SunQM-6s6: Using {N,n} QM Field Theory to Study the Atomic Electron Configuration, the Pre-Sun Ball's {N,n} QM Structural Configuration, and the Nuclear Proton Configuration

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Abstract

Solving Schrodinger equation for an H-atom directly produced $r_{1s} < r_{2p} < r_{2s} < r_{3d} < r_{3p} < r_{3s} < r_{4f}$ … in Born probability density's radial function, and it fitted perfectly for the pre-Sun ball's {N,n} QM structural configuration (as proved in paper SunQM-3s3 by assigning the |5,4,m> and |4,0,0> QM states to Jupiter surface atmosphere's zonal bands and belt bands). However, in all QM text books, for a Z > 1 atom, its ground state electron configuration is always $r_{1s} < r_{2s} < r_{2p} < r_{3s} < r_{3p} < r_{3d}$ … , (that reversed *l* sub-shell sequence in comparison with the Schrodinger equation's solution for an H-atom). All QM text books have to explain this difference by using some kind of patches. In the current paper, I (qualitatively) solved this problem by changing the potential $V = V_r$ to $V = V_r + V_{\theta\varphi}$ in Schrodinger equation (with $V_r < 0$), and with either $V_{\theta\varphi} > 0$ for the electron-electron's repulsive interaction in the same *l* sub-shell, or $V_{\theta\varphi} < 0$ for the pre-Sun ball's attractive interaction between the objects in the same *l* sub-shell. After assuming $V_{\theta\varphi} << V_r$, and treating $V_{\theta\varphi}$ as a small perturbation of V_r, and then forcing $V_{\theta\varphi}$ to be a function of r-1D, I was able to analyze the Schrodinger equation's solution semi-quantitatively, and obtained the expected result. Then, I explored Schrodinger equation for $V_r > 0$, and guessed out a (Bohr formula equivalent) formula for a point-centered repulsive force field, (also with $r_n = r_1 n^2$, $E_n = E_1 / n^2$, but with $n \leq 1$, or n" = 1/n, with n" > 0). Then, I proposed a brand new "proton-electron mirror-coupled orbit" model: for an atom with the ground state electron configuration of $r_{1s} < r_{2s} < r_{2p} < r_{3s} < r_{3p} < r_{3d}$, its nuclear protons has a E/RFe-force energy level ground state configuration of (approximately) $r_{1s} > r_{2s} > r_{2p} > r_{3s} > r_{3p} > r_{3d}$. Furthermore, the 1s proton and 1s electron, the 2s proton and 2s electron, etc., are always dynamically (or transiently) coupled. This model may be useful in the explanation of the K-capture, or the formation of the black hole (from a {-2,1} star during the gravity collapse). Based on that, I proposed a second new hypothesis: the γ decay may can be attributed to the nuclear proton's pure E/RFe-force energy level de-excitation (without involving the S/RFs-force). Some semi-quantitative estimations have been calculated to support this hypothesis.

Key Words: Quantum mechanics, {N,n} QM, electron configuration, nuclear proton configuration

Introduction

In August 2016, I discovered that the Solar system follows the {N,n//6} quantum mechanical structure [1]. Based on that result, I further developed the {N,n} QM theory, and showed that not only the formation of Solar system [1] ~ [16], but also the formation of the whole universe [17] ~ [25], may can be described by the {N,n} QM. (Note: As an independent scientist, some of my research work may belong to the citizen scientist leveled work). As part of the {N,n} QM development, I designed a completely new {N,n} QM field theory [23] ~[24], [26] ~ [29]. The foundation of this theory includes: the four fundamental forces (Gravity, Electromagnetic, Strong, Weak, abbreviated as G-, E/M-, S-, W-forces) have been re-classified into three pairs of force (E/RFe-force, G/RFg-force; S/RFs-force, see SunQM-6); all point-centered fields (including the mass

