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The Electron Catalyzed Fusion Model (ECFM) Reconsidered with Special Emphasis Upon the Production of Tritium and Neutrons

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Abstract

The author's ECFM ("Electron Catalyzed Fusion Model") first presented at the ICCF-4 is re-examined with special reference to the production of tritium and neutrons. The model is of some interest in that it is the first model to fit excess power-vs-loading fraction data of McKubre et al. (SRI International/EPRI) and, independently, that of Kunimatsu et al. (IMRA). Of special note is that the peak of the theoretical curve of tritium production versus loading fraction, which is related to that for neutrons by a branching ratio scaling factor, is found to be at a fractional D/Pd loading of approximately 0.825, which is in good agreement with the empirical value of 0.83 announced at the ICCF-5 by Iwamura et al.(Mitsubishi) for both tritium and neutrons. It is of interest then that this theoretical ECFM tritium production curve arises essentially from purely statistical mechanical considerations involving the deuteron occupation of the three-dimensional interstitial lattice, rather than arising from the details of a specific nuclear mechanism. The model shows why tritium is ordinarily not observed when excess heat is being observed. For the neutron-to-triton branching ratio a theoretical lower limit $(r/R)^{12}$ results (r is the protonic charge radius and R is the deuteronic charge radius.) yielding a value of 2×10^{-9} in agreement with the empirical value of 2×10^{-9} for the neutron-to-triton branching ratio.

1. Introduction: Review of the ECFM

The author's ECFM[6]("Electron Catalyzed Fusion Model") employs collapsed electron orbits catalyzing genuine cold fusion reactions between deuterons within the Pd. The orbital collapse is hypothesized to be the result of the weakening of the zero point field induced by the cathodic environment, as explained in reference (6). It is based upon work of Boyer[1,2] and Puthoff[3] according to which, on the basis of "stochastic electrodynamics" (SED), the electronic ground state of an electron in an atom is a dynamic state in which the energy radiated away by the accelerating electron is compensated for by stimulated absorption from the zero point electromagnetic field. The ECFM has been highly successful at fitting data on excess power versus loading fraction, S, for the data of McKubre et al.[4], (SRI International/EPRI)]as shown in Fig. 1, and for the data of Kunimatsu et al.[5] (IMRA)].

Fig. 1

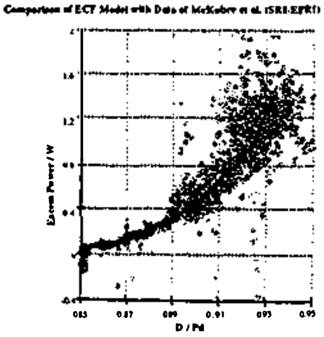
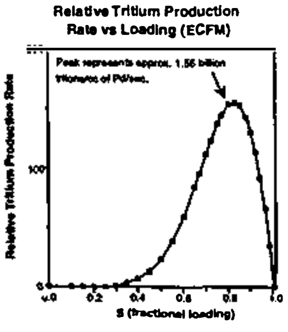


Fig. 2



2. Statistical Mechanical Picture: Tritium /Neutron Production vs Heat Production

Much of the dependence in the ECFM of the formulas for power or particle production upon S (fractional loading) arise from strictly statistical features of the deuteron occupation of the interstitial lattice. To that extent the S-functionality is independent of a specific nuclear mechanism and therefore exploitable. Thus, the experimental corroboration of such nuclear mechanism nonspecific behavior would provide additional proof that the phenomenon is genuine.

Consider a 1-dimensional interstitial lattice configuration:

(Key: ● represents an interstitial D, o represents an empty interstitial site.)

o ● o ● o ● o ● o ● o .... etc. (1)

(1) represents a hypothetical one dimensional lattice configuration for which no cold fusion occurs due to a lack of nearest-neighbor D's.

Clearly, then, any expression for excess power will contain a factor that is a function of loading fraction, S, and arises strictly from the statistical mechanical picture accounting for the different possible interstitial lattice configurations that can contribute to cold fusion. Quoting from ref.(6) we make the distinction in the context of the model between the situation for heat production and that of triton production (At this stage we merely note that neutron production is linked to triton production in the ECFM via a branching ratio.): "We hypothesize that the cold fusion reaction D + D -> He^4 + 24 MeV occurs for lattice configurations with nearest-neighbors on either side to produce a "sideways charge polarization" of the D's with protons directly opposite neutrons so that collisions are highly "guided" (lattice assisted anti-Tokamak regime):

o ● ● ● o + o ● ● ● ● o + o ● ● ● ● ● o + ... etc. (2)

(S^3) (S^4) (S^5)

Thus, each D near the center of these configurations sees a nearest-neighbor D on either side. It is further hypothesized that tritium and neutrons result from the opposite situation; viz. the oscillatory collision of two nearest-neighbor D's isolated from their neighbors for which charge polarization favors neutronic components of the D's facing each other, thus heavily favoring tritium production via D + D -> T + p + 4.03 Mev as an Oppenheimer-Phillips type nuclear reaction :

o ● ● o + o ● ● o ● ● o + o ● ● o ● ● o ● ● o +. . . .etc. (3)

