(General and Physical)
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[General Analysis on Room Temparature Nuclear Fusion.]

General Analysis on Room Temaparature Nuclear Fusion from the View of Statistical Hybrid Hamiltonian Theory

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General theoretical condition for the room temparature nuclear fusion with a metal cathalyzer of high electron density is discussed from the view of statistical hybrid Hamiltonian and so on.1:A high electron density space can weaken the Coulomb energy relatively to the momentum one in a charged particles system.Consequently a charged nuclei tends to behave as aproximately free particles,which is just the room temparature semi-plasma state and to yield colisions toward the nuclear fusion.2:After all,a free particle's remarkable and great role is its spatial tunneling motion with the

realization probability mesure = 1 on time axis, and only by the free particles, a reaction as a colision of them become possible. This fact became evident by the statistical hybrid Hamiltonian theory. 3: And a ordinary hot plasma state and a room temparature plasma one are found to be the reciprocal aspect of Fourier transform between the configuration space and the momentum one with a scaling method for the spatial and momentum variables respectively. 4: Generally telling, in order to accelate a reaction, there exists essential two way. The 1st is increasing the temparature(momentum space), or the 2nd is increasing the density of electron on the catalyzer's surface(configuration spece).

Theoretical

In 1989, Fleishmann, Pons, Hawking[1, 2], and Jones[3] had reported so called room temparature nuclear fusion in a test tube. At first their results had been suspected, however follwing suceeded experiments after their works had made author to convince it true. In the other hand, author-himself had been occupied with the work denoted statistical hybrid Hamiltonian theory(SH^2 theory) for developing the fundamentals for time evolutional statistical mechanics since 1987. Consequently author had noticed the possibility of time discontineous Coulomb interaction between nuclei in the reaction due to statistical hybrid properties of Hamiltonian when author encounterd the news.Thus author thought that it never alway be necessary to accelate the positive charged nuclei for the reaction.However author could not find out the quantitical expression for the reaction at that time.But fortunately author happened to encounter an excellent book⁴⁾ which had described the electron density effect on a Hamiltonian structure of general many body system.Consequently author had found the systematical view for the general reaction's feature caused by temparature effect and by the electron density one in reaction space.Therefore following results can be considered universal one for a material reaction.And also the theory is fairly simple and visible.

§1.The summary of statistical hybrid Hamiltonian theory.

In anyway,to accomplish full understanding of this report,reader must know the SH² theory⁵·⁶·⁷·⁸·⁹⁾.However almost of them are now serious thema on the discussion table of Phys.Soc.Jpn.Therefore we shall descirbe their summary at here.The most important kernel point is Heisenberg's uncertainity principle especially as for time and energy.

$$\Delta t \cdot \Delta E \sim \hbar . \qquad \text{(UP)}$$

[1]A quantum state under Hermitian Hamiltonian($\equiv H_0$) must be stationary,or H_0 can't cause quantum state transition in general.

Proof:Under Hermitian Hamiltonian condition,we can derive so called Liouville equation from Schrödinger EQN.

$$i\hbar\frac{\partial}{\partial t}\rho_{jl}(t)=\Sigma_{k=0}^{\infty}[H_{0jk}\rho_{kl}(t)-\rho_{jk}(t)H_{0kl}]. \qquad (1\text{-}1)$$

Hereupon state density operator $\rho(t)$ is orginaly Hermitian,so it can be diagonalized,then Eq(1-1) is,

$$i\hbar\frac{\partial}{\partial t}\rho_{jj}(t)=\Sigma_{k=0}^{\infty}[H_{0jk}\rho_{kj}(t)-\rho_{jk}(t)H_{0kj}]$$

$$=H_{0jj}\rho_{jj}(t)-\rho_{jj}(t)H_{0jj}=0. \qquad (1\text{-}2)$$

Thus a state density ρ can't depend on time under H_0 !.

