INTERNAL CONVERSION MECHANISM IN COLD FUSION

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ABSTRACT

By using the internal conversion mechanism inside the nucleus, a possible solution for cold fusion is discussed. When a target nucleus reacts with the pellet nucleus (P^+, D^+, or T^+, etc.), an internal conversion electron emitted from the target nucleus is absorbed by the pellet nucleus, which becomes a neutral nucleus, so the Coulomb barrier of the target nucleus can be passed through easily, then a nuclear reaction happens. Since the internal conversion coefficient $\alpha \propto Z^3$. It will be favorable to those heavy nuclei. The mechanism can solve the difficulty of the barrier penetration and a part of the fusion energy is transformed to the electromagnetic radiation. Further, some results may be detected by the experiments.

The analysis of numerous experiments [1,2] and the calorimetric studies of the Pd-D_2O and Pd-D systems [3,4] at ICCF4 have proved that nuclear reactions exist in cold fusion. But the physical mechanism of cold fusion waits still for further research. When n(D)/n(Pd) > 0.83, cold fusion may happen in a Pd-D system. The Hamiltonian function of the system is approximately

$$H = H_1 + H_2 + H_{int} \tag{1}$$

$$H_{int} = \sum_i Ze^2 / |r_i - R| , \tag{2}$$

where H_1 and H_2 are the Hamiltonian function of a target nucleus, whose charge is Z, and a pellet nucleus (P^+, D^+ or T^+), respectively.

The reaction between both nuclei is mainly the Coulomb force. It produces many photon transitions from infrared ray to X-ray. But, even if we have introduced the multistage nuclear reaction mechanism, the penetration factor at very low energy is small [5].

This paper is analogue with the internal conversion theory of nuclear physics, a possible mechanism of cold fusion is discussed. The transition probability formula of internal conversion electron is

$$W_{fI} = 2\pi \int |\langle F | H_{int} | I \rangle|^2 \rho \, dv , \tag{3}$$

where I and F are the wave functions on initial and final states, ρ is the density of energy levels of an initial state. It may be estimated by a formula

$$\rho(E) = 1/D(E) = Ce^{2\sqrt{aE}} , \tag{4}$$

Where E is excited energy, D is an interval of energy levels, C and a are two parameters. The equation

(3) is

$$W_{fI} = 2\pi c e^{2\sqrt{aE}} \int |<F|H_{int}|I>|^2 dv. \quad (5)$$

$$<F|H_{int}|I> = <\psi_f u_f|H_{int}|\psi_i u_i>$$

$$= \sum_{i=1}^{Z} \int d^3 R \int d^3 r_i \psi_f u_f \frac{1}{|R - r_i|} \psi_i u_i, \quad (6)$$

$$\frac{1}{|R - r_i|} = \sum_{L,M} \frac{4\pi}{2L+1} \frac{r_i^L}{R^{L+1}} Y_{LM}(\Theta, \psi) Y^*_{LM}(\Theta_i, \varphi_i), \quad (7)$$

and

$$\frac{1}{|R - r_i|} = \begin{cases} \Sigma \frac{r_i^L}{R^{L+1}} P_L, & (R > r_i \quad outside\ nucleus) \\ \Sigma \frac{R^L}{r_i^{L+1}} P_L & (R \le r_i \quad inside\ nucleus) \end{cases} \quad (8)$$

It is called the finite nucleus effect, which is important for heavy nucleus, whose Z is larger. The internal conversion electron is a mechanism which compete with the photon transition, therefore the integral inside nucleus contributes and the internal conversion electron is emitted from the nucleus, when the photon transition is forbidden and the integral outside nucleus is zero. Through the simplification from equation (5)

$$W_{fI} = A \sum_L \frac{K^{2L-3}}{[(2L+1)!!]^2} \sum_M |Q_{LM}|^2 \quad (9)$$

can be obtained, where K is wave function of the internal conversion electron, A is a total constant, $\Sigma |Q_{LM}|^2$ is reduced, transition probability of the photon transition, so the internal conversion coefficient is

$$\alpha = \frac{\omega_{fi}}{\omega_8} \simeq BZ^3 \frac{L}{L+1} \left(\frac{2mc^2}{E}\right)^{L+5/2} \quad (10)$$

