Investigation of Deuteron-Deuteron Cold Fusion in a Cavity

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Abstract

A cavity in a solid, first of all, serves as a place of confinement for a Deuterium molecule. Two deuterons in the molecule are trapped together in close proximity. Thus, they may engage in 'Low Energy Nuclear Reaction' which requires longer time, unlike collision type of nuclear reaction. Secondly, the electric field in the cavity (to be shown below) superimposed on this deuteron-pair would lower the Coulomb barrier between them facilitating a 'Low Energy Fusion' reaction. Furthermore, neutron exchange reaction between two deuterons (in an analogous manner like the electron exchange that forms a Deuterium molecule) is like a 'Long Range' force (as compared to the range of nuclear force) that can pull two deuterons together. This range is longer than that of the pi-plus exchange nuclear force between a proton and a neutron, because neutrons are charge neutral. [1] Longer reaction time; [2] Lowered Coulomb Barrier; [3] Longer range are the necessary conditions for (d-d) 'Cold Fusion'.

Earlier, in reference (1), the neutron exchange potential was modeled as a slow-varying function of the (d-d) separation.

$$V_{ex} = -A - B \exp(-K r_{dd}) \qquad (1)$$

A = 4.4 MeV corresponds to twice the neutron binding energy in deuteron when the two deuterons are far apart, and A+B = 28.4 MeV corresponds to the sum of the binding energies of the two neutrons in ^{4}He nucleus, when the two deuterons are combined.

This potential is not for a 'new' force between two deuterons. It is simply a manifestation of proton-neutron nuclear force. Just like the electron exchange interaction that binds two hydrogen atoms to form a molecule is a manifestation of Coulomb force between electron and proton. This exchange interaction between two neutral hydrogen atoms is mediated through the exchange of electrons when the two Hydrogen- wavefunctions overlap. One does not need to solve a four-body [two protons with two electrons] quantum mechanical problem using Coulomb forces. Because, the two protons in the pair of hydrogen atom are sufficiently far apart even after the molecule is formed. Only the Coulomb potential energy between them needs to be considered. Likewise here, the interaction mediated through neutron exchange when the two Deuteron-wavefunctions overlap has a range larger than that of nuclear force. One does not need to solve a four body (ppnn) quantum mechanical problem using nuclear force because the two protons of the deuteron pair trapped inside a cavity are also far [comparing to nuclear force range] apart.

Together with the Coulomb-repulsion potential

$$V_c = k / r_{dd} \tag{2}$$

the total potential

$$V_T = V_{ex} + V_c \tag{3}$$

as a function of r_{dd} depending on the values of K and k could have no maximum or minimum [monotonously drops from positive infinity to -4.4 MeV], one plateau, or one minimum and one maximum [V_T drops from positive infinity to a minimum then rises up to a maximum, finally asymptotically approaches -4.4 MeV].

In a space free of external field like inside a Deuterium molecule in vacuum, $k = e^2 / (4\pi\varepsilon_o) = 14.4$ eV/ (10^{-10} m) is a constant, not an unknown parameter. Since 'Cold fusion' of the two deuterons in a Deuterium molecule has never been observed, a lower limit for K = 9 (1/ fermi) [1 fermi = 10^{-15} m] can be determined (see reference 3). In other words, K for the neutron exchange potential must be larger than this lower limit. Which means, in vacuum space the Coulomb barrier dominates over the attraction (due to neutron exchange) at all ranges of deuteron separation. In reference (3) K = 12 (1/f) [larger than the lower limit mentioned above] was chosen to investigate cases of 'weakened' Coulomb repulsions. It was found, if the Coulomb field is weakened by 50% or more, a shallow minimum (around $Kr_{dd} = 1$) plus a broad low maximum (around $Kr_{dd} = 10$) of V_T [the total potential] exists. A pair of deuteron under this condition can in time via tunneling through this broad and low barrier ends up in this potential minimum region. Then, through de-excitation (via radiation emission) this pair may energetically drop into a stable bound state and finally fused together forming a He^4 nucleus (see reference 3).

In reference (2), it was argued that the electric field inside a cavity (or void) of a solid is not zero. Instead, this field should be very much like that inside a virtual 'anti-atom'. Here, a cavity is the void created by taking away one atom from a perfect solid. One can visualize this argument by placing or superimposing an 'anti-atom' into a perfect solid. This anti-atom would charge-wise neutralize one of the atoms and thus generating a charge void or cavity. Consequently, the electrostatic field inside a cavity can be considered to be the superposition of two fields, one due to the charge distribution of an anti-atom the other due to all atoms in a perfect solid at this site. In a first order approximation, one assumes the average field inside a perfect solid is everywhere zero because all atoms are neutral. In that case, since the field inside an anti-atom is negative or attractive to positive charges both deuterons in a trapped Deuterium molecule are pulled toward the center of the cavity. Effectively, this field inside a cavity does 'weaken' the Coulomb repulsion between the two deuterons and thus facilitating a scenario of 'Cold Fusion' described above.[1] *

[1] The assumption that the average field inside a solid is zero everywhere is hard to justify. Furthermore, to assume the charge distribution at the location of the cavity is exactly like that of a ‘free’ atom such that the charge distribution of a ‘free’ anti-atom will charge-neutralize this location creating a charge-void like the cavity is equally hard to justify. The author is grateful to a reader of the draft for pointing out the weakness of arguments. (C.M.F.)

Direct measurement of this field is difficult. One can probably do it indirectly by measuring the energy shifts of inner-shell transition of the atoms trapped inside such cavities. It is also not easy to determine such a field analytically. Large scale simulation or numerical calculation should yield useful results to strengthen the argument for the feasibility of dd-cold fusion inside a cavity.

References

1. C.M. Fou "Deuteron-Deuteron (dd) Binding via Neutron Exchange," Infinite Energy, Vol. 11, issue 66, 26-28 (2006)
2. C.M. Fou "Coulomb Field for LENR in Solid," Infinite Energy, Vol. 12, issue 71, 25-27 (2007)
3. C.M. Fou "Calculation for dd-fusion in a weakened Coulomb Field," Infinite Energy, Vol. 14, issue 83, 57-60 (2009)

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* *Editor's note:* A reviewer has argued that the author's ingenious construction (here and in ref. (2)) appears to contradict Gauss's law, to the extent that it entails a charge-free region with an electrical flux directed inward everywhere on the surface. The reviewer concurs that further work is desirable to clarify the character of the field.