[2]The realization of unique simuletaneous eigen state of H_0's maximum observable($\equiv$ **MO**).

$$\mathbf{MO}\equiv\{\mathbf{A}_j\mid i\hbar\frac{\partial}{\partial t}\mathbf{A}_j=[\mathbf{A}_j,H_0]=0,j=1,2,\cdot\cdot,M\}. \qquad (1\text{-}3)$$

[··] is comutation relation.The validity is as follows.If so called superpositional state of H_0's eigen one could be, then,

$$\psi(t) = \Sigma_{n=0}^{\infty} a_n(t)|E_n\rangle. \qquad (1\text{-}4)$$

$$\Delta E^2 = \Sigma_{n=0}^{\infty} |a_n(t)|^2 [E_n - \langle E\rangle]^2 > 0. \qquad (1\text{-}5)$$

In the other hand, state under the H_0 must be stationary, so

$$\Delta t = \infty. \qquad (1\text{-}6)$$

$$\Delta t \cdot \Delta E \rightarrow \infty$$

This contradicts with Heisenberg uncertainity principle. Thus we can not stop to conclude $\Delta E=0$ in Eq(1-4). Then we know that superpositional solution is forbidden under H_0. After all, degenerated state of $|E_n\rangle$ is also denyed. The proof is used uncertainity, but is deleted here.

Caution: If $|E_n\rangle$ is not H_0's eigen state, it's all right !.

[3] Markovian stochastic process property of quantum one. It is caused by [2].

[4] Only by nonHermitian Hamiltonian[$\equiv H_s(t)$], quantum state transition can become possible, however $H_s(t)$ can't be analytical Hamiltonian, that is singular one !.

Validity:

$$\langle E\rangle \equiv \langle \psi \mid H_s \psi \rangle \neq \langle H_s \psi \mid \psi \rangle \equiv \langle E\rangle^* . \qquad (1\text{-}7)$$

Eq(1-7),we know that expected energy value $\langle E\rangle$ is not real number,in other words, $H_s(t)$ can't have a definite energy,so $H_s(t)$ can't be a analytical operator,or nonobservable.Then nonobserval energy system should have infinitive energy fluctuation.

$$\Delta E = \infty . \qquad (1\text{-}8)$$

Then Heisenberg's uncertainity principle (1-10) demands,

$$\Delta t = 0. \qquad (1\text{-}9)$$

$$\Delta t \cdot \Delta E \sim \hbar . \qquad (1\text{-}10)$$

Thus we know the phenomena of $H_s(t)$ is instataneous one. Consequently we can derive serious conclusions for quantum process,that is,

(1)Schrödinger EQN with $H_s(t)$ must yield bifurcated solutions in nondeteministic way,that is just the origin of state transition probability.

(2)The origin of irreversibility of physical and chemical process in general caused by singular $H_s(t)$.

[5]Statistical hybrid Hamiltonian structure.

$\mathring{\mathbf{H}}(t) = H_0 \cup H_s(t)$. 〈$\cup$ means exclusive "or".〉 (1-11)

That is,a time dependent Hamiltonian is alternative sequence of $H_s(t)\{\Delta t=0\}$ and $H_0\{\infty \geqq \Delta t > 0\}$,where Δt is each interval Hamiltonian's life time.And also the configuration of $H_s(t)$ on time axis is entirely statistical.The statistics is detemined from [6].

[6]Principle of evolution by energy fluctuation.

$$\Pr[\mathring{\mathbf{H}}(t) = H_s(t) \mid u+dt \geqq t \geqq u] = \Theta(t)\cdot dt. \tag{1-12}$$

$$\Pr[\mathring{\mathbf{H}}(t) = H_0 \mid u+dt \geqq t \geqq u] = 1 - \Theta(t)\cdot dt = 1. \tag{1-13}$$

$$\Theta(t) = \Delta E(t)/\hbar .$$

$$= \hbar^{-1}\cdot\sqrt{\ }\{\Sigma_{j=0}{}^{\infty}\,\omega_j(t)\langle\varepsilon_j - \Sigma_{k=0}{}^{\infty}\,\omega_k(t)\,\varepsilon_k\rangle^2\} \tag{1-14}$$

ω_j is a state density.The proof takes fairly long pages.

