Takahashi, A. *Tetrahedral And Octahedral Resonance Fusion Under Transient Condensation Of Deuterons At Lattice Focal Points*. in *The 9th International Conference on Cold Fusion, Condensed Matter Nuclear Science*. 2002. Beijing, China: Tsinghua University: Tsinghua Univ. Press.

TETRAHEDRAL AND OCTAHEDRAL RESONANCE FUSION UNDER TRANSIENT CONDENSATION OF DEUTERONS AT LATTICE FOCAL POINTS

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ABSTRACT

To attempt to explain the very strange claim of observation by Mitsubishi group on the mass-8-and- charge -4-transferred (increased) transmutation (Mo-96 or Pr-141) out of sample zone of Sr-88 or Cs-133 in the D-diffusion type experiment with multi-layered Pd plate, our multi-body deuteron fusion model in transient lattice focal points has been extended to hypothesize the occurrence of 4D tetrahedral and 8D octahedral resonance fusion. High energy Be-8 particles by 8D fusion can induce selectively capture process to form mass-8-and-charge-4-increased transmutation out of Sr-88 or Cs-133 near PdDx lattice.

1. INTRODUCTION

Recently, the CF research group of Mitsubishi Co. has reported [1,2] a very strange observation that the mass-8-and-charge-(atomic number)-4-increased transmutation (Mo-96 or Pr-141), from 2 nm thin sample layer of Sr-88 or Cs-133 pasted on a multi-layered Pd/CaO/Pd plate under the diffusion process of deuterium, took place selectively with significant quantity (several tens percent) rapidly in a week, without hard radiation of gamma rays and neutrons. This is a big challenge to theoretical modeling. Iwamura et al of Mitsubishi has proposed a model of 4 di-neutrons capture process and successive 4 stages of beta-decay to get to Mo-96 from Sr-88 (or Pr-141 from Cs-133) . Unfortunately, the existence of stable isotope (e.g., Zr-96) on the way in the beta-decay chain from Sr-96* totally blocks to get to Mo-96, even if we hypothesize very hard case of di-neutron emission.

In this paper, we have attempted to extend our multi-body deuteron fusion model[3] for the possibility of selective occurrence of resonant 8D fusion, due to the equilaterally tetrahedral and octahedral geometrical configurations in deuteron-clustering at PdDx lattice focal points and in addition in exchanging strong force (charged pions) symmetrically with every partner deuteron. An 8D fusion emits two high energy (47.6 MeV) Be-8 particles which overcome with 20-30 MeV high Coulomb barrier to make capture (fusion) reaction with neighboring Sr-88 or Cs-133 nuclei and will produce transmuted nuclei with mass-8-and-charge-4-increased transfer. To draw a reasonable story, we need several steps of modeling of transient D-cluster formation, super-screening of Coulomb repulsive force by the hypothesized transient (short time in 1-10 ps) *bosonization* of 4d-shell electrons of Pd atoms, and resonant enhancement of 4D and 8D simultaneous fusion, which should occur selectively among the competing process of 2D, 3D, 4D, 5D, 6D, 7D, 8D, etc. clustering process, as we explain in the following.

The extended model should contain consistent story of He-4 production without neutrons and mass-8-and-charge-4-increased transmutation without hard radiation. Around focal points (t-sites, o-sites, defects, etc.), microscopic coherence in radial dynamic motion of neighboring deuterons may realize the short-time bosonization of electrons to make sufficient screening of Coulomb repulsion for fusion.

2. TETRAHEDRAL AND OCTAHEDRAL CONDENSATION

In our previous model[3] of 3D and 4D fusion around lattice focal points, transient clustering of two (2D), three (3D) and four (4D) deuterons was considered to make competing process. The possibility of anomalous enhancement of 4D and 3D fusion compared to 2D fusion was reasoned by two effects: 1) the excluding rule between 2D, 3D and 4D clustering probabilities in the atomic motion level and 2) the resonant increase of 3D and 4D fusion cross sections (effective S-values) in the strong nuclear interaction level . Especially, 4D fusion rate could become very large as 100 W/cc (10^{13} f/s/cc) power level to meet the condition of experimental claims on consistent amount of He-4 production in correlation with excess heat without neutrons, if the equilaterally tetrahedral condensation in short time (less than 1 ns) of 4 deuterons formed at focal points: We call this tetrahedral resonance fusion (TRF). The tetrahedral configuration in PdDx lattice is illustrated in Fig.1.

