later for the comparative evaluation of yield of ^{4}He produced in this reaction, and, perhaps, in order to determine their contribution to the abundance of helium nuclei formed in the primordial nucleosynthesis of the Universe.

We emphasize once again that we could not find the results of other papers with calculations of the astrophysical *S*-factor or the considerable reaction rate obtained by other methods, in spite of the appreciable interest that this reaction represents in terms of some astrophysical problems. Currently available errors of measurements of the astrophysical *S*-factor [5] may significantly affect the value of the reaction rate of radiation p^{3}H capture leading to ambiguities in calculations of ^{4}He yield and, ultimately, affect the results obtained for its abundance. Perhaps it is time to eliminate the existing problems in measuring the astrophysical *S*-factor of the considerable reaction and obtain, eventually, more accurate results for the reaction rate.

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АСТРОФИЗИКАЛЫҚ S-ФАКТОР ЖӘНЕ ^{3}H(p, γ)^{4}He РАДИАЦИЯЛЫҚ БАСЫП АЛУ РЕАКЦИЯЛАРЫНЫҢ ЖЫЛДАМДЫҒЫ

Аннотация. Түрленген әлеуетті кластерлік модель (ТӘКМ) шеңберінде Юнг сызбалары және изоспин бойынша ядролық бөлшектердің орбиталық жағдайының жіктеуімен 1 кэВ-дан 10 МэВ-ға дейінгі энергия кезінде радиациялық p^3H басып алу реакциясының астрофизикалық S-факторының есептері орындалды және 50 кэВ-дан 5 МэВ-ға дейінгі энергия аумағында қолда бар эксперименттік мәліметтерді сипаттау мүмкіндігі көрсетілді. Бұл реакция Әлемнің бастапқы нуклеосинтезінде белгілі бір рөл атқара алатындықтан, оның жылдамдығы 0.05-ден 2 T_9. дейінгі температураларда есептелген

Түйін сөздер: Ядролық астрофизика; бастапқы нюклеосинтез; жеңіл атом ядролар; астрофизикалық энергия; радиациялық басып алу; термоядролық процесстер; әлеуетті кластерлік модель; тыйым салынған жағдай, p^3H жүйе.

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АСТРОФИЗИЧЕСКИЙ S-ФАКТОР И СКОРОСТЬ РЕАКЦИИ РАДИАЦИОННОГО $3H(p,\gamma)^4He$ ЗАХВАТА

Аннотация. В рамках модифицированной потенциальной кластерной модели с классификацией орбитальных состояний ядерных частиц по схемам Юнга и изоспину выполнены расчеты астрофизического *S*-фактора реакции радиационного *p*3H захвата при энергиях от 1 кэВ до 10 МэВ и показана возможность описания имеющихся экспериментальных данных в области энергий от 50 кэВ до 5 МэВ. Поскольку эта реакция может играть определенную роль в первичном нуклеосинтезе Вселенной, рассчитана ее скорость при температурах от 0.05 до 2 Т9.

Ключевые слова: Ядерная астрофизика; первичный нюклеосинтез; легкие атомные ядра; астрофизические энергии; радиационный захват; термоядерные процессы; потенциальная кластерная модель; запрещенные состояния, *p*3H система.

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