[7]The establishement of Langevinized Schrödiger Equation.

$$i\hbar\frac{\partial}{\partial t}\psi(t) = \mathring{\mathbf{H}}\,\psi(t). \tag{1-15}$$

Thus time evolutional system's Schrödiger EQN must be stochastic one with relation Eq(1-12),(1-13) and(1-14).

[8]Heisenbergian Markov process formulation(HM process).

This is equivalent to Langevinized Schrödiger Equation.

$$\frac{d}{dt}\omega_j(t) = \Theta(t)\Sigma_{k=0}^{\infty}[T_{jk} - \delta_{jk}]\omega_k(t), \qquad (1\text{-}16)$$

,where ω is state density, Θ is reaction rate, T_{jk} is 1st order |k>→|j> state transition probality matrix elements caused by $H_s(t)$. δ is unit matrix.These details are mentioned in $^{5,6,7,8,9)}$.A general relaxation process had been derived from (1-16).The results [5] is especially important in following our discussion.

§2.Stationary Hermitian Hamiltonian H_0 is comosed from statistical hybrid of interacting $H_s(t)$ and noninteracting H_F(≡A free particle's Hermetian Hamiltonian).

Now we shall analysis on Hermitian Hamiltonian H_0 which yields stationary state only.For example,hydrogen atom's <kinetic energy+Coulomb force> Hamiltonian is a kind of H_0,which yields stationary state $\psi(\mathbf{x})$.However the $\psi(\mathbf{x})$ is that of configuration space.In momentum space there exists state transition obviously at each instant,but they accomplishes equilibrioum as a whole.

$$\psi(\mathbf{x}) = (2\pi\hbar)^{-3}\int dp^3 \exp[-\mathbf{px}/i\hbar]\,\Phi(\mathbf{p}). \qquad (2\text{-}1)$$

Eq(2-1) means that $\psi(\mathbf{x})$ is a statistical mixture of a free particle of various momenta.This is nothing without a phenomena caused by the state transition with $H_s(t)$ in the momentum space.Thus H_0 must contain $H_s(t)$ in it.Then we ask $H_0 = H_s(t)$ or not ?.This is ridiculous.Because H_0 is during nonzero time interval,in the other hand, $H_s(t)$ can be only at spot time.And also contineous realization of $H_s(t)$ is impossible due to the sigularity $\Delta E = \infty$.Thus time axis gap of $H_s(t)$ must be filled up with noninteracting Hamiltonian,that is nothing without a free particle Hermitian Hamiltonian($\equiv H_F$).Thus we obtain,

$$H_0 = H_F \cup H_s(t). \qquad (2\text{-}2)$$

This conclusion just corresponds with Eq(2-1),that is, $\psi(\mathbf{x})$ is a linear mixture of free particle states with various momenta.Eq(2-2) is general conclusion.Consequently we can derive marvelous conclusion that Coulomb interaction between plasma state nuclei is not a time discontineous one. Therefore,there must exists a finite time interval when particles are that of free.Consequently the wave packet of free particles shall expand enough to make overlapping with other particle's one.This is nothing without the colisions for our concerning reaction,that is nuclear fusion.The details will be described in the later.

§3.A reaction will be possible by particle colisions estimated by free particle's wave packet overlapping with each other.

Our fundamental idea for reaction is particle colisions which will be represented by the wave packet overlapping for concerning two particles.P_{RC} is Reaction probability at D.

$$P_{RC}(D,t)=\int_D dx^3 |\psi(\mathbf{x};t)|^2\cdot|\phi(\mathbf{x};t)|^2. \qquad (3\text{-}1)$$

$$CDF(\mathbf{x};t)\equiv|\psi(\mathbf{x};t)|^2\cdot|\phi(\mathbf{x};t)|^2. \qquad (3\text{-}2)$$

If overlapping CDF was zero,it is evident that nothing will happen.In the other hand,if ψ were ϕ are both free particle's wave packets,CDF is maximum,On the contraly if ψ and ϕ were both delta fuction just caused by $H_s(t)$'s instantaneous interaction,CDF is zero.