field, the force field, and the energy field) can be represented by the Schrodinger equation/solution (in form of non-Born probability as well as in the form of 3D spherical wave packet, see SunQM-6s4); the non-Born probability description that equals to the re-explanation of the Born probability density as the collection of all elliptical orbital tracks (or, the Born probability density map's contour lines can be re-explained as the trajectory of the moving electron, see SunQM-6s2's Fig-2), the 3D wave packet description and the dis-entanglement of the outmost shell (i.e., the "general decaying" process, see SunQM-6s1, -6s2, -6s3), the "|nL0> elliptical/parabolic/hyperbolic orbital transition model" (see SunQM-6s2, -6s3), and the trick that using the high-frequency n' quantum number to pin-point any small region in the {N,n} QM field (see SunQM-3s11, -6s1, etc.). In the current paper, first I solved the problem (in a semi-quantitative way) that why the solution of the Schrodinger equation for the H-atom has a glitch for the explanation of the atomic electron configuration at the ground state, but has no glitch for the explanation of the QM states of Jupiter's surface mass (see SunQM-3s3's section I-a, or, more generally, has no glitch for the explanation of the pre-Sun ball's {N,n} QM structural configuration). Then I tried to use the similar idea to study the nuclear proton's E/RFe energy level configuration at the ground state (and even in the excited state).

Note: QM means Quantum Mechanics. For {N,n} QM nomenclature as well as the general notes, please see SunQM-1 sections VII & VIII. Note: Microsoft Excel's number format is often used in this paper, for example: x^2 = x^2, 3.4E+12 = $3.4*10^{12}$ = 3.4×10^{12}, 5.6E-9 = $5.6*10^{-9}$. Note: The reading sequence for the (30 posted) SunQM series papers is: SunQM-1, 1s1, 1s2, 1s3, 2, 3, 3s1, 3s2, 3s6, 3s7, 3s8, 3s3, 3s9, 3s4, 3s10, 3s11, 4, 4s1, 4s2, 5, 5s1, 5s2, 7, 6, 6s1, 6s2, 6s3, 6s4, 6s5, and 6s6. Note: for all SunQM series papers, reader should check "SunQM-9s1: Updates and Q/A for SunQM series papers" for the most recent updates and corrections. Note: |n*l*m> means |n,*l*,m> QM state, "nLL" or |nLL> means |n,*l*,m> QM state with *l* = n-1 = L, and *m* = n-1 = L. "nL0" or |nL0> means |n,*l*,m> QM state with *l* = n-1 = L, and m = 0. Note: In the current paper, the single "E" or "E_n" means energy, "E/RFe-force" means the electric force. Note: In the current paper, the cited SunQM series numbers of those pre-posted SunQM papers may not be the final SunQM series numbers (after posting), so, readers may need to match the right SunQM series number (for those pre-posting SunQM papers after they are posted, according to the list of "A series of SunQM papers that I am working on" at the end of current paper) before reading those (pre-posted) citations.

I. The original Schrodinger equation based explanation for the electron configuration in a H-atom

I-a. The H-atom's Schrodinger equation solution can not accurately explain a Z > 1 atom's ground state electron configuration

(Note: in this section, all major equations are copied from Davis J Griffiths' book "Introduction to Quantum mechanics, 2nd ed. 2005". The "eq-4.xx" is the equation number in Griffiths' book). According to Griffiths text book, the Schrodinger equations for a single (non-relativistic) particle that orbiting around a point-center attractive force center, (notice that it is valid for both Hydrogen atom and pre-Sun ball models), is

$$i\hbar\frac{\partial}{\partial t}\Psi(r,\theta,\varphi,t) = \left[\frac{-\hbar^2}{2m}\nabla^2 + V(r,\theta,\varphi,t)\right]\Psi(r,\theta,\varphi,t) \qquad \text{eq-1 (Griffiths eq-1.1)}$$

and it has a time-independent form:

$$\left[\frac{-\hbar^2}{2m}\nabla^2 + V(r,\theta,\varphi)\right]\psi(r,\theta,\varphi) = E\,\psi(r,\theta,\varphi) \qquad \text{eq-2 (Griffiths eq-4.8)}$$

