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"Jones' Neutron Data Explained Using the TNCF Model – A Short Note –"

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Abstract

The first data of neutron detection in the cold fusion phenomenon by Jones et al. in 1989 and the following null result by the same group in a low background environment in 1993 were analyzed using the TNCF model, proposed by us. The result shows that it is possible to interpret the both experimental results consistently with a value $\sim 10^{11}$ cm^{-3} of the adjustable parameter n_n in the model, the density of the trapped neutrons supplied from the ambient background neutrons. The value of n_n is in the range of values determined earlier in various materials used in the cold fusion research with positive results.

1. Introduction

Now, it is not necessary to speak about the reality of the cold fusion phenomenon which was discovered in 1989 because there is so much evidence of the generation of the excess heat, tritium, helium ^{4}He, nuclear transmutation (NT) and others with good qualitative reproducibility in various materials and situations. The TNCF model[1–6] proposed by one of the present authors (H.K.) in 1993 at ICCF4 has been applied to more than 40 typical experimental data with success. The model is a phenomenological one with a single adjustable parameter n_n, the density of the assumed trapped neutron, with several supplementary premises which are not adjustable.

One of the most precise neutron measurements done in the cold fusion research by Jones et al.[7, 8] has shown at one time the existence of neutrons with an energy of 2.45 MeV, which was expected from a probable reaction between deuterons[7], and they have denied its existence in an experiment done in a laboratory with a very low neutron background[8]. These results tell us clearly that the cold fusion phenomenon is intimately related with the existence of background neutrons.

In addition to this information by Jones et al. about the relation of the cold fusion phenomenon and background neutrons, there are several evidences of the effects of thermal neutrons on the cold fusion phenomenon. The first published data by Shani et al.[9] and following by several[10 – 14] have shown clearly enhancement of the cold fusion products by irradiation of thermal neutrons on the cold fusion materials.

It is now well established that the most popular products of the cold fusion phenomenon are excess heat, tritium, helium ^{4}He and transmuted nuclei but not neutrons. The detection of neutrons had been tried successfully, but the occurrence was scarce compared with others. In addition to the scarcity of neutrons generation, the energy of the detected neutrons was in wide distribution, up to more than 10 MeV, and not restricted to the 2.45 MeV detected by Jones et al.[7] This riddle about neutrons in the cold fusion phenomenon misled many people to doubt and leave the reality of the phenomenon which was explored by a few enthusiastic pioneering scientists. Interpreting the experimental results as data obtained by probes for the cold fusion phenomenon, we have disclosed some phases of the entangled facts in the phenomenon by the TNCF model[1–6].

In this paper, we will show the consistency of the experimental data obtained by Jones et al.[7, 8] with others and again enforce the reality of the cold fusion phenomenon.

2. Experimental Data of Jones et al.

Jones et al.[7] made a precise measurement of 2.45 MeV neutrons from electrolytic cells with Pd and Ti cathodes and an electrolytic solution of several electrolytes. The electrolyte was typically a mixture of ~ 160 **g** D_2O plus various metal salts in ~ 0.1 g amount each: $FeSO_4$-$7H_2O$, $NiC1_2$-$6H_2O$, $PdCl_2$, $CaCO_3$, Ll_2SO_4-H_2O, Na_2SO_4-$10H_2O$, $CaH_4(PO_4)2$-H_2O, $TiOSO_4$-H_2S0_4-$8H_2O$.

There were 5 runs out of 14 with a significant amount of neutrons more than experimental errors. We'll take up one of 5 cases, run-number 6, a particularly noteworthy one with a statistical significance of approximately five standard deviations above background, as the authors of the original paper[7] described. Fused titanium pellets were used as the negative electrode, with a total mass of ~ 3 g. The neutron production rate increased after about one hour of electrolysis. After about eight hours, the rate dropped dramatically, as shown in the follow-on run 7. The experimental rate of neutron detection was $(4.1 \pm 0.8) \times 10^{-3} s^{-1}$ with the neutron detection efficiency including geometrical acceptance 1.0 ± 0.3%. The D/Ti ratio was estimated at 2.