$$CDF(\mathbf{x};t)\equiv|\delta(\mathbf{x}-\mathbf{x}_1;t)|^2\cdot|\delta(\mathbf{x}-\mathbf{x}_2;t)|^2=0.\langle \mathbf{x}_1\neq\mathbf{x}_2\rangle$$

After all probability of reaction will entirely depend only on the volume of the wave packet,which is determined from the strength of the interaction or in another words,the height of the potential barier V_{RB} of the reaction's obstacle.Then we know there exists two way to overcome the V_{RB}.Now we shall imagine two particles A and B on 1dimensional X axis.B is assumed to be stop still at x=0 and to generate a square potential barier V_{RB} around B with heigt $\infty > V_{RB} > 0$ and with space width $\infty >$ □x > 0.A is assumed to be asymptoticaly free particle on $x = -\infty$ and to go toward B.

〈1〉Increasing the kinetic energy of the particle A enough to overcome V_{RB}.This usually called operation of increasing temparature.

〈2〉Decreasing the V_{RB} itself by setting a catalyzer around B enough to weaken the V_{RB} for A.This is our main thema concerned with room temparature nuclear fusion.

The remarkable common feature of 〈1〉 and 〈2〉 is that both of them will make A free particle as its supreme aim in order to touch B with A's wave packet,that is just the colision for the reaction $A+B \rightarrow C+C'$.You must notice that this is univesal method to obtaitn reaction by A and B's colision no concern with the particle kind.

§4. High electron density effect on many body system with Coulomb interaction (The role of methal catalyzer of high electron conductivity).

Now we shall describe 2nd kernel concept. (1st is statistical hybrid structure of H_0, that is $H_0 = H_F \cup H_S(t)$ and the special role of H_F and of a free particle state to yield reaction.) After all, the high free electron density will weaken the Coulomb interaction energy term relatively to the kinetic energy one in general many body charged particles Hamiltonian structure, which is as follows. This section is mainly cited from the book[4].

$$H_0 = \Sigma_{j=1}^{N}(-\hbar^2/2m_e)\Delta_j + \tfrac{1}{2}\Sigma\,\Sigma_{j\neq k}^{N} e^2/|\mathbf{x}_j - \mathbf{x}_k|$$

$$+ \Sigma_{J=1}^{M}(-\hbar^2/2m_D)\Delta_J + \tfrac{1}{2}\Sigma\,\Sigma_{J\neq K}^{M} e^2/|\mathbf{x}_J - \mathbf{x}_K|$$

$$+ \Sigma_{J=1}^{M}\Sigma_{j=1}^{N} e^2/|\mathbf{x}_J - \mathbf{x}_j|. \qquad (4\text{-}1)$$

, in which suffix $_{e,j}$ and $_{D,J}$ are N pieces of electron and M pieces of deuterium respectively in fixed volume Ω. Hereupon Coulomb term is expanded as follows.

$$1/|\,\mathbf{x}_j-\mathbf{x}_k\,| = \Sigma_k (4\pi/\Omega k^2)\exp[i\cdot\mathbf{k}(\mathbf{x}_j-\mathbf{x}_k)]. \qquad (4\text{-}2)$$

Then we introduce a renormalized cordinate x' by average distance of electron r_0 in a fixed volume Ω.

$$\Omega/N \equiv (4\pi/3)r_0^3. \qquad (4\text{-}3)$$

$$x \equiv r_0 x'. \qquad (4\text{-}4)$$

$$r_0 \equiv r_s\times L_0 \equiv r_s\times L\times a_0 \equiv r_s\times L\times(\hbar^2/m_e e^2). \qquad (4\text{-}5)$$

,where a_0 is Bohr radius and L is certain fixed number to yield fixed critical length L_0 and scaling variable r_s.Thus we mesure distance with renormalized variable x' with r_s. Then Eq(4-1) is rewrited with renormalized variables.