In the spherical coordinate, eq-2 becomes

$$\frac{-\hbar^2}{2m}\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial\psi}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial\psi}{\partial\theta}\right) + \frac{1}{r^2\sin^2\theta}\left(\frac{\partial^2\psi}{\partial\varphi^2}\right)\right] + V\psi = E\psi \qquad \text{eq-3 (Griffiths eq-4.14)}$$

The eigenstate (with the spherical harmonics function) of this equation is

$$\psi(r,\theta,\varphi) = R_{nl}(r)\, Y_{lm}(\theta,\varphi) \qquad \text{eq-4 (Griffiths eq-4.15)}$$

By separating the variable r from that of θ and φ, eq-3 can be re-written as

$$\frac{1}{R}\frac{d}{dr}\left(r^2\frac{dR}{dr}\right) - \frac{2mr^2}{\hbar^2}[\,V_r - E\,] = l(l+1) \qquad \text{eq-5 (Griffiths' eq-4.16)}$$

$$\frac{1}{Y}\left[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial Y}{\partial\theta}\right) + \frac{1}{\sin^2\theta}\left(\frac{\partial^2 Y}{\partial\varphi^2}\right)\right] = -l(l+1) \qquad \text{eq-6 (Griffiths' eq-4.17)}$$

For the simplest model of a H-atom, the Coulomb's law (under the point-centered attractive force field) is the only the potential energy in eq-5

$$V_{prot-elec}(r) = -\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r} \qquad \text{eq-7 (Griffiths' eq-4.52)}$$

Notice that the V(r) is a negative value. Solving eq-5 with eq-7, the steady state energy of each n orbit was

$$E_n = \frac{E_1}{n^2}\ ,\ n= 1, 2, 3, \ldots, \text{where } E_1 = -\left[\frac{m}{2\hbar^2}\left(\frac{e^2}{4\pi\varepsilon_0}\right)^2\right] = -13.6 \text{ eV} \qquad \text{eq-8 (Griffiths' eq-4.70, eq-4.77)}$$

Notice that eq-8 is the same as that of Bohr's formula of quantum energy [30]. In the text books, after solving eq-5, the radial wavefunction $R_{n,l}(r)$ was obtained, and was shown here in Figure 1 (in the form of Born probability of $r^2[R_{n,l}(r)]^2$ that plotted against r/r_1). We can see that for the nLL QM state (e.g., |2,1,1>, |3,2,2>, 4,3,3>, …), it becomes the famous Bohr formula of quantum radius [31]

$$r_n = r_1 n^2\ ,\ n= 1, 2, 3, \ldots \qquad \text{eq-9}$$

Thus, for H-atom's electron, the lower the n value, the shorter the r_n, (i.e., the closer the orbit to the nucleus), and the lower the orbital energy E_n will be (i.e., the more negative value will be). For atoms with Z > 1, the calculation is more complicated (or even no analytical solution has been obtained), but the trend is the same: the lower the n, the shorter the r_n, and the lower the orbital energy E_n will be.

According to above result, the sequence of $r_{n,l}$ should be as $r_{1s} < r_{2p} < r_{2s} < r_{3d} < r_{3p} < r_{3s}$ … (see Figure 1, at least for H-atom, Z=1). However, in all text books, the ground state electron configurations of other atoms (with Z >1) are always in the form of $r_{1s} < r_{2s} < r_{2p} < r_{3s} < r_{3p} < r_{3d}$ … etc. To fix this discrepancy, all current text books need to use some kind of patch to explain. For example, Griffiths' book used "screen effect" as the patch, Atkins' book used "penetration and shielding" theory as a patch, etc. (See Atkins "Physical Chemistry"11th ed. 2018, page 320, "*An s electron has a greater penetration through inner shells than a p electron, in the sense that an s electron is more likely to be found close to the nucleus than a p electron of the of the same shell. .. as a result of the combined effects of penetration and shielding, an s electron is more tightly bound than a p electron of the same shell*").

