Theoritical Study For Calculation The Neutron- Proton Energy Emitted From D-D Thermal Nuclear Fusion Reactions

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Abstract

The most important application in plasma physics deal with hydrogen in general the two branches of the reactions D(d,p)T and $D(d,n)^3$ He have approximately equal probability.
Isotopes(Deuteron and Tritium) in energy production fields, because of the greatest energy emitted from these reactions in comparison with other applications especially the fission reactions which have many dangerous effects.In the recent research we concentrated on the calculation of proton-neutron energy emitted srom D-D reaction as a function of deuteron energy and angle of reaction.

Theoretical Considerations

The nuclear fusion reactions are a reaction between two nuclei of light atoms such as (^{2}D and ^{3}T) leads to rearrangement their nuclei to compose another heavy atom and this reaction correspond with particles emission and energy released which called fusion energy as a result of the mass defect.
The nuclear fusion caused by heating called thermonuclear reaction (1).
In order to occur the fusion process it is necessary that the nuclei approach each others in very small distance and this need an energy to overcome the coulomb repulsion force and this process is exactly opposite to the fission product in which that occurs by neutron capture with a hesvy nuclei such as (^{235}U) and this atoms undergoes many spontaneouc fission with energy released.

Since the range of nuclear forces are approximately of the order magnitude (5×10^{-13}cm) we need an energy of a mount (0.3MeV) to overlaps the nuclei with each other, against coulomb repulsion force.
The most important nuclear fusion reaction used in applications are those so called (D-D),(D-T),(D-^{3}He) which given as follows (2) :-

$${}^2_1D + {}^2_1D \rightarrow {}^3_2He(0.82MeV) + {}^1_0n(2.45MeV)$$

$${}^2_1D + {}^2_1D \rightarrow {}^3_1T(1.01MeV) + {}^1_1H(3.02MeV)$$

$${}^2_1D + {}^3_1T \rightarrow {}^4_2He(3.5MeV) + {}^1_0n(14.1MeV)$$

$${}^2_1D + {}^3_2He \rightarrow {}^4_2He(3.66MeV) + {}^1_1H(14.64MeV)$$

In general the (D-D) nuclear reaction occurs with approximately equal probability and the cross-setions for the above reactions as a function of deuteron energy is presented in Fig.(1) (3).
It is necessary to maintain some useful points corresponding with the nuclear fusion reactions:-
-Released high energy from the above fusion reactions where about (3-4 MeV) and (17-18 MeV)for(D-D) and (D-T) reactions respectively.
-The charaged particle released with energy of about (60%) for (D-D)reaction and (20%) for (D-T) reaction.
-In addition that the (D-D) fusion reaction appear more likely because of the availability of deuterium in nature but the (D-T)fusion reactions are more suitable according to their high probability for interaction(2).
The energy for neutrons or protons emitted from (D-D)reactions depending on the energy of reacting deutrons (E_d)and on the reaction angle in the laboratory system (θ_L) is given by (4):-

$$\mathbf{E_{p,n} = \left(\frac{3}{4} Q_{p,n} + \frac{3}{8} E_d\right) \left[(1-\gamma^2 \sin^2\Theta_L)^{1/2} + \gamma \cos\Theta_L\right]^2}$$

Where

$\mathbf{Q_n = 3.27}$ **Mev ,** $\mathbf{Q_p = 4.03}$ **Mev and** $\gamma = \mathbf{[E_d/(6Q_{n,p} + 3E_d)]^{1/2}}$

The fast deuteron distribution function is chosen in the from:

$$f_d(E_d, \phi_d) = (\cos \frac{\phi_d}{2})^{n}_{d} f_e(E_d)$$

Where
ϕ_d and E_d

Are the initial deuteron direction and the deuteron energy, respectively.n_d represenst the anisotropic emission is described:

$$n_d = \frac{2\ln A_d}{\ln 2} \qquad \text{with} \qquad A_d = \frac{f(end-on)}{f(side-on)}.$$

Calculations and results

The energies for neutrons and protns emitted from the (D-D)reaction were deduced from the deuteron energies between (4and20KeV), and a reaction angle in the laboratory system between (30^0 and 90^0) in order to give a good comparison or evidence with the experimental results (5).

Calculated values for the energy of neutron and proton as a function of incident deuteron energy at a fixed reaction angle is presonted in Tables (1-5), and the general behavior for the variation of the emitted neutron, proton energies as a function of the incident deuteron energy are presented in figures (2-7).

