Dynamic Mechanism of TSC Condensation Motion

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Abstract

This paper gives further discussions and explanations on the time-dependent quantum-mechanical behaviors of electron-clouds in 4D/TSC condensation motion by Langevin equation, in comparison with steady ground state electron orbits and their de Broglie wave lengths for D-atom and D_2 molecule.

1. Introduction

The formation of 4D/TSC (tetrahedral symmetric condensate) at T-sites of a regular PdD lattice under D-phonon excitation, or on topological (fractal) nano-scale surface of PdDx and/or along interface of metal-oxide-metal nano-composite was proposed as seeds of deuteron-cluster fusion to produce heat with helium-4 as 4D fusion ash[1]. Dynamic motion of TSC condensation was quantitatively studied by the quantum-mechanical stochastic differential equation (Langevin equation) for many-body cluster systems of deuterons and electrons under Platonic symmetry[2-6].

This paper gives further discussions and explanations on the time-dependent quantum-mechanical behaviors of electron-clouds in 4D/TSC condensation motion, in comparison with steady ground state electron orbits and their de Broglie wave lengths for D-atom and D_2 molecule.

2. Condensation Motion of 4D/TSC by Langevin Equation

The basics of methods with Langevin equations for D-cluster dynamics, especially for D-atom, D_2 molecule, D_2^+ ion, D_3^+ ion, 4D/TSC (tetrahedral symmetric condensate) and $6D^{2-}$/OSC (octahedral symmetric condensate) are described in our latest paper[4] and book[6].

First one-dimensional Langevin equations for D-clusters with the R_{dd} (d-d distance) are formulated under the Platonic symmtery[2,6] of multi-particle D-cluster systems with deuterons and quantum-mechanical electron centers. Under the orthogonally coupled Platonic symmetry for a Platonic deuteron-system and a Platonic electron system, dynamic equations for so-many-body system of deuterons and electrons with metal atoms a simple one-dimensional Langevin equation for the inter-nuclear d-d distance R_{dd} can be formulated, as we showed in our previous papers[4,6]. The Langevin equation of electron-cloud-averaged expectation value of d-d distance R_{dd} for D-cluster is given by,

$$N_e m_d \frac{d^2 R}{dt^2} = -\frac{k}{R^2} - N_f \frac{\partial V_s}{\partial R} + f(t) \qquad (1)$$

This is the basic Langevin equation for a Platonic symmetric D-cluster having N_e d-d edges and N_f faces of "d-d-e" (D_2^+) or "d-e-d-e" (D_2) type. Here, R is the d-d distance and m_d is the deuteron mass, V_s is the d-d pair trapping potential of either "d-e-d-e"-type (i=2) or "d-d-e"-type (i=1) molecule. The first term on the right side in Eq. (1) is the total Coulomb force converted to a one-dimensional variable R, of D-cluster system, and f(t) is the fluctuation of force for which we introduce quantum mechanical fluctuation of deuteron positions under condensation motion. The quantum mechanical effect of electron clouds is incorporated with the second term of right hand side as "friction" in Langevin equation. Parameters for different D-clusters are given in Table 1.

Table 1: parameters of D-cluster Langevin equation

Cluster	N_e: Number of d-d edges	K: Total Coulomb Force parameter (keVpm)	Type of electron trapping potential on a surface	N_f: number of faces
D_2	1	0	i = 2	1
D_2^+	1	0	i = 1	1
D_3^+	3	6.13	i = 1	6
4D/TSC	6	11.85	i = 2	6
$6D^{2-}$/OSC	12	29.3	i = 1	24

By taking QM ensemble average with d-d pair wave function, assumed as Gaussian distribution, we derived Langevin equation for 4D/TSC. By taking QM ensemble average we obtained Eq. (2) for expectation value $<R_{dd}>$ we obtained the time-dependent TSC-cluster trapping potential[3)] shown in Eq. (3).