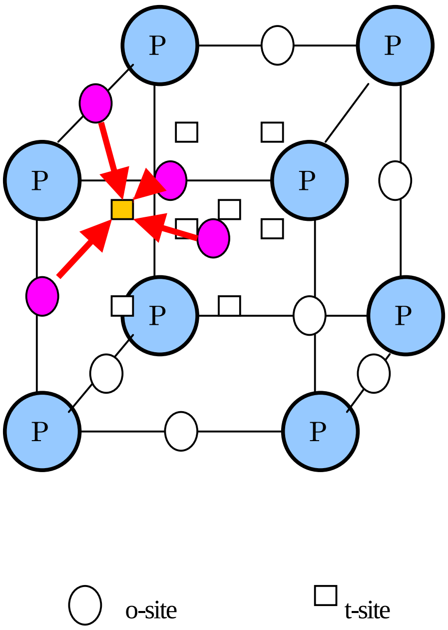

Fig.1: Tetrahedral condensation
, p denotes palladium

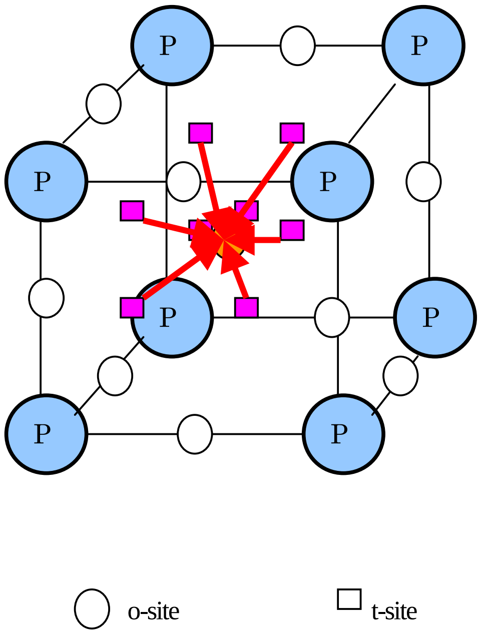

Fig.2: Octahedral condensation
, p denotes palladium

The multi-body fusion model is still hypothetical, especially due to the assumption of super screening of Coulomb barrier by 4d-shell electrons in dynamic motion. Strong coupling between lattice phonons and electrons was assumed as is the case of high-Tc superconductivity, which may be explained by the formation of quasi-particles of electrons like Cooper pairs in short time interval (few ps) in particular direction of hole doped copper oxides. A. Lanzara et al. has reported the observation of such quasi-particles by the angle-resolved photon emission spectroscopy analysis[4)]. The transient quasi-particle of electrons can behave as more negatively charged heavy mass electron which can play drastic screening effect on Coulomb barrier between clustered deuterons, and possibly open the window of cold fusion[5)]. In usual sense, the fermion nature (Pauli's exclusion principle) of electrons blocks the way to drastic screening effect on low energy d-d fusion in metal: The screening effect by electron Thomas-Fermi gas is not sufficient enough to see visible fusion rates[5)]. The phenomena of high-Tc super-conductivity however suggest the existence of transient quasi-particle of electrons, which the author calls here as *transient bosonization of electrons*. The author conceives that the liberation from the Pauli rule, only in short time, for transient electron pairing under strong coupling of lattice phonon vibration is the key to the CF effect. To estimate fusion rate, the effective Gamow integral $2\Gamma_n$ for a screened potential Vs(r) of a d-d pair in a deuteron cluster (2D, 3D, 4D, etc.) may be calculated[3)]. Fusion rate Λ_n of n-body deuteron fusion is written as;

$$\Lambda_n = v\,(S_n/E)\exp(-n\,\Gamma_n) \qquad (1)$$

Where v is the relative velocity of a deuteron, E is the relative deuteron energy in CM system and S_n is the effective S-value of multi-body fusion cross section as regarded as the superposition of sequential two body reactions.

When PdDx lattice is locally over-loaded as x>1.0, 8 deuterons can occupy tetrahedral sites surrounding an octahedral site. This situation is not chemically stable and the 8 deuterons move dynamically through deeper potential at octahedral site. At this moment, we may have a chance that 8 deuterons form a cluster in short time (few ps), namely the octahedral condensation. The octahedral condensation is illustrated in Fig.2. In this transient motion of octahedral condensation, the competing process of clustering and multi-body fusions can be considered:

$$2D \rightarrow n + {}^{3}He + 3.25\,MeV, \quad p + T + 4.02\,MeV \tag{2}$$

$$3D \rightarrow d + {}^{4}He + 23.8\,MeV, \quad t + {}^{3}He + 9.5\,MeV \tag{3}$$

$$4D \rightarrow {}^{4}He + {}^{4}He + 47.6\,MeV \tag{4}$$

$$5D \rightarrow {}^{10}B^{*}(53.7\,MeV) \tag{5}$$

$$6D \rightarrow {}^{4}He + {}^{8}Be + 75.7\,MeV \tag{6}$$

$$7D \rightarrow {}^{14}N^{*}(89.08\,MeV) \tag{7}$$

$$8D \rightarrow {}^{8}Be + {}^{8}Be + 95.2\,MeV \tag{8}$$

and ${}^{8}Be$ has short life time of 6.7×10^{-17} s decaying to two alpha-particles.

