COLD FUSION

TECHNICAL NOTE

KEYWORDS: *subbarrier fusion, weak interaction, weak capture*

ON A WEAK FLAVOR FOR COLD FUSION

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Received April 1, 1991
Accepted for Publication May 6, 1991

The possibility of recent reports of cold fusion in deuterated metals being manifestations of primal nucleoweak reactions catalyzed by the host environment is investigated. Resulting experimental signatures are predicted.

Recent reports of cold fusion in deuterated metals[1-3] highlight the importance of the barrier penetration effect. While subbarrier fusion of light nuclei is known to be catalyzed readily by negative muons,[4] its amuonic manifestation is still highly controversial. There have been many theoretical attempts to explain the reports. To match even the lowest experimental values, screening of the Coulomb barrier to distances of ≤ 0.1 Å is required.[5]

This technical note explores the possibility of these results being a manifestation of not just a pure fusion reaction, but one flavored by weak interaction. It may appear strange that one should invoke an interaction known to be much weaker than nuclear forces. However, the motivation is to explore whether electron-involved reactions could ease the barrier suppression so as to give the weak-flavored reactions a positive advantage over the strongly barrier-suppressed pure fusion reactions in the deuterated metal environment. Hagelstein[6] has also considered similar reactions but relied on superradiant neutrinos. His use of virtual neutron transfer has recently been criticized.[7]

This technical note assigns to the electron the tasks of energy borrowing and of putting the reaction on threshold. Since the electron is a reactant for these weak-flavored reactions, this role is more natural than for pure fusion reactions, where the electron has to engineer abnormal screening effects while being a mere spectator to the actual reaction. The most common examples of weak-flavored nuclear reactions, or nucleoweak reactions, are the primal p-p reactions that ignite star birth:

$$p + p \rightarrow d + e^{+} + \nu_e \tag{1}$$

and

$$p + p + e^{-} \rightarrow d + \nu_e \ . \tag{2}$$

Both reactions have to be routed through the basic weak processes:

$$p \rightarrow n + e^{+} + \nu_e \tag{3}$$

and

$$p + e^{-} \rightarrow n + \nu_e \ . \tag{4}$$

Reactions (3) and (4) are both forbidden from energy conservation and can only be put on threshold by coupling to radiationless fusions of the type

$$n + p \rightarrow d + \text{energy} \tag{5}$$

to yield the combined reactions (1) or (2).

Under normal suprabarrier conditions, the inherent weakness of the weak coupling constant causes reactions (1) and (2) to have a much lower probability than the other hydrogenic fusion reactions. However, for subbarrier fusion of the same nuclei, the longer residence in confined zones may increase the number of impacts on the barrier and so enhance the nucleoweak sectors as compared with the sudden approaches in the suprabarrier scenario. Considering reactions (1) and (2), while the former is strictly forbidden except by barrier penetration, we suggest that reaction (2) could perhaps be enhanced under conditions of abnormal electron densities as it is strongly sensitive to electron density, and the approach of the nuclei could also be facilitated.

Reaction (2) is also nearer threshold than reaction (1) by ~1 MeV, as the electron (positron) mass goes into the positive rather than negative balance. At low energies, reactions (1) and (2) depend on the joint probability of the protons coming close enough to each other simultaneously with the transformation of one of them into a neutron. The former criterion is the familiar barrier penetration effect.

At this stage, we look at the possible extensions of reaction (2) in the deuterated metal scenario. These could be

$$d + d + e^{-} \rightarrow t + n + \nu_e \, \text{(as shown in Fig. 1)} \tag{6}$$

and

$$d + d + d + e^{-} \rightarrow t + t + \nu_e \tag{7}$$

along with other possible permutations. In the presence of protium,

$$p + d + e^{-} \rightarrow t + \nu_e \ , \tag{8}$$

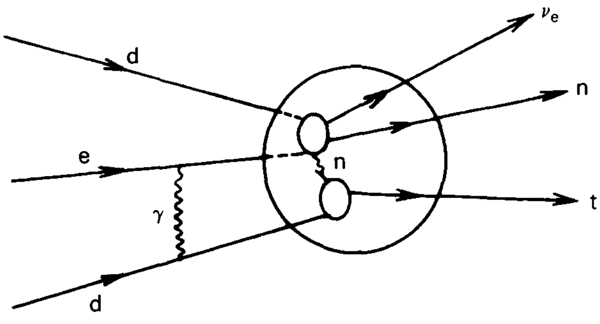

Fig. 1. The *d-d-e* nucleoweak reaction.

and reaction (2) itself could occur. All these reactions are routed through the basic weak capture process [reaction (4)] involving a proton of one of the deuterons, although in these cases the deuteron disintegration energy is also to be supplied by the fusion sector.