$$6 m_d \frac{d^2 \langle R_{dd} \rangle}{dt^2} = -\frac{11.85}{\langle R_{dd} \rangle^2} - 6 \frac{\partial V_s(\langle R_{dd} \rangle; m, Z)}{\partial \langle R_{dd} \rangle} + 6.6 \left\langle \frac{(R' - R_{dd})^2}{R_{dd}^4} \right\rangle \quad (2)$$

$$V_{tsc}(R' : R_{dd}(t)) = -\frac{11.85}{R_{dd}(t)} + 6V_s(R_{dd}(t); m, Z) + 2.2 \frac{|R' - R_{dd}(t)|^3}{[R_{dd}(t)]^4} \quad (3)$$

Similar Langevin equation and trapping potential were derived for $6D^{2-}$ ion molecule also[4,6)]. We compared central potential curve (at $R'=R_{dd}$) in Fig. 1. The balancing to the Platonic symmetry after distortion (deviation from symmetry) works by the 3rd term of Eq. (3). We found that 4D(or H)/TSC can condensate ultimately to very small charge neutral entity and has no stable or ground state. This may be the reason that we do not observe D_4 molecule in nature. On the contrary, the $3D^+$ molecule and $6D^{2-}$ molecule have stable and ground states[4,6)]. Equation (2) was numerically solved by the Verlet method[3,6)], and the result is shown in Fig. 2.

Time dependent barrier penetration probabilities (as a function of R_{dd}, since we have one-to-one relation between elapsed time and $R_{dd}(t)$) were calculated by the Heavy-Mass Electronic Quasi-Particle Expansion Theory (Heavy Mass EQPET, HMEQPET) method[3,6)] .

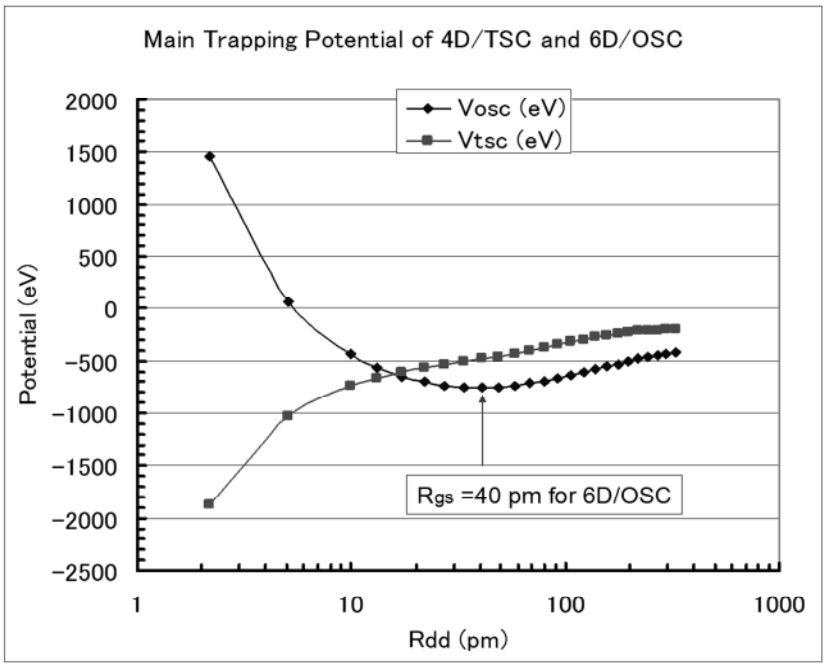

Figure 1. Comparison of cluster trapping potential between 4D/TSC and $6D^{2-}$/OSC. TSC condenses ultimately to very small R_{dd} value (ends at R_{dd}-min=about 20 fm), while OSC converges at R_{dd}=about 40 pm (corresponding to the ground state).