$$ {}^{8}Be \rightarrow {}^{4}He + {}^{4}He \tag{9}$$

Our necessary explanation in the competing process is *how 4D (tetrahedral) and 8D (octahedral) fusions can be selective*. The explanation is given in the next section. But shortly saying, three dimensionally equilateral configuration realizes geometrically symmetric charged pion exchanges to enhance drastically effective S-values of 4D and 8D fusions, while in 5D, 6D and 7D process partial tetrahedral configuration will realize 4D TRF process superior to all-D condensation. Thus we may have a selective occurrence of octahedral resonance fusion (ORF) as the 8D fusion (8).

3. PION EXCHANGE PROCESS

The second key factor for the coherent enhancement of 4D and 8D fusion is how fusion cross section, i.e. effective S-factor S_n, can be drastically increased in the strong interaction of charged pion exchange process. The feature of pion exchange for D+D fusion (2D fusion) is shown in Fig.3.

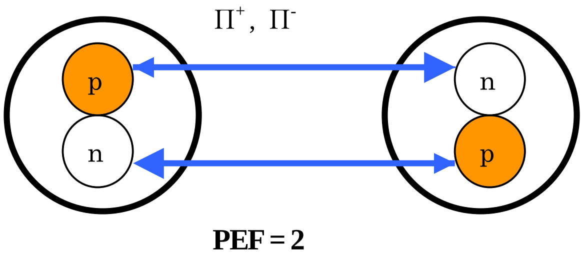

Fig.3: Charged pion exchange for D + D fusion

The relative force strength of pion exchange for two nucleons (n-p) interaction is defined as PEF = 1. The two nucleons interaction can be rewritten with quark exchange, which is however identical result with the charged pion exchange. So, we may scale the strong interaction for fusion by using the PEF unit. For D+D fusion we obtain PEF = 2, as illustrated in Fig.3.

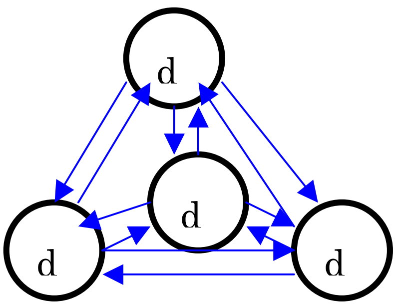

Fig.4: Pion exchange for 4D TRF

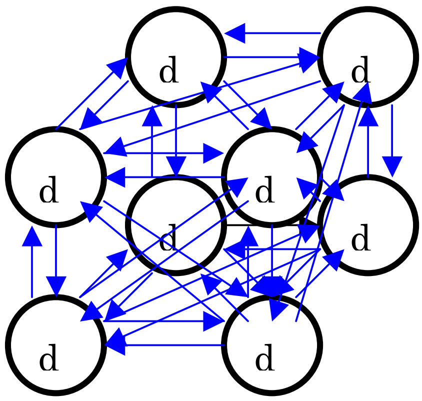

Fig.5: Pion exchange for 8D ORF

Feature of pion exchanges for 4D (equilateral tetrahedron) and 8D (equilateral octahedron) are illustrated in Fig.4 and Fig.5, respectively. We count PEF = 12 for 4D interaction, and PEF = 56 for 8D interaction. The 4D tetrahedral interaction may have ideal resonance condition, because of identical inter-deuteron distances (ideal symmetry) for all deuterons. If one deuteron is added in a cluster to form 5D, the ideal symmetry is broken and local choice of 4D equilateral tetrahedron will be selective for fusion reaction. We can make same discussion for 6D and 7D processes to select 4D resonance. In the 8D equilaterally octahedral configuration (Fig.5), a deuteron can have 6 shortest identical inter-deuteron distances for pion exchange to neighboring 3 deuterons, as same as the case of 4D fusion, while for other 4 deuterons distances are longer with weaker pion-exchange force. Nevertheless, we count here PEF = 56 for 8D ORF for simplicity.