Conclusions and discussion

From figs. (2-7) it is clearly appears the optimum agreement for the neutron-proton energy released values when compared with the standard experimental fixed in the equations for thermonuclear fusion reactions of type (D-D).

We concluded from the optimum agreement the good accuracy for calculating the energy values when compared with the fixed in the reaction equations which in terms reflect the exact confidence in using the theoretical formula and for these cases we compared our results with other published experimental results.

From above figures we concuded that the reaction angle play an important rule in calculating the energy for the released paticles

(proton, neutron) where when the reaction angle decreases the particles released energy increases and this effect is agree with the fact that the particles velocities is at maxmum values at the center (5-7).
It is necessary to apply the using equation in this recent research for others incident deuteron energies more than 20KeV(E_d>20KeV).

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Table(1) Relation between the incident deuteron energy and the neutron , proton energy at Θ=30^0.

	Θ=30^0	
E_d(KeV)	E_n (KeV)	E_p (KeV)
4	2514.929	3091.609
6	2529.452	3107.632
8	2541.838	3121.282
10	2552.858	3133.416
12	2562.909	3144.472
14	2572.225	3154.714
46	2580.961	3164.310
18	2589.222	3173.379
20	2597.085	3182.007

Table(2) Relation between the incident deuteron energy and neutron energy ,proton energy at $\Theta=45^0$.

$\Theta=45^0$		
E_d (KeV)	E_n (KeV)	E_p (KeV)
4	2503.555	3079.011
6	2515.451	3092.131
8	2525.600	3103.313
10	2534.634	3113.257
12	2542.877	3122.322
14	2550.520	3130.720
46	2557.688	3138.591
18	2564.468	3146.031
20	2570.923	3153.111

Table(3) Relation between the incident deuteron and neutron energy, proton energy at $\Theta=60^0$.

$\Theta=60^0$		
E_d (KeV)	E_n (KeV)	E_p (KeV)
4	2488.809	3062.668
6	2497.318	3072.044
8	2504.592	3080.049
10	2511.077	3087.178
12	2517.002	3093.684
14	2522.502	3099.719
46	2527.666	3105.381
18	2532.556	3110.738
20	2537.216	3115.840

Table(4) Relation between the incident deuteron and neutron energy, proton energy at $\Theta=75^0$.

$\Theta=75^0$		
E_d (KeV)	E_n (KeV)	E_p (KeV)
4	2471.743	3043.744
6	2476.364	3048.814
8	2480.344	3053.173
10	2483.615	3057.078
12	2487.196	3060.660
14	2460.256	3063.998
46	2493.143	3067.143
18	2495.887	3070.129
20	2498.512	3072.983

Table(5) Relation between the incident deuteron and neutron energy, proton energy at Θ=90°.

	Θ=90°	
E_d (KeV)	E_n (KeV)	E_p (KeV)
4	2453.556	3023.562
6	2454.068	3024.076
8	2454.579	3024.588
10	2455.088	3025.098
12	2455.597	3025.607
14	2456.104	3029.116
46	2456.612	3026.624
18	2457.118	3027.131
20	2457.625	3027.639