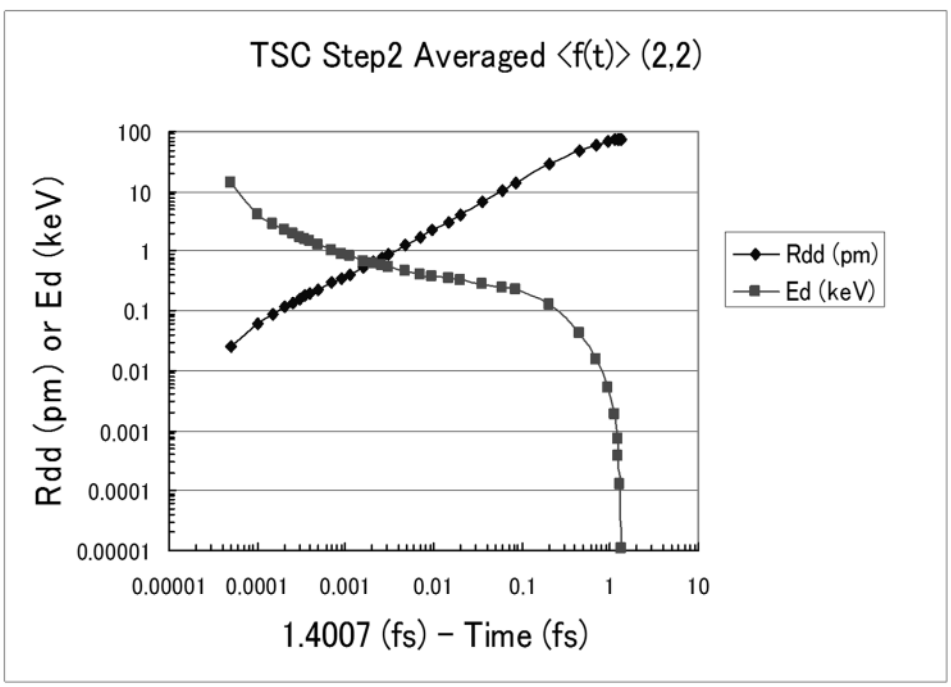

Figure 2. Numerical solution of Eq. (2) by the Verlet method[3]. Time is reversed starting from the condensation time 1.4007 fs.

The fusion rate is calculated by the following Fermi's golden rule[3,4,6],

$$\lambda_{nd} = \frac{2}{\hbar}\langle W \rangle P_{nd}(r_0) = 3.04 \times 10^{21} P_{nd}(r_0)\langle W \rangle \quad (4)$$

Here P_{nd} is barrier factor for nD-cluster and <W> is the averaged value of imaginary part of nuclear optical potential[3,4]. The extrapolation of <W> value to 4d fusion was made[3] by using the scaling law $\langle W \rangle \propto (PEF)^5$ with PEF-value which is given in unit of derivative of one pion exchange potential (OPEP) (a simple case of Hamada-Johnston potential[4] for the pion exchange model). We estimated the next value of 4D fusion yield per TSC generation,

$$\eta_{4d} = 1 - \exp(-\int_0^{t_c} \lambda_{4d}(t)dt) \quad (5)$$

Using time-dependent barrier factors, we obtained[3] $\eta_{4d} \cong 1.0$. This result means that we have obtained a simple result that 4D fusion may take place with almost 100% yield per TSC generation, so that macroscopic 4d fusion yield is given simply with TSC generation rate Q_{tsc} in the experimental conditions of CMNS.

The ultimate condensation is possible only when the double Platonic symmetry of 4D/TSC is kept in its dynamic motion. **The sufficient increase (super screening) of barrier factor is also only possible as long as the Platonic symmetric 4D/TSC system is kept. Therefore, there should be always 4 deuterons in barrier penetration and fusion process, so that 4d simultaneous fusion should take place predominantly. The portion of 2D (usual) fusion rate is considered to be negligible[3].** The order (or constraint) of condensed matter incubates this[6]. Typical nuclear products of 4D fusion are predicted to be two 23.8 MeV α-particles, although the final state interaction of ^{8}Be* is complex, and yet to be studied[5,6].

3. Time Dependent QM Behavior of Electron Clouds

We consider now the principle of dynamic condensation motion of TSC in the view of Heisenberg uncertainty principle (HUP).