$(1-S)^2 S^2$ $(1-S)^3 S^4$ $(1-S)^4 S^6$

For He^4 production the configurations in (2) yield a sum of probabilities (dependent upon fractional occupation, S):

$$p = S^3 + S^4 + S^5 + \dots \quad \text{etc.} \tag{4}$$

that, when combined with other considerations, leads to an expression for excess power production given by

$$P_{exc} = (26.07)\bullet\{[(2-S)/(1-S)]^3 S\}\bullet(e^{\theta/T} - 1)^{-1}\bullet 10^{[23.6 - (24.774)S^{-1/12}]} \tag{5}$$

3. Tritium Production on the Basis of the ECFM

From (3) the sum of the probabilities is

$$p = (1-S)^2 S^2 + (1-S)^3 S^4 + (1-S)^4 S^6 + \dots \quad \text{etc.} \tag{6}$$

Ref. (6) shows that this leads to the following

$$\underset{(\text{Tritons/cm}^3\text{/sec})}{N(S,T)} = (6.789\times 10^{12})\bullet S(1-S)[1 - (1-S)S^2]^{-3} \bullet (e^{\theta/T} - 1)^{-1}\bullet 10^{[23.6 - (24.774)S^{-1/12}]} \tag{7}$$

Fig. 2 shows a graph of triton production rate (tritons/cm^3 of Pd·sec) based upon (7) for a temperature of 60C showing a peak value of about 1.6 x 10^9 tritons/(cm3 of Pd.sec.). A computer study of the S-dependent part of (7) shows that the peak of the production curve is located at about S=0.825. This is of some interest since it was reported by Iwamura et al.[7] (Mitsubishi) at the ICCF-5 that tritium production was maximized at about S=0.83. (Presumably the uncertainty in their experimental result would put this in reasonable agreement. with S=0.825.) In a second ICCF-5 paper Iwamura et al.[8] reported that neutron emission was also maximized at about S=0.83. This feature is of special interest here since the ECFM simply relates neutron production to triton production via a branching ratio; i.e., the theoretical neutron production curve is simply a uniformly scaled down version for that of tritium.

In their abstract, Iwamura et al.[7] note that they had "previously reported that neutron emissions and tritium production were observed even with low deuterated palladium metals (D/Pd = 0.66). It is expected that the yield of nuclear products will increase using highly deuterated palladium metals (D/Pd = 0.8), since it has been widely recognized that anomalous nuclear effects are related to the D/Pd ratio." In this regard, note from Fig. 2 that the theoretical tritium (or neutron) production rate at S=0.66 would be about half of what it is at the peak of about S=0.83. Additionally we note from Fig. 2 that the curve plunges more steeply with S to the right of the peak than to the left. It is this latter feature that accounts for two general observations: (1)Tritium production is rarely observed simultaneously with excess heat production [Recall that excess power grows with increasing values of S above about 0.8.] (2)Neutron emission decreases as excess power increases. With regard to (2) note that Takahashi et al. [9] (Osaka University) in their ICCF-5 abstract state that "the neutron emission rate was about 2n/s at most and appeared to decrease when the excess heat rates increased, as was the case for our 1922 experiments." The present author[10] has reported observing a decrease in the emission rate of thermal neutrons as excess heat increases. Finally the neutron emission rate reported by Takahashi et al.[9] of about 2n/s is apparently in reasonable agreement with the prediction of the ECFM, which is now shown: Note from Fig 2 the value of 1.55 billion tritons/ cc of Pd.sec. Multiplying this by the theoretical branching ratio of 1.64 x 10^{-9} given in the next section yields a neutron production rate of about 2.54 neutrons/cc of Pd.sec. [In reference (6), Fig. 8 shows the theoretical tritium production vs S (ECF Model) for three different temperatures (100C, 600C, and 1200C) and emphasizes that the production peak does not shift with temperature, but remains fixed at about S=0.825.]

4. Neutron Production

Based upon the ECFM[6], neutron production is given by N in (7) multiplied by an appropriate branching ratio highly favoring (T,p)-production over (He^3,n)-production. The author[11] has derived an extreme limiting branching ratio based upon charge polarization considerations, which reduces to a good approximation to

$$BR = (r/R)^{12} \tag{8}$$

where r is the protonic charge radius, and R is the deuteronic charge radius.

Substituting $\mathbf{r = 0.8x10^{-13}}$ **cm**, and $\mathbf{R = 4.31x10^{-13}}$ **cm**, from DeBenedetti[12], yields

$$BR = 2 \times 10^{-9}, \tag{9}$$

which compares well with the best experimental value[13] for the smallest branching ratio given by about

$$(BR)_{exp} = 2 \times 10^{-9}. \tag{10}$$

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