A NEW THEORETICAL MODEL (Nu-Q^*) FOR RATIONALIZING VARIOUS EVENTS OF 'COLD FUSION' IN DEUTERIUM LOADED PALLADIUM CATHODES

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ABSTRACT

A model is proposed based on di-neutrons, Nu, to rationalize most of the high energy and some of the low energy events observed in electrochemically induced 'cold fusion'. Using pressure induced electron capture (EC) by deuterons as the triggering mechanism for the creation of Nu, this model calls for the absorption of Nu by deuterons, creating a highly unstable isotope Quatrium, Q^*, which decays instantly to yield tritium and neutrons. Because of electron spin considerations the dominant EC mechanism is shown to yield two kinds of Nu, namely, a low lying Nu_L and a less stable higher lying Nu_H. Thus, the Nu-Q^* mechanism is shown to yield a doublet in the gamma ray spectrum. Another form of di-neutron, Nu^*, is also expected to be created from the coalescence of neutrons. The theoretically calculated gamma ray lines are in excellent agreement with the experimentally observed lines. Another possible coalescence is that of neutrons with deuterons which may result in significant heat production. Heat production is also rationalized as being due to neutron and di-neutron absorption of heavier elements in the cathode, as well as from UV photon emission which is the by-product of EC mechanisms.

THEORY

The model proposed here gets around some of the difficulties inherent in the usual deuterium-deuterium (D•D) collision-fusion model. The weaknesses of the D•D fusion model have been reviewed recently[1]. Accordingly, the fusion model's inherent weakness is the forbidding Coulomb barrier. The proposed model does not have this problem because of the use of di-neutrons. It is suggested that under the conditions of electrolysis of heavy water, a di-neutron, hereafter designated as Neutrium (Nu) is formed according to the following electron capture (EC) mechanism[2], a process which is enhanced by pressure[3],

$$ {}^{0}_{-1}e + {}^{1}_{1}H \xrightarrow{(EC)} {}^{2}_{0}Nu + \nu + \gamma \qquad (1), $$

where ν represents a neutrino. Since this process is not favored for low Z, it is essential to enhance it by very high pressures. Moreover, since the EC process is the initiating mechanism, the problem of irreprodicibility, well known to be associated with the 'cold fusion' phenomena, may be assigned to not having sufficiently high and/or reproducible pressures. The biggest problem with this model, however, is that a di-neutron has never been observed before. However, it should be noted that Teller suggested some time ago[4] that some sort of a hitherto unobserved neutral particle is involved in 'cold fusion'. If Nu can be created, then its reaction with D is no longer fusion but rather conventional absorption of cold neutral particles, and, therefore, the 'cold fusion' terminology should be disbanded in favor of cold absorption of Nu by D which is pressure induced. More specifically,

$$ {}^{2}_{0}Nu + {}^{2}_{1}H \rightarrow {}^{4}_{1}Q^{*} \qquad (2), $$

where the completely unstable isotope Quatrium, Q^*, can yield the following reactions:

$$ {}^{4}_{1}Q^{*} \rightarrow {}^{4}_{2}He + {}^{0}_{-1}\beta + \bar{\nu} \qquad (3), $$

and

$$ {}^{4}_{1}Q^{*} \rightarrow {}^{3}_{1}H + {}^{1}_{0}n + \gamma \tag{4} $$

It is pertinent at this point to recall that the D•D fusion model has 3 branches, one branch producing ^{4}He and γ, another producting Tr, and ^{1}H, and the third yielding ^{3}He plus neutrons and γ. Thus, there are significant qualitative differences between the Nu-D absorption (coalescence) model and the D•D fusion model, the most important of which is that Tr and n are produced in the same branch with the Nu-D model but ^{3}He is not produced, a substance that has not been observed to date. In terms of quantitative evaluation between the two models, the most significant differentiation is that the γ-ray signatures observed do not agree at all with the γ-ray signatures called for by the fusion model. In contrast, as shown below, the coalescence model accurately assigns three such lines.

Since di-neutrons have not been observed before, it is essential to evaluate whether or not Nu would be stable with respect to its formation out of neutrons.

$$ {}^{1}_{0}n + {}^{1}_{0}n \rightarrow {}^{2}_{0}Nu^{*} + \gamma^{*} \tag{5} $$

Whether or not Nu^{*} is exothermic depends on the rest mass of Nu^{*}. As a first approximation it can be assumed that the coalescence via equation (5) is thermodynamically equivalent to the EC mechanism of (1), i.e.,

$$ M(Nu^{*}) = M(D) + M(e) \tag{6} $$

or more simply,

$$ Nu^{*} = D + e \tag{7} $$

Under this stipulation γ^{*} in (5) has a value of 2.496 MeV, which is exactly the experimental value reported by the Univ. of Utah (UU) group[5]. Thus, if this assignment is correct, then Nu^{*} is highly stable with resepect to dissociation to isolated neutrons formed out of coalescence.

However, in the EC mechanism of equation (1) it is not necessarily true that the enthalpy, Q = 0. Moreover, previous discussion of the EC process did not take into account the nature of the proton (p) and neutron (n) spins in their ground state configuration, and this may be important for deuteron but not for higher Z. The stable ground state configuration[2] of D is $^{3}S_{0}$, which means that p and n have parallel spins, that is, (p↑)(n↑). Consequently, since due to Pauli forces, Nu must have a ground state configuration of (n↓)(n↑), the EC mechanism can create two kinds of di-neutrons depending upon the spin of the incoming electron. If the electron spin is down, then there are no problems since the transitional configuration just prior to neutralization is (e↓)(p↑)(n↓), which readily relaxes to the desired singlet configuration $^{1}S_{o}$ of (n↓)(n↑), yielding a stabilized low lying singlet for Nu, labelled Nu_{L}. On the other hand, if the spin of the incoming electron is up, then the transitional configuration would yield (e↑)(p↑)(n↑), which would yield an anti-Pauli configuration of (n↑)(n↑). To circumvent this, the electron spin of the incoming electron needs to be flipped just as it enters the nucleus, yielding (e↓)(p↑)(n↑), which would yield a desired singlet Nu_{H}, but at a higher level. The maximum energy of this spin flip mechanism cannot exceed .51 Mev, i.e., the rest mass of the electron.