$$x \equiv r_0 x'. \qquad (4\text{-}4)$$

$$\mathbf{k} \equiv (1/r_s L_0)\,\mathbf{k}'. \qquad (4\text{-}6)$$

$$\Delta \equiv (1/r_s L_0)^2\cdot\Delta'. \qquad (4\text{-}7)$$

$$\Omega \equiv (1/r_s L_0)^3\cdot\Omega'. \qquad (4\text{-}8)$$

Then we derive,

$$H_o = (e^2/2LL_0)\{ - (1/r_s)^2 \Sigma_{j=1}^{N} \Delta_j'$$

$$+ (L/r_s)(4\pi/\Omega')\Sigma_{k'}(1/k')^2 \Sigma\ \Sigma_{j=1}^{N} \exp[i\cdot \mathbf{k'(x_j'-x_k')}]$$

$$- (1/r_s)^2 \Sigma_{J=1}^{M} \Delta_J'$$

$$+(L/r_s)(4\pi/\Omega')\Sigma_{k'}(1/k')^2 \Sigma\ \Sigma_{J\neq K}^{M} \exp[i\cdot \mathbf{k'(x_J'-x_K')}]$$

$$+(L/r_s)(8\pi/\Omega')\Sigma_{k'}(1/k')^2 \Sigma_{J=1}^{M} \Sigma_{j=1}^{N} \exp[i\cdot \mathbf{k'(x_J'-x_k')}]\}$$

·······(4-9)

Then we can see the serious role of electron density parameter r_s.

$r_s = (r_0/L_0)$. (4-10)

If we compared average distance of electron with critical length L_0 and if $r_0 \ll L_0$, then $r_s \ll 1$. Then we see that kinetic energy term of electron and that of deuterium will increase by $(1/r_s)^2$ relatively to Coulomb interaction energy term which depends by $(1/r_s)$.That is $r_s \to +0$ will cause free deuteriums to arise the nuclear fusion.Because we never be likely to find out any powerful accelation mechanism 'to yield enough high temparature deuteriums to arise the nuclear fusion.This is our fundamental view for the condition for the reaction of room-temparature nuclear fusions.Consequently we shall see that Eq(4-10) is just the critical parameter for the reaction.After all,it depends only on "r_0" of catalyzer's material constant.This is a remarkable feature to estimate the possiblity of the reaction.According to many experiments as for the reaction, almost them are very critical to obtain the reaction by any method with catalyzer.so it seems to us that the success of the reaction may depends on the local fluctuation of the free electron density and that of deuterium on the catalyzer's surfaces.

§5.The scaling symmetry between the Hamiltonian of ordinary hot plasma in the momentum space and that of cold-plasma in the configuration onee.

By coordinate scaling method in the cofiguration space,we proved the realization tendency of free particles. Hereupon to say for momentum space which is related by

Fourier transform, we had found existence of the same analogy which represents the tendency of realization of free particles. It is just ordinary hot plasma state. Thus we had known the being of symmetry or reciprocality between the universal methods of accelating reaction 〈1〉 and 〈2〉 mentioned in §3. Now let's take Hamiltonian Eq(5-1), and give its Schrödinger equation. Then we will take Fourier transform of the equation.

$$H_0 \equiv \Sigma_{j=1}^{N}(-\hbar^2/2m_j \Delta_j + ½\, \Sigma\, \Sigma_{j\neq k}^{N} e_j e_k/|\, \mathbf{x}_j - \mathbf{x}_k\, | . \qquad (5\text{-}1)$$

$$i\hbar\, \partial_0 \psi\, (x_0,\ \mathbf{x}_1, \cdots, \mathbf{x}_N\ ) = H_0 \psi\, (x_0,\ \mathbf{x}_1, \cdots, \mathbf{x}_N\ ). \qquad (5\text{-}2)$$

$$\Phi\, (p_0,\ \mathbf{p}_1, \cdots, \mathbf{p}_N\ ) \equiv\ \mathbf{F}\ \ \psi\, (x_0,\ \mathbf{x}_1, \cdots, \mathbf{x}_N\ ).$$

$$\equiv \int dp_0 dp_1{}^3 \cdot\cdot dp_N{}^3 \exp[(-p_0 x_0 + \Sigma_{j=1}^{N}\ \mathbf{p}_j \mathbf{x}_j\ )/i\hbar\,]\ \psi\, (x_0,\ \mathbf{x}_1, \cdot, \mathbf{x}_N)$$

$$\cdots\cdots (5\text{-}3)$$

, where $p_0 \equiv E/c$, $x_0 \equiv ct$.