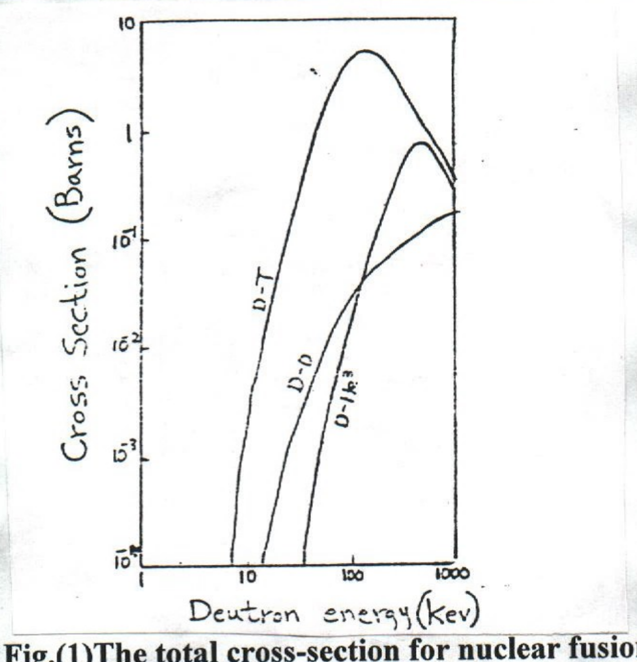
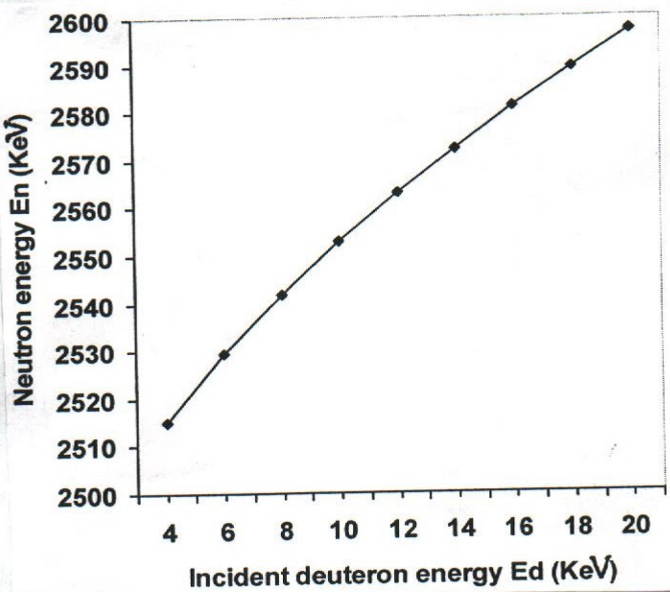


Fig.(1)The total cross-section for nuclear fusion reactions types (D-T,D-D,D-^{3}He) as a function of incident energy.



Fig(2) Variation of neutron energy as a function of incident deuteron energy at $\theta = 30^0$.

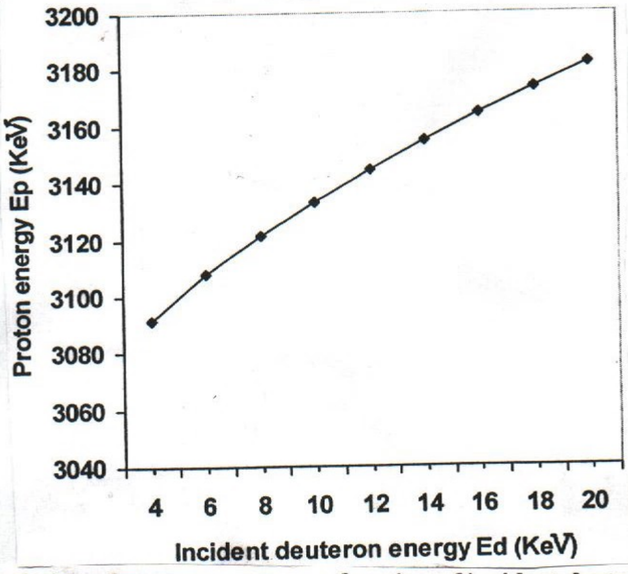


Fig.(3)Variation of proton energy as a function of incident deuteron energy at $\theta = 30^0$.

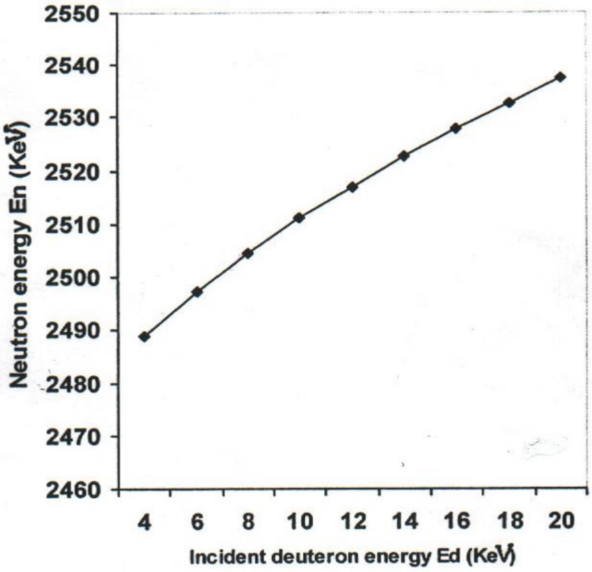


Fig.(4) Variation of neutron energy as a function of incident deuteron energy at $\theta = 60^0$.