Crude estimation of effective S-values for 4D TRF and 8D ORF was made by rough eye-guide extrapolation of known S-values for H+D, D+D and D+T fusion, assuming that S-value can be scaled with PEF number, as shown in Fig.6. By this assumption, quite large values are given for 4D and 8D fusion.

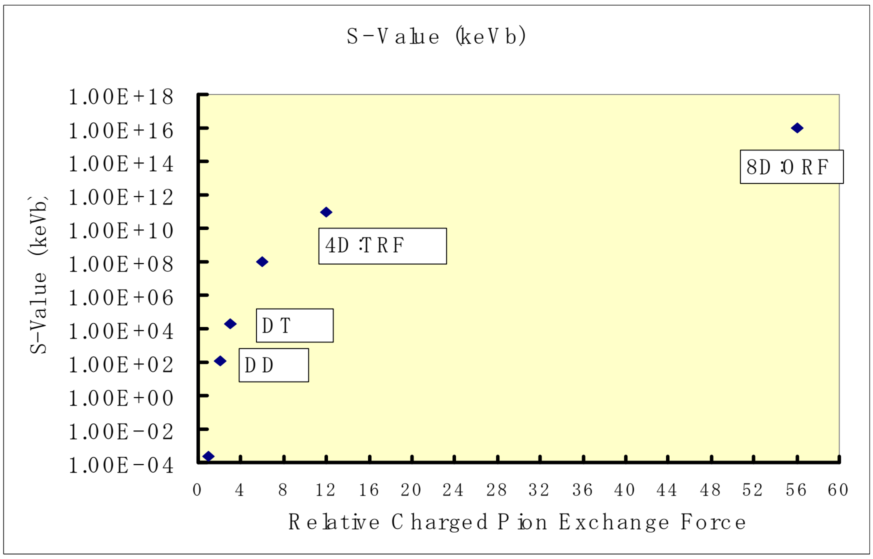

Fig.6: Effective S-values for 4D TRF and 8D ORF multi-body fusion

4. PRODUCTS OF TRF AND ORF

As already discussed in the previous paper[3)], product of 4D TRF is two ^{4}He particles + 47.6 MeV energy release as shown in reaction (4). Many branches of energy share between two ^{4}He particles (alpha-particles) and photons (gamma-rays) are discussed previously[3)]. Here we assume the simplest exit channel of two ^{4}He particles with 23.8 MeV kinetic energy per each. The emitted 23.8 MeV alpha-particles are slowed down in the media and deposit energy in lattice phonon vibration. In Pd metal, ionization cross section of K-shell electrons is very small for 23.8 MeV alpha-particle, while ionization of L- and M-shell electrons are considerable. Convey electrons by alpha-particles may have energy less than 12 keV and emit secondary continuous X-rays in the energy range less than 12 keV in the slowing down process: This is the major source of X-ray emission by 4D TRF, and minor components of L- and M-X-rays from Pd will be superposed on the continuous spectra. Therefore, no characteristic K-X-rays of Pd (about 22 keV) will be observed in the reaction.

The product of 8D ORF is estimated to be ^{8}Be and ^{4}He, since the intermediate compound state of ^{16}O* is speculated to be an excited state of alpha-clustered nucleus, namely ^{16}O is formed with 4 alpha-particles. The ground state of ^{16}O has an equilaterally tetrahedral arrangement of 4 alpha-particles, and its excited states are 1) collective deformation to two parts of two-alpha-particles (^{8}Be sub-particles) or 2) an alpha-particle and ^{12}C nucleus. Consequently, ^{16}O* by 8D fusion breaks up to two ^{8}Be particles or alpha-particle + ^{12}C nucleus. Since emitted ^{8}Be has high kinetic energy (47.6 MeV), secondary capture (fusion) reaction with heavier nuclei in media is quite possible as discussed in the next section. Otherwise, ^{8}Be decays shortly to two alpha-particles.

5. SPECULATION TO MITSUBISHI EXPERIMENT

The strange result of mass-8-and-charge-4-transferred transmutation was obtained by the Mitsubishi experiments[1,2] using a D-gas diffusion type CF experiment with a multi-layered Pd(10 nm)/CaO(100 nm)/Pd(0.1 mm) plate. They made deposit thin layer (2 nm) of ^{88}Sr or ^{133}Cs on the 10 nm Pd layer of the plate, and in few weeks of run they observed significant amount of ^{96}Mo or ^{141}Pr accumulation on the surface region, by the in-situ XPS analysis.