which is directly proportional to Z^3, so it increases rapidly for the heavy nuclei. For example, the energy level density D(E) of Pd nuclei is larger, D(E) ≈ 1 - 100ev for A ≈ 100. A series of the photon transitions from infrared ray to X-ray may happen for the D-Pd system, E_r ~ 1-100ev. In this case, both nuclei are resisted by the Coulomb barrier, the nuclear reaction is difficult. But if the photon energy reaches a threshold value, for instance, E ≃ 130 KeV, which had been found by Jiang Tang He and Peter Hagelstein et al., an internal conversion electron is emitted from the Pd nucleus, and is combined with a deuteron to become a dineuteron n^2 [6], so there is no obstacle of Coulomb barrier to the target nucleus, the nuclear reaction may produce

$$Pd^{A} + D^{+} \rightarrow Ag^{A} + e^{-} + D^{+} \rightarrow Ag^{A} + n^{2} \rightarrow Ag^{(A+2)*} , \qquad (11)$$

so various nuclear reactions in the References [1,2] can happen. An excited nucleus $Ag^{(A+2)*}$ produces a symmetric bifission, e.g., V and Cr, etc., the fission release energy $E_f \sim 36 - 43$MeV, which is larger than the fission barrier, so the fission should happen instantaneously. If it is $Pd^{102} \rightarrow 2V^{51} + 20$ MeV, the fission release energy is smaller than the fission barrier, the probability of the spontaneous fission is very small.

Since the fission release energy is very high, an excited energy per fragment is 15 - 20Mev, which can evaporate neutron or can release a pair electron $e^{+} e^{-}$ or electron e^{-} of internal conversion, these phenomena will compete with the photon transition. Moreover, the neutron n may raise another fission. The electrons at high energy may produce bremsstrahlung, so a part of the energy will transform to an electromagnetic radiation. If $e^{+}e^{-}$ happens, the annihilation effect should appear for a process of the slowing-down of the positrons, then a characteristic radiation $E_r = 511$ KeV will be able to be detected by the experiment.

A D-D system is a boson. The multiple D-D systems possess the Bose-Einstein condensation. When two deuterons are very close to each other, the photon transition will appear. Further, if both nuclei combine, the binding energy of 23.8 MeV will be released, then the system will transit to a stable state. When the D-D system forms a compound nucleus, an internal conversion electron will be produced,

$$D^{+} + D^{+} \rightarrow D^{+} + e^{-} + He^{2} \rightarrow n^{2} + He^{2} \rightarrow He^{4*} \qquad (12)$$

The spin-parity of n^2 may be 0^+ or 1^+, one of He^2 is 0^+ or 1^+, so one of He^{4*} should be 0^+, 1^+ or 2^+. The binding energy emmited from an excited nucleus He^{4*} to ground state is $\Delta E = 23.8$ MeV. The spin-parity for the ground state He^4 is 0^+. Because the photon transition cannot happen for $0^+ \rightarrow 0^+$ and $2^+ \rightarrow 0^+$, it is necessary that He^{4*} releases energy mainly through a competition between the internal conversion electrons e^+e^- (or e^-) and multistage photon transitions. The electrons at high energy may produce bremsstrahlung, whose energy is lower than X-ray, so the greatest part of the energy will transform to electromagnetic radiation. Therefore, it should be much less for $D+D \rightarrow He^3 + n$(2.45 Mev) and $D+D \rightarrow T+P$(3.03 MeV), and which is consistent with the present experiments.

REFERENCES

[1] Chuan-Zan Yu, Yi-Fang Chang, ICCF4, T2.4; *Fusion Facts,* vol 5, no 7, (1994) p 26.

[2] Chuan-Zan Yu, Yi-Fang Chang, Hui-Lan Wang, ICCF4, T2.11; *Fusion Facts,* vol 5, no 7, (1994) p 25.

[3] M. Fleischmann, S. Pons et al., ICCF4, C1.1.

[4] M.C.H. McKubre et al. ICCF4, C1.5.

[5] Yi-Fang Chang, Chuan-Zan Yu, ICCF4, T2.8; *Fusion Facts,* vol 5, no 7, (1994) p 21.

[6] Fu Yang Jie et al., ICCF4, T3.5; *Fusion Facts,* vol 5, no 7, (1994) p 24.