This result of neutron detection means that the observed neutron generation is 0.4/s from a fused Ti cathode of three spheres of 1 g each, the volume of which was ~0.22 cm^3 and a linear dimension ~ 7.4 mm.

3. Analysis of the Experimental Data

We will analyze the above experimental data of run 6 using the TNCF model in this section.

From our point of view, the trapped neutrons in the TNCF model are supplied initially from the ambient background neutrons. In a situation where is no background neutron, therefore, the parameter n_n, the density of the trapped neutrons is expected to be zero and no event of the cold fusion phenomenon occurs at all. This is consistent with the null result obtained in a low background experiments which was done to precisely check the neutron generation from the electrolytic cell, which had shown positive results with finite background neutrons.

In the presence of the background neutrons, the trapped neutrons with a density n_n is expected to exist and fundamental reactions in the TNCF model used to analyze the experimental data by Jones et aI.[7, 8] are written down as follows.

The trigger reactions

$$n + {}^{A}_{Z}M = {}^{A+1-b}_{Z-a}M' + {}^{b}_{a}M'' + Q, \qquad (1)$$

occur between a trapped thermal neutron n and one of nuclei in the lattice ${}^{A}_{Z}M$ with a mass number A and an atomic number Z generating an excess energy Q and nuclear products

${}^{A'}_{Z}M'$, where ${}^{0}_{0}M \equiv \gamma$, ${}^{0}_{1}M \equiv$ n, ${}^{1}_{1}M \equiv p$, ${}^{2}_{1}M \equiv d$, ${}^{3}_{1}M \equiv t$, ${}^{4}_{2}M \equiv {}^{4}He$, etc.

The rate per unit time of the above reaction is expressed by the following relation:

$$P_f = 0.35 n_n \, v_n \, n_N V \sigma_{nN} \, \xi, \qquad (2)$$

where $0.35 n_n v_n$ is the flow density of the thermal neutrons per unit area and time, n_N is the density of the nucleus, V is the volume where the reaction occurs, σ_{nN} is the cross section of the reaction. The factor ξ expresses an order of the stability of the trapped neutron in the trapping region; $\xi = 0.01$ for reactions which occur in volume and $\xi = 1$ for reactions in surface layer, as explained in the previous papers[4,5].

The energetic particles generated by the trigger reactions react with particles in the lattice and cause breeding reactions written below. The rate per unit time of a reaction between an energetic particle with an energy ε and stable nuclei in the solid is given by a similar formula as the above one:

$$P_\tau = 0.35 N_\varepsilon \, n_N \, \sigma_N \, l \qquad (3)$$

where N_ε is the number of the particle with an energy ε per unit time, l is the path length of the energetic particle in the solid, n_N is the density of the nucleus, and σ_N is the cross section of the reaction.

In the case of the electrolytic system used in the experiment[7], the relevant reactions are written down as follows:

$n + {}_3^6\mathrm{Li} = {}^4{}_2\mathrm{He}\ (2.1\ \mathrm{MeV}) + t\,(2.7\ \mathrm{MeV}),$ (4)

$n + d = t\,(6.98\ \mathrm{keV}) + \gamma\,(6.25\ \mathrm{MeV}),$ (5)

$t\,(\varepsilon) + d = {}^4{}_2\mathrm{He}\ (3.25\mathrm{MeV}) + n\,(14.1\mathrm{MeV}) + \varepsilon,$ (6)

$n(\varepsilon) + d = n(\varepsilon') + d(\varepsilon'')$ (7)

$d(\varepsilon) + d = {}^3{}_2\mathrm{He}\ (0.82\mathrm{MeV}) + n\,(2.45\ \mathrm{MeV}) + \varepsilon.$ (8)

Cross sections σ of these reactions are given as follows from data book[15, 16]