However, when I used the result in Figure 1 to explain the pre-Sun ball {N,n} QM structure (in 2016), I found that it is perfect that $r_{1s} < r_{2p} < r_{2s} < r_{3d} < r_{3p} < r_{3s} < r_{4f}$ …, and, $E_{1s} < E_{2p} < E_{2s} < E_{3d} < E_{3p} < E_{3s} < E_{4f}$ …, there was no need to make any patch. So, for many years, I was always trying to figure out why. In the next section, I showed one possible way to solve this problem.

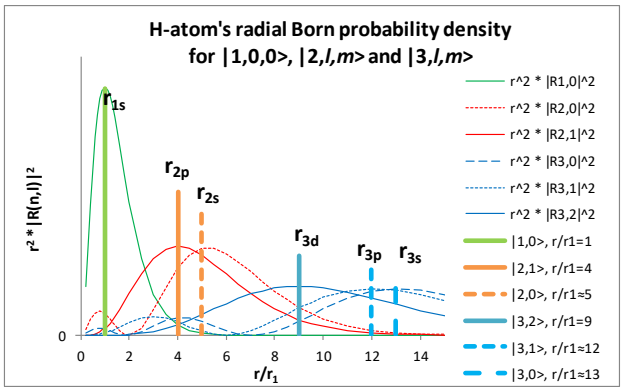


Figure 1. The calculated radial Born probability density for an H-atom at |1,0,0>, |2,*l*,m>, |3,*l*,m> QM states (where *l* = 0, 1, …, n-1, m = -*l*, … +*l*). It clearly showed that $r_{1s} < r_{2p} < r_{2s} < r_{3d} < r_{3p} < r_{3s}$ …

I-b. Using the electron's potential energy V_r as the unit to view the electron's quantum orbital energy E_n

Before studying the real problem, let me first show a new way to present H-atom's quantum orbital energy E_n by using its (quantized) Coulomb potential as the unit. Under the {N,n} QM, we can quantize the Coulomb potential (by using the quantized r_n) as

$$V_{prot-elec,n}(r) = -\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r_n} \qquad \text{eq-10}$$

Although r_n is a quantized number, but according to the {N,n} QM theory (see SunQM-7's Appendix-D), we can move the r_1 inward "freely" so that the high-frequency n' becomes very big value, and when $r_1 \to 0$, $n' \to \infty$, this quantum description becomes a practically continuous description (or a classical physics description). Notice that in this operation, the original base-frequency n value (or the Eigen n value) does not change. (This is the magic part of the {N,n} QM, see Appendix A for more discussion).

As we had shown in SunQM-6s1's eq-2, from $F_{electric} = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r_n^2}$, and from $F_{centrifugal} = m\frac{v_n^2}{r_n}$; for the bound state, $F_{electric} = F_{centrifugal}$, or, $\frac{1}{4\pi\epsilon_0}\frac{e^2}{r_n^2} = m\frac{v_n^2}{r_n}$, or, $mv_n^2 = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r_n}$, or, $v_n = \sqrt{\frac{1}{4\pi\epsilon_0}\frac{e^2}{r_n m}}$; then from $v_n = \frac{v_1}{n}$, and from $r_n = r_1 n^2$, (notice that $v_n = v_{n,gr}$ is the group orbital velocity of the electron), we obtained

$$v_1 = v_{1,gr} = \sqrt{\frac{1}{4\pi\epsilon_0}\frac{e^2}{r_1 m}} \qquad \text{eq-11}$$

Then, from $\lambda = \frac{h}{mv}$, or, $\lambda_n = \frac{h}{mv_{n,gr}}$, we have $\frac{h}{m} = \lambda_n v_{n,gr} = \frac{2\pi r_n}{n} v_{n,gr} = 2\pi r_1 n^2 \frac{v_{n,gr}}{n} = 2\pi r_1 v_{1,gr} = 2\pi r_1\sqrt{\frac{1}{4\pi\epsilon_0}\frac{e^2}{r_1 m}}$, or

$$\frac{h}{m} = 2\pi r_1\sqrt{\frac{1}{4\pi\epsilon_0}\frac{e^2}{r_1 m}} \qquad \text{eq-12}$$