At the starting condition of 4D/TSC (t=0), d-d distance R_{dd} was estimated to be the same value (74.1 pm) as that of a D_2 molecule. At this starting point, the mean electron kinetic energy of one "d-e-d-e" face EQPET molecule out of TSC 6 faces was 17.6 eV (19 eV by semi-classical model[6]). During the non-linear condensation of TSC, the size of "d-e-d-e" EQPET molecule as a face of 4D/TSC decreases from R_{dd}=74.1 pm at t=0 to R_{dd}=20.6 fm at t=1.4007 fs. In the view of HUP, electron wave length should decrease accordingly to the decrement of R_{dd}. At around t=1.4007 fs, the mean kinetic energy of electron for "d-e-d-e" EQPET molecule was estimated[3] to be 57.6 keV. The original Langevin equation for D_2 molecule, before the quantum-mechanical ensemble averaging is done, as given by,

$$m_d \frac{d^2 R_{dd}}{dt^2} = -(4\sqrt{2} - 2)\frac{e^2}{R_{dd}^2} + \frac{2m_e v_e^2}{(R_{ee}/2)} - \frac{\partial V_{s2}(R_{dd};1,1)}{\partial R_{dd}} + f(t) \quad (6)$$

We consider the averaged force-balance between the first term and the second term of right side of Eq. (6), with ensemble averaging by weight of "adiabatic electron wave function" of

modified 1S wave function with decreased de Broglie wave length during every small time step interval. R_{ee} is the distance between two quantum mechanical electron centers.

We understand that the effective quantum mechanical wave length of trapped electron in TSC has decreased dramatically in the 1.4007 fs condensation time. The estimated trapping potential depth of TSC at t=1.4007 fs was -130.4 keV. This state is understood as an adiabatic state in very short time interval (about 10^{-20} s) to trap such high kinetic energy (57.6 keV) electrons in very deep (-130.4 keV) trapping potential, to fulfill the HUP condition. By the way, mean kinetic energy of relative d-d motion was estimated[3)] to be 13.68 keV at this adiabatic state, which also diminished relative deuteron wave length trapped in the adiabatic TSC potential. In this way, very short R_{dd} (in other words, super screening of mutual Coulomb repulsion) was realized in the dynamic TSC condensation in very fast condensation time (t_c=1.4007 fs) to give however a very large 4D simultaneous fusion rate[3,4)].

We know that the ground state electron orbit (sphere) of D (or H) atom is the Bohr radius (R_B=52.9 pm). The mean kinetic energy of 1S electron is 13.6 eV, the de Broglie wave length of which is 332 pm. And we know $2\pi R_B$=332 pm to satisfy the continuation of 1S electron wave function (same with the Bohr's condition) by one turn around the central deuteron. No other states with shorter or longer wave length can satisfy the condition of smooth continuation of wave function, as ground state, for which we must in addition keep the condition that mean centrifugal force equals mean centripetal force.

On the other hand, electron orbit in a "d-e-d-e" quasi-molecular system of a face of 4D/TSC under time-dependent condensation makes a spiral track, finally getting to the center-of-mass point of TSC, with tail of time-varying "relatively long" effective wave length.

Similarly to the case of a D-atom, the ground state electron wave function of D_2 molecule has a steady ground state torus (ring) orbit of two centers of electron clouds[4,6)]. The mean kinetic energy of a centrifugal electron motion around the center-of-mass point (middle point of d-d distance) was calculated to be 17.6 eV, de Broglie wave length of which is 234 pm and equals to $2\pi R_B/1.4142$ to satisfy the smooth continuation of electron wave function along the torus orbit around the center-of-mass point. Dynamic motion of "d-e-d-e" 4 body system by Langevin equation (Eq. (6)) is illustrated in Fig. 3-a. When starting with an arbitrary electron wave length (or momentum), the center of electron cloud draws spiral orbit to converge finally to the steady torus (ring or circle) orbit with 234pm one turn length which equals to the ground state effective electron wave length of D_2 molecule. When we have the strong constraint of TSC trapping potential, center of electron cloud draws spiral orbit time-dependently as shown in Fig. 3-b **without converging ground state.** Calculated mean (eigen) energy-values of D_2 molecule are E_{gs} (ground state system energy) = -35.1 eV, E_c (mean Coulomb energy) = -70.3 eV, $E_{d\text{-}d}$ (mean relative deuteron energy) = 2.7 eV and E_{ke} (mean electron kinetic energy) = 35.2 eV for two electrons (17.6 eV per electron)[3,6,7)].