$$\mathbf{F}\ \ \{i\hbar\, \partial_0 \cdot \psi\, (x_0,\ \mathbf{x}_1, \cdots, \mathbf{x}_N\ )\} = p_0 \Phi\, (p_0,\ \mathbf{p}_1, \cdot\cdot, \mathbf{p}_N\ ). \qquad (5\text{-}4)$$

$$F\ \{\Sigma_{j=1}{}^{N}(-\hbar^{2}/2m_{j})\Delta_{j}\cdot\psi(x_{0},\ \mathbf{x}_{1},\cdots,\mathbf{x}_{N}\ )\}$$

$$=\Sigma_{j=1}{}^{N}(\ \mathbf{p}_{j}{}^{2}/2m_{j})\cdot\Phi(p_{0},\ \mathbf{p}_{1},\cdots,\mathbf{p}_{N}\ ).\qquad(5\text{-}5)$$

For Coulomb term's transform,we use convolution theorem as follows,where Q and Φ are Fourier transform of q and ψ respectively.Note on negative singn on "p" in the integral.

$$F\ \{q(x_{0},\ \mathbf{x}_{1}\ ,\cdots,\ \mathbf{x}_{N}\ )\psi(x_{0},\ \mathbf{x}_{1}\ ,\cdots,\ \mathbf{x}_{N}\ \}$$

$$=\int dq_{0}dq_{1}{}^{3}\cdots dq_{N}{}^{3}\,Q(q_{0},\ \mathbf{q}_{1}\ ,\cdots,\ \mathbf{q}_{N}\ )$$

$$\times\ \Phi(q_{0}-p_{0}\ ,\ \mathbf{q}_{1}-\mathbf{p}_{1}\ ,\cdots,\ \mathbf{q}_{N}-\mathbf{p}_{N}\ ).\qquad(5\text{-}6)$$

$$F\ \{\tfrac{1}{2}\,\Sigma\,\Sigma_{j\neq k}{}^{N}e_{j}e_{k}/|\ \mathbf{x}_{j}-\mathbf{x}_{k}\ |\}\equiv Q(p_{0},\ \mathbf{p}_{1}\ ,\cdots,\ \mathbf{p}_{N}\ ).\qquad(5\text{-}7)$$

From Eq(5-6) and (5-7),we derive Fourier transform of Qoulomb term QE(p) as follows.

$$QE(p)\equiv\ F\ \{[\tfrac{1}{2}\,\Sigma\,\Sigma_{j\neq k}{}^{N}e_{j}e_{k}/|\ \mathbf{x}_{j}-\mathbf{x}_{k}\ |]\times\psi(x_{0},\ \mathbf{x}_{1}\ ,\cdots,\ \mathbf{x}_{N}\ \}$$

$$\equiv Q\ (p)\ \text{※}\ \Phi\ (p)$$

$$= \int dq_0 dq_1{}^3 \cdots dq_N{}^3 \, Q\,(q_0,\ \mathbf{q}_1\ , \cdots,\ \mathbf{q}_N\ )$$

$$\times\ \Phi\,(q_0 - p_0,\ \mathbf{q}_1 - \mathbf{p}_1\ , \cdots,\ \mathbf{q}_N - \mathbf{p}_N\ ). \qquad (5\text{-}8)$$

Consequently we derive Fourier transformed Schrödiger EQN.

$$p_0 \cdot \Phi\,(p_0,\ \mathbf{p}_1, \cdots, \mathbf{p}_N\ ) = \Sigma_{j=1}{}^N (\ \mathbf{p}_j\ {}^2/2m_j) \cdot \Phi\,(p_0,\ \mathbf{p}_1, \cdots, \mathbf{p}_N\ )$$

$$+\ Q\,(p) ※ \Phi\,(p). \qquad (5\text{-}9)$$

Then we take the scaling to test the momentum depedence.