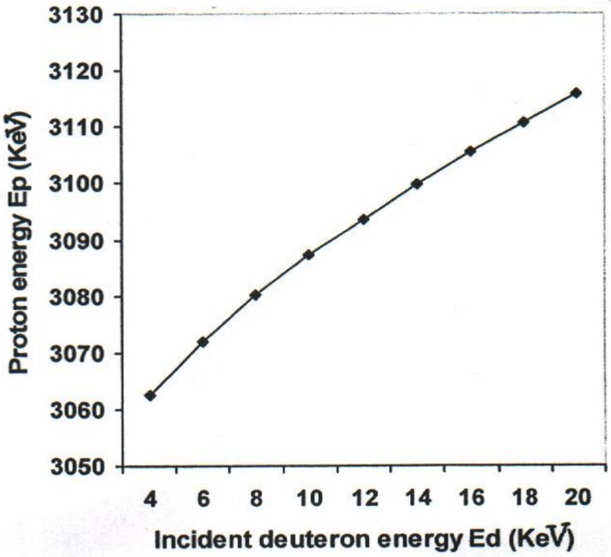


Fig.(5) Variation of proton energy as a function of incident deuteron energy at $\theta = 60^0$.

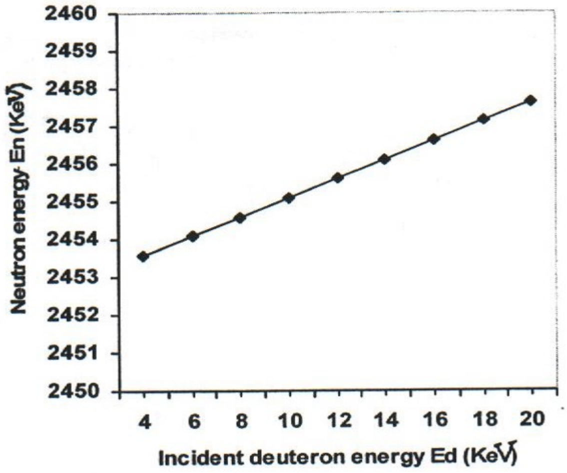


Fig.(6) Variation of neutron energy as a function of incident deuteron energy at $\theta=90^0$.

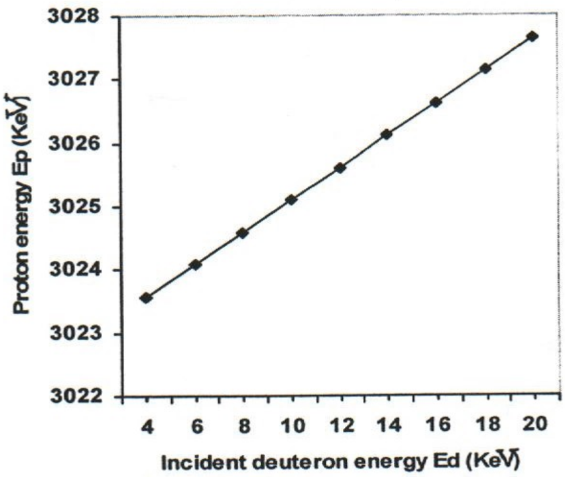


Fig.(7) Variation of proton energy as a function of incident deuteron energy at $\theta=90^0$.

دراسة نظرية لحساب طاقة النيوترون- البروتون المنبعثة من التفاعلات النووية الاندماجية الحرارية

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الخلاصة

من ابرز التطبيقات الحديثة في فيزياء البلازما وهي استغلال نظائر الهيدروجين الخفيف والثقيل (الديوترون والتريتيوم) في انتاج الطاقة بسب الطاقة الهائلة المنبعثة من هذه التفاعلات مقارنة" مع التطبقات الاخرى (المفاعلات الانشطارية) التي تتميز بمحاظرها الواسعة.

(المعلوم فيزيائيا" ان التفاعلات النووية الاندماجية الحرارية D(d,p)T و $D(d,n)^3$ He بصورة عامة تمتلك احتمالية متساوية لفرعي التفاعل).

في البحث الحالي تم التركيز على حساب طاقة البروتون- النيوترون المنبعثة من هذه التفاعلات كدالة لطاقة الديوترون الساقط وزاوية التفاعل.