As a result, centrifugal electron motion in a "d-e-d-e" face draws a spiral curve conversing to the central focal point as illustrated in Fig. 3-b. If we do not have the strong centripetal Coulombic condensation force by the first term of Eq. (1) right side, for 4D/TSC, "d-e-d-e"

EQPET molecule must go back and converge to the ground state orbit of D_2 molecule, as drawn in Fig. 3-a.

4D/TSC has no steady ground state and effective electron wave length of a "d-e-d-e" face varies from time to time as illustrated in Fig. 3-b.

The spiral motion of an electron center under 4D/TSC condensation is illustrated with an expanded scale (right figure), compared with the estimation of mean rotation number of electron in each discrete change of R_{dd} steps, as given in Fig. 7 of our detailed paper to JCMNS[7].

The electron center rotates about 6 times in each step of R_{dd} changes, as shown in Fig. 7 of Ref. 7. This means the time-dependent electron wave function distributes with "long" tail along the spiral orbit. This situation does not contradict the Heisenberg uncertainty principle, as steady ground state does not exist and particles are non-linearly moving from time to time.

4. Conclusions

A further explanation on 4D/TSC condensation motion by quantum-mechanical stochastic differential equations (Langevin equations) has been given in this paper.

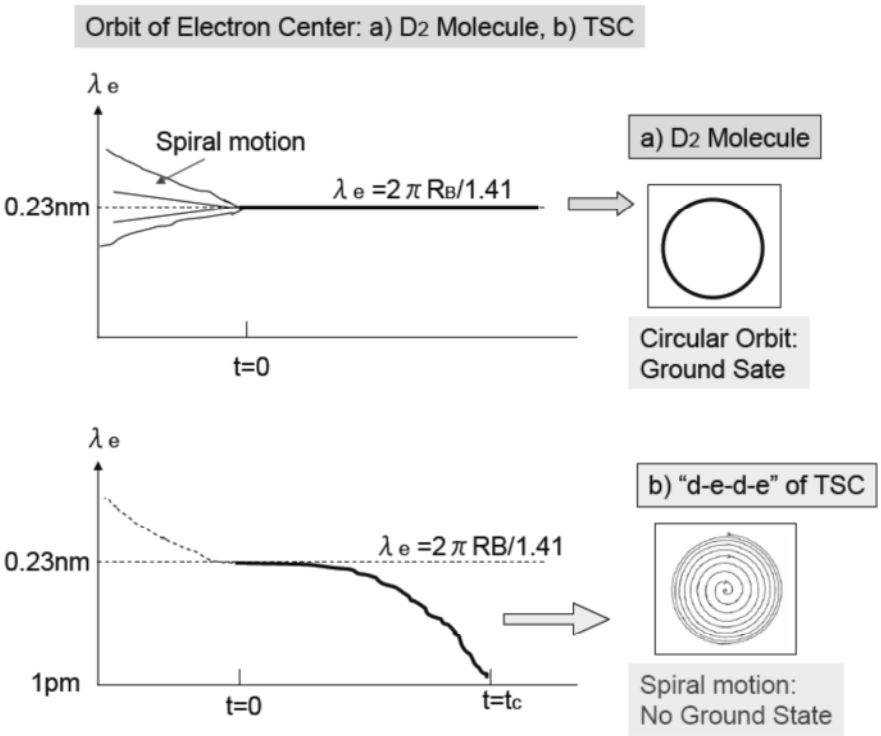

Figure 3. Time dependent behavior of effective electron wave length, a) D_2 molecule, b) "d-e-d-e" EQPET molecule of 4D/TSC

The electron orbit in a "d-e-d-e" quasi-molecular system of a face of 4D/TSC under time-dependent condensation makes a spiral track, finally getting to the center-of-mass point of

TSC, with a tail of time-varying effective wave length. This does not contradict the Heisenberg uncertainty principle. A more detailed paper on this work will appear in JCMNS[7].

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