(also see SunQM-2's eq-4 and eq-5 for the similar equation but for the gravity force field), or

$$\hbar = \frac{h}{2\pi} = \sqrt{\frac{e^2}{4\pi\epsilon_0} r_1 m} \qquad \text{eq-13}$$

Then, using eq-13 and eq-9, eq-8 can be re-written as

$$E_n = -\left[\frac{m}{2\hbar^2}\left(\frac{e^2}{4\pi\varepsilon_0}\right)^2\right]\frac{1}{n^2} = \frac{-m}{2}\left(\frac{1}{\hbar^2}\right)\frac{e^2}{4\pi\varepsilon_0}\frac{e^2}{4\pi\varepsilon_0}\frac{1}{n^2} = \frac{-m}{2}\left(\frac{1}{\frac{e^2}{4\pi\epsilon_0} r_1 m}\right)\frac{e^2}{4\pi\varepsilon_0}\left(\frac{e^2}{4\pi\varepsilon_0}\frac{1}{n^2}\right) = \frac{-1}{2}\left(\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r_1 n^2}\right) = \frac{-1}{2}\left(\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r_n}\right) = \frac{1}{2}V_{prot-elec,n}(r) = \frac{-1}{2}\left|V_{prot-elec,n}(r)\right| \qquad \text{eq-14}$$

This is almost the same as that in the classical physics' deduction (for the bound state orbital energy)

$$E_n = K_n + V_n = \frac{1}{2}mv_n^2 - \frac{e^2}{4\pi\epsilon_0}\frac{1}{r_n} = \frac{1}{2}mv_n^2 - mv_n^2 = \frac{-1}{2}mv_n^2 = \frac{1}{2}\left(-\frac{e^2}{4\pi\epsilon_0}\frac{1}{r_n}\right) = \frac{1}{2}V_n = \frac{-1}{2}|V_n| \qquad \text{eq-15}$$

(also see SunQM-6s1's eq-3). Thus, for H-atom, the quantum orbital energy E_n of the electron (that deduced from either Bohr model, or from Schrodinger equation) is the same as that of deduced from the classical physics (for a circular moving particle). This also hinted us that we may can use the absolute value $|V_{n,l}|$ as the unit to judge the relative value of the $E_{n,l}$ at the different *l* quantum number (see the next section for the usage).

II. Using Schrodinger equation for H-atom (with $V_{0\varphi} > 0$) to explain the Z > 1 atom's ground state electron configuration (without using the "penetrating" theory)

According to Griffiths' book, for a neutral atom with atomic number Z, its Z electrons' Hamiltonian should use Griffiths book's eq-5.24 (copied here as eq-16, see Griffiths' book for detailed explanation).

$$H = \sum_{j=1}^{Z}\left\{\frac{-\hbar^2}{2m}\nabla_j^2 - \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{Ze^2}{r_j}\right\} + \frac{1}{2}\left(\frac{1}{4\pi\varepsilon_0}\right)\sum_{j\neq k}^{Z}\frac{e^2}{|\vec{r}_j - \vec{r}_k|} \qquad \text{eq-16 (Griffiths' eq-5.24)}$$

Although the Schrodinger equation with eq-16 will give the accurate QM state energy $E_{n,l}$ for every electron, it is unsolvable analytically (for Z > 1).