Using this more sophisticated version of the EC process for equation (1) a doublet is expected in the gamma ray spectrum, namely γ_{H} and a γ_{L} with a maximum energy separation of 0.51 MeV and to be in the region of 2.74 and 3.76 MeV, which corresponds to the rest mass range of D±e. The published experimental observations of the UU group[5] mentions a doublet at 3.01 and 3.52 MeV yielding values of (D + .55e) for Nu_H and (D - .45e) for Nu_L.

Still another possible mechanism for Nu creation is the coalescence of a neutron with D, i.e.,

$$ {}_0^1n + {}_1^2H \rightarrow {}_0^2NU^{**} + {}_1^1H + \gamma^{**} \qquad (8) $$

Again, conventional scattering (collisional) experiments between n and D have not produced a di-neutron, but again it is suggested that under the conditions of very high pressure in these electrolytic experiments it may be possible to do so. If the rest mass resulting from this kind of coalescence is designated by Nu^{**}, and if Nu^{*} is set equal to Nu^{**}, then γ^{**} would have a value of 0.27 MeV, and this could definitely yield appreciable heat in the electrolytic cell. Moreover, mechanism (8) together with (4) constitute a chain reaction.

With respect to the absorption of thermal di-neutrons by the various Pd isotopes, it can be shown readily that the γ-ray spectra would be very complex but should be observable somewhere between 7 and 8 MeV. Fundamentally, there are three possible mechanisms for each of the isotopes. The three different kinds of mechanisms are, thermal absorption of n and of di-neutrons with and without dissociation of the di-neutrons. Moreover, for each of the di-neutron absorptions there are three different kinds of Nu involvements yielding over 30 possible γ ray lines.

The (102) Pd isotope enrichment presents a very special case since

$$ (102) + Nu \rightarrow (103) + n + \gamma \qquad (9) $$

However, (103) decays according to an exothermic EC process, namely,

$$ {}_{46}^{103}Pd + {}_{-1}^{0}e \rightarrow {}_{45}^{103}Rh + \gamma + \nu \qquad (10). $$

where the decay energy is .57 MeV, thus leading to some heat production as well. Moreover, according to the rules of EC mechanism there should be a detectable Rh-K emission spectrum, and this could be used to monitor the overall process. Of the other possible enrichment, Oxygen is another interesting one since that could be used to monitor any oxygen involvement in the cathode. Finally the involvement of Li in the overall process could also be used to reveal why Li appears to be so critical in most of the present experiments. Considering the importance of gamma ray signatures for monitoring the various thermal absorption processes, it appears crucial to monitor these signatures with relatively high resolution and accurate calibration.

So far it has been shown that low energy gamma rays are involved in some heat production. Another very important source of heat production is due to the filling of the vacancy left behind upon electron capture. This kind of vacancy has not been treated before. While the details of the filling of this kind of vacancy is a very interesting topic by itself, briefly, the electronic transitions that may be involved yield photons primarily in the UV region. The filling of this vacancy is exactly equivalent to the phenomena with higher Z elements, more specifically with Z>3, where the filling of the vacancy yields characteristic X-rays involving the isobaric nucleus. In this case the isobaric Nu is free to go as it pleases, so the filling of this vacancy may have nothing to do with the properties of Nu and more with the partial density of states of p character of the atoms surrounding the vacancy. This, of course, assumes that the vacancy will remember its original character.

DISCUSSION

While the proposed coalescence model appears to be more suitable than the conventional D•D fusion model, the most important weakness of the proposed model is that di-neutrons have never been observed before. As already argued, just because di-neutrons have not been observed before under low pressure-high energy scattering experimental conditions does not mean that di-neutrons could not be created under low energy (cold) high pressure conditions. If the energy calibration of the gamma ray spectrum is correct, then the gamma ray signatures assigned here represent a good validation of the proposed model. Moreover, even if the MIT group's argument[6] about 2.5 MeV really being 2.8 MeV is correct, everything presented here would still be valid, since the 3.01 and 3.52 MeV lines would be merely shifted by the same amount. The argument by the MIT group that the lines reported by the UU group must be instrumental artifacts is fallacious because this group assumed that these lines were due to conventional neutrons arising from D•D. collision. All the MIT group can claim is that the 'cold fusion' model is invalid, and, of course, this discussion offers further proof. Here, the argument is presented that the UU group's gamma lines are real and represent a partial verification of the di-neutron coalescence model.

While the subject matter of low energy events, heat buildup, and their irreproducibility has not been dealt with in detail, all of these phenomena may be shown to be connected to di-neutron formation where the EC step represents the crucial initiating and dominant mechanism. Since the EC process is extremely sensitive to the pressure buildup, which may vary from grain to grain and from surface to bulk of each grain, it is suggested that if the model presented is valid, then the understanding and monitoring of the pressure on a microscopic and macroscopic basis and as a function of grain depth may be one of the important ways for understanding most of the frustrating aspects of the so-called 'cold fusion' phenomenon.

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