$\sigma_{n\text{-}Li} = 9.4\times 10^2$ barn, $^{-2}$

$\sigma_{n\text{-}d} = 5.5\times 10^{-4}$ barn,

$\sigma_{t\text{-}d} = 1.42\times 10^{-1}$ barn ($\varepsilon_t = 2.7$ MeV),

$= 3.0\times 10^{-6}$ barn ($\varepsilon_t = 6.98$ keV),

$\sigma_{d\text{-}d} = 8.86\times 10^{-3}$ barn ($\varepsilon_d = 12.5$ MeV),

$\sigma_{n\text{-}d} = 5.5\times 10^{-1}$ barn ($\varepsilon_n = 14.1$ MeV),

The energy of the deuteron of 12.5 MeV used for $\sigma_{d\text{-}d}$ in the reaction (8), for simplicity of calculation, is the maximum one obtained in the reaction (7).
We assume following values for experimental parameters which are reasonable in the experiment though they have not been written down in the paper[7]; the cathode used in the experiment was aspherical shape and its weight was 3 g, on the surface of which was a layer of Li with a thickness 1 μm deposited by the electrolysis. Following the recipe described before[4], we take the factor $\xi = 0.01$ and $l = 1$ μm for all charged particles and $l = \infty$ for neutrons. By the two four-step-reaction **(a)** series from (4) to (8) through (6) and (7), and **(b)** series from (5) to (8) through (6) and (7), both of which finally generate neutrons with 2.45 MeV, we can determine n_n using the relations (2) and (3) by the experimental data explained in Section 2, i.e. 0.4 n/s. If only one of the two series is effective, we obtain following values of n_n for the above series (a) and (b), respectively:

$n_n = 4.4 \times 10^{11}\ \mathrm{cm}^{-3},$

$n_n = 5.9 \times 10^{19}\ \mathrm{cm}^{-3},$

Thus, the first series (a) starting from the reaction (4) played main role in this system and the density of the trapped neutrons was $10^{11}\ \mathrm{cm}^{-3}$. This value of n_n will change by one order of magnitude, depending on the change of the nature of the surface layer of the cathode which we assumed as Li metal with a thickness of 1 μm.
Details of the calculation will be given elsewhere.
It is clear that the experiment[7] was done in an environment where there was a lot of background neutrons as shown in Fig.2 of the paper, which guarantees the existence of

the trapped neutrons of this density.

The surface to volume ratio *S*/*V* of the Ti cathode was 8.1 cm^{-1}. The *S*/*V* ratio is an index of the qualitative reproducibility of the cold fusion phenomenon[7] and this value of 8.1 cm^{-1} belongs to the minimum range of values where the cold fusion phenomenon has been observed. This is, perhaps, an origin of the poor reproducibility of the Jones' result of neutron generation.

On the other hand, in the experiments conducted in an environment where there were few background neutrons, it could not be expected that the piling up of the trapped neutrons occurred in the sample. In such a situation as this, it is clear that the null result[8] reported by them is a natural consequence of the circumstance using the TNCF model.

4. Conclusion

To develop a new science, it is usually necessary to have new experimental facts and a new concept about them. Various events in the cold fusion phenomenon, though some of them were obscured by the patent barrier, disclosed some phases of a new science to the people who were eager to consider them without the dogma barrier in their mind.

The density of $n_n = 4.4 \times 10^{11}$ cm^{-3} is in the upper range of other values $n_n = 10^7 - 10^{12}$ cm^{-3} obtained often in the past analyses[3–6]. As a cause of this characteristic of Jones et al.[7] data, we can point out the electrolytes used in the experiment. As shown in the Section 2, the electrolyte used in the experiment contained several metal salts and it was probable that the surface layer had a complex structure which worked more effectively to trap neutrons than usual Li or $PdLi_x$ layer.

In addition to the results of analyses of more than 40 experimental data on the excess heat, tritium, helium and NT, the present interpretation of the fine experimental results for neutrons by Jones et al.[7, 8], has shown a promising standpoint from which to develop a new science, solid state - nuclear physics, or the physics of neutrons in solids.

The technical successes in the application of the cold fusion phenomenon accomplished by now to produce the excess heat[17, 18] and to diminish radioactivity[19] will be accelerated by progress in scientific clarification of the phenomenon.

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