Speculative explanation by the author based on TRF and ORF as modeled is in the following. Electron Fermi-level gap between layers of the plate may enhance electron flow and electron-bosonization at lattice focal points of 10 nm Pd (actually PdDx) zone to induce strong screening effect for fusion reactions. Then TRF (4D fusion) and ORF (8D fusion) took place at focal points. High energy ^{8}Be particle made capture (fusion) reaction with neighboring Sr or Cs nuclei, as illustrated in Fig.7, as;

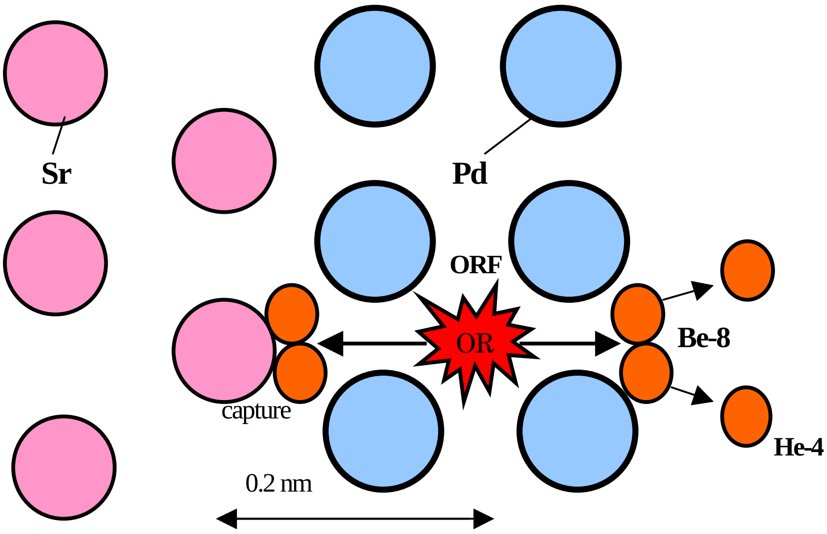

Fig.7: What happens near interface

$$M(A,Z) + {}^{8}Be \rightarrow M(A+8, Z+4) + Q \qquad (10)$$

In general and for Sr and Cs;

$$^{88}Sr + {}^{8}Be\,(KE=47.6\text{ MeV at most}) \rightarrow {}^{96}Mo(Ex) + KE \qquad (11)$$

$$^{133}Cs + {}^{8}Be\,(KE=47.6\text{ MeV at most}) \rightarrow {}^{141}Pr(Ex) + KE \qquad (12)$$

where KE denotes the kinetic energy and Ex does the nuclear excited energy.

Since ^{8}Be is unstable and deformed nucleus of rather weakly coupled two alpha-particles, large contact surface in capture (fusion) with Sr or Cs may enhance greatly cross section of fusion reaction. Its high kinetic energy 47.6 MeV is well over Coulomb barrier of fusion reaction, 22.5 MeV for the reaction (11) and 30.1 MeV for the reaction (12), to induce fusion (capture) reaction. These barrier heights were obtained by using the effective Coulomb interaction distance R = R1 + R2 + 2 fm (pion range) with target radius R1 = $1.2A^{1/3}$ and the ^{8}Be radius R2. And we used Vc = 1.44Z1Z2/R in MeV and fm unit.

The capture (fusion) reaction may be highly non-elastic. KE of compound nucleus (Mo or Pr) may have KE from 47.6 MeV at most to zero in CMS at least. Considering a liquid drop-like nature of collision, large portion of 47.6 MeV can be transferred to KE of Mo or Cs. If so, Ex = about 4.8 MeV for ^{96}Mo and Ex= 2.9 MeV for ^{141}Pr, and electromagnetic transition to ground state emit gamma rays. However, most released energy of the reaction will go to lattice phonon by slowing down of heavy ions (Mo or Cs) and no intense X or gamma-rays will be seen. Since the discussion is highly speculative, we need future study on reactions (11) and (12).

6. CONCLUSION

In this paper, we have proposed that basic coherent fusion in PdDx system may be tetrahedral (4D) and octahedral (8D) resonance fusion. Major ash of reactions are He-4 with 23.8 MeV energy release per d-d pair of 4D or 8D fusion. Selective transmutation with increase of mass 8 and charge 4 is possible by octahedral resonance fusion emitting high energy Be-8 particles.

Since the model contains several key assumptions, further effort is needed to fix up the model.

ACKNOWLEDGMENT

The author acknowledges the kind discussion with Dr. Y. Iwamura and Dr. S. Kuribayashi, Advanced Technology Center, Mitsubishi Heavy Industry Co..

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