$$p_j\ \rightarrow\ wp_j. \qquad (5\text{-}10)$$

Time derivative term. ⇒ $w \cdot p_0 | \Phi\,(wp_0, w\ \mathbf{p}_1\ , \cdots, w\ p_N\ )\rangle$ (5-11)

Kinetic term. ⇒ $w^2 \Sigma_{j=1}{}^N (\ \mathbf{p}_j\ {}^2/2m_j) | \Phi\,(wp_0, w\ \mathbf{p}_1\ , \cdots, w\ p_N\ ).$

$\cdots\cdots$ (5-12)

C~~K~~oulomb term. ⇒ $w \cdot Q\,(p) ※ \Phi\,(wp).$ (5-13)

The C~~K~~oulomb term ($\equiv$ Q E) is rather complicated to derive.

Now review the Fourier transform on the term as follows.

$$FQE(p) \equiv \mathbf{F}\ \{QE(x)\} = (2\pi\hbar)^{-(3N+1)/2}$$

$$\times \int dx_0 dx^3 \cdot\cdot dx_N{}^3 \exp[(-p_0 x_0 + \Sigma_{j=1}{}^N\ \mathbf{p}_j \mathbf{x}_j\ )/i\hbar]$$

$$\times \{ \tfrac{1}{2}\ \Sigma_{r\neq s} e_r e_s / |\ \mathbf{x}_r - \mathbf{x}_s\ | \}. \qquad (5\text{-}14)$$

Then we replace p→wp in (5-14) and shifts w to x_j's term sides.

$$FQE(wp) = (2\pi\hbar)^{-(3N+1)/2}$$

$$\times (w)^{-(3N+1)} \int dwx_0 dwx^3 \cdot\cdot dwx_N{}^3 \exp[(-p_0 wx_0 + \Sigma_{j=1}{}^N\ \mathbf{p}_j\ w\ \mathbf{x}_j\ )/i\hbar]$$

$$\times\ w\{ \tfrac{1}{2}\ \Sigma_{r\neq s} e_r e_s / |\ \mathbf{x}_r - \mathbf{x}_s\ | \} = (w)^{-3N}\ FQE(p). \qquad (5\text{-}15)$$

On the other hand, considering the covolution integral (5-6), the term $\int dq_0 dq_1{}^3 \cdot\cdot dq_N{}^3$ shall yield w^{3N+1} scaling factor. Hence we derive w's dependence of Coulomb terms in the Hamiltonian as follows.

$$Q\,E\,(wp) = w\,Q\,(p) \text{※} \Phi\,(wp).$$

As a whole, we derive following relation by the scaling w.

$$w p_0 |\Phi\rangle = w^2 \Sigma_{j=1}{}^{N} (\, p_j{}^2/2m_j) |\Phi\rangle + w\cdot Q\,(p) \text{※} \Phi\,(wp). \quad (5\text{-}16)$$

Dividing both side of Eq(5-16) by "w", we derive,

$$p_0 |\Phi\,(wp)\rangle = w \Sigma_{j=1}{}^{N} (\, p_j{}^2/2m_j) |\Phi\,(wp)\rangle + Q\,(p) \text{※} \Phi\,(wp). (5\text{-}17)$$

Then we can see that the kinetic terms will increase by w, while Coulomb terms will be constant. Thus we shall know,

<<1>>: w→ ∞ , kinetic term's sole dominant = hot plasma state.

<<2>>: w→ 0 , Coulomb term's sole dominant = cold solid state.

Thus we can know all the phase of states in general.

To tell for the relation of the section §4, hot plasma state and the (room temparature) cold-plasma state is symmetric or reciprocal between the momentum space and the configuration one. And also we can refer to the symmetry between the discussion of <1> and of <2> mentioned in §3, That is, there exists two essential methods to accelate the reaction of chemical material in general.

1: Increasing the temparature.

2: Increasing the density of catalyzer electrons, as for Coulomb barier, a high electron density is effective to accelate the reaction. An aim of this report is just the recognition of the role of 2:.

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