If one does not break up the reaction into its constituent protonic part, the deuteron binding energy is automatically accounted for in the energy balance. We propose the dual enhancement of these electron-involved nucleoweak processes through increased electron densities and easier barrier crossing. In essence, we rely on the excess electron clouds in the deuterated metal and their sudden fluctuations to put the reactions on observation threshold. It has been suggested[5] that sudden eddy current-type fluctuations caused by additional deuteron influx after deuteration of all interstitial sites could perhaps effect the strong screening required to enhance the rate. It is now further postulated that such sudden increases in electron density may make it easier to put the electron-involved weak-flavored reactions on observation threshold rather than the pure nuclear ones. The reason is clear. The electron is now an integral ingredient of the reaction rather than a mere spectator as in the pure fusion case. It has no Coulomb barrier to overcome and can approach any deuteron as closely as it likes. It can form a bridge between Coulomb-separated deuterons to borrow from one the energy defect required for it to be swallowed by the other, thus materializing the weak sector of the reaction. The neutron formed in the weak sector is easily able to fuse with the first deuteron, repaying the loan. Similar arguments apply to reactions (6), (7), and (8), with the additional feature that reaction (7) could be further aided by many-body effects to yield the excess tritium observed over the neutron count.[3]

In a collisional scenario, moving deuterons and electrons can approach each other as closely as they wish. Close screening permits the second deuteron to reach the system. The point to be stressed is that both deuterons need to interact with the electron in the entrance channel rather than each other, so that this electron bridge eases the barrier problem.

Although this is only a qualitative analysis, some numerical estimates would be interesting. For electron capture from atoms, the rate depends on the electron density as the square of the wave function at contact, i.e., on $(z/a_0)^3$. Sudden availability of, for example, the ten electrons of a palladium atom, could increase this by a factor of ~1000, which is clearly far short of the required enhancement. Additional deuterons and electrons could increase this but still not enough. One must therefore rely more on the bridging of the barrier by the active electron. The crucial question is how long must the relevant $[(nd)e]$ cluster (n being the number of participating deuterons) be confined, and how closely, for the nucleoweak processes in the metal host to acquire detectable rates. Barrier penetration calculations[5] indicate that for separations <0.1 Å, Jones et al. rates[2] for cold fusion can be recovered for the pure fusion reactions. Electron bridging of the barrier and excess densities must therefore be able to materialize the nucleoweak processes at deuteron separations >0.1 Å for them to be a viable alternative to the pure fusion reactions. We repeat that under suprabarrier conditions, weak-flavored processes can never hope to compete with strong nuclear processes. It is only when the pure fusion reactions are severely suppressed by Coulomb repulsion under deeply subbarrier conditions that excess electron population and electron bridging could attempt to enhance the electron capturing nuclear reactions compared to the pure fusion processes. Note that the factor $(z/a_0)^3$ may not be the ideal in estimating electron densities as electrons can, in principle, approach a capturing deuteron much more closely and for any time span. A more favorable density factor would give the nucleoweak reaction a greater advantage.

The appeal of the explanation proposed here lies in the absence of the need to invoke any exotic physics or unnatural mechanism to justify the results, as excess electron densities are expected to be a natural feature of the host environment and the electron bridging proposed does not really violate any basic principles. The following experimental signatures would serve to vindicate these ideas: (a) the absence of final-state protons as the protonic constituents are used up in the weak sector and (b) identical experiments with pure water should produce deuterons according to reaction (2) at comparable rates.

To date none of these have been invalidated. Protons produced in the expected *t-p* exit channel in *d-d* fusion have not been reported at the rate at which tritium is produced. The pure water tests carried out with the heavy water experiments have only looked for neutrons or tritons in the control experiments. The samples have not been tested for increased deuterons. Neutrinos would not have been detected in any of the experiments.

We also face the provocative question of whether part of the deuterium in the sea could have been formed in natural replications of the cold fusion experiments. To create an isotopic ratio of 10^{-4} for the *d-p* nuclei, an approximate age of one thousand million years for the sea would imply a rate of production of deuterium from *p-p* pairs of $\sim 10^{-20}$ s^{-1}. If part of the deuterium were primordial, a rate of the order of 10^{-23} reaction/s could account for 1% of the deuterium. The match with the projected cold fusion rates is interesting.

The astrophysical consequences deserve mention. In an electron-poor environment, the *p-p* chain could ignite only by reaction (1). Gravitational collapse is assumed to condense the hydrogenic dust clouds to ignition conducive densities and temperatures. But gravitational interaction is far weaker than even weak interaction. Considering even the low barrier penetration probability and the low weak interaction probability, the conjecture that star birth can be ignited by cold fusion in competition with gravitational collapse cannot be ruled out and inspires further investigation.

ACKNOWLEDGMENTS

The author wishes to thank Magnus Jandel, P. K. Iyengar, and M. Srinivasan for discussions. Financial support from the University Grants Commission and Department of Atomic Energy is gratefully acknowledged.

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