(Note: Following discussions are using an atom's n=3 shell's *l* = 0, 1, 2 sub-shells as an example). Our purpose here is to understand why H-atom (Z=1)'s $r_{3s} > r_{3p} > r_{3d}$ is opposite of a Z > 1 atom's ground state electron configuration of $r_{3s} < r_{3p} < r_{3d}$, and why we used H-atom's $r_{3s} > r_{3p} > r_{3d}$ for the pre-Sun ball {N,n} QM structure and the result looks reasonable. Or, this related to an even a more fundamental question: "Is it correct to use H-atom's $r_{3s} > r_{3p} > r_{3d}$ for the pre-Sun ball's {N,n} QM structure?". To understand this, we don't have to get $E_{n,l}$ for every electron of the atom. Instead, we only need to know that for an atom with Z > 1, its outmost electron (that has the longest radius $r_{n=3,l}$) is r_{3s}, or is r_{3d} ? (Note: Based on the known spectrum experimental data assignment, we knew that it has $E_{3s} < E_{3p} < E_{3d}$). Thus, here we don't use eq-16, but still based on H-atom's Schrodinger equation eq-2, and with eq-7 changed to $V_{prot-elec}(r) = -\frac{Ze^2}{4\pi\varepsilon_0}\frac{1}{r}$.

Now the question becomes a little bit clear: under the H-atom's Schrodinger equation with Z#, we want to see the outmost electron (at n=3 shell) is at r_{3s} state, or at r_{3d} state? To do that, we further simplified our atom model as that in atom's n=3 shell, r_{3s} , r_{3p} , and r_{3s} are fully occupied by two, six, and ten electrons respectively, so that we have $(1s)^2(2s)^2(2p)^6(3s)^2(3p)^6(3d)^{10}$ electrons. This means, we used an atom with total **Z=28** as the example (of course, suppose we don't know whether it is $r_{3s} > r_{3p} > r_{3d}$ or $r_{3s} < r_{3p} < r_{3d}$). We also simplified our atom model as that if the outmost sub-shell is r_{3s}, then the outmost sub-shell has only two electrons, and the effective atomic number Z' for any one of these two electrons (after the shielding effect) is Z' = 28 –[$(1s)^2(2s)^2(2p)^6$~~$(3s)^2$~~$(3p)^6(3d)^{10}$] = 2. On the other hand, if the outmost sub-shell is r_{3d},

then the outmost sub-shell has 10 electrons, and the effective atomic number Z' for any one of these ten electrons (after the shielding effect) is $Z' = 28 - [(1s)^2(2s)^2(2p)^6(3s)^2(3p)^6(3d)^{10}] = 18$. (Sorry, much of this may be well known for QM scientists, but is not that familiar for me. So much part of this section is written for myself to read).

Then, according to the general physics, the potential of a (singe one) electron that located at the outmost sub-shell of the atom should be something like

$$V_{total} = V_{prot\text{-}elec} + V_{elec\text{-}elec} + \delta V \qquad \text{eq-17}$$

where

$$V_{prot-elec}(r) = -\frac{Z'e^2}{4\pi\varepsilon_0}\frac{1}{r} \qquad \text{eq-18}$$

is the effective Coulomb interaction between the outmost electron and the (effective) nucleus, $V_{elec\text{-}elec}$ is one outmost sub-shell electron's Coulomb interaction with the rest neighboring electrons (that are also in the same outmost *l* sub-shell), and δV are some minor interaction items, like the spin-spin interaction, etc. (that we usually ignored).

Now we need to further simplify eq-17. We will keep the $V_{prot\text{-}elec}$ (as eq-18) because it is the major contributor of the V_{total} (and also we know how to work on it). The δV spin-spin interaction is mainly the RFe-force of the orbit moving electron interacts with the RFe-force of the nucleus or the other electrons (i.e., a kind of non-Coulomb interaction). At this time, I don't know how to use an analytical formula to present it, and we also believe its contribution the V_{total} is very small, thus, we choose to ignore it. For the same reason, we also choose to ignore all other items in δV.

For $V_{elec\text{-}elec}$ (i.e., caused by the mutual Coulomb repulsion among electrons in the same *l* sub-shell, but subjected by a single electron that we are interested in), it is too complicated to be written as one analytical formula (at least for me). (Note-1: Remember that in SunQM-3's Figure 1b for the pre-Sun ball's force analysis, we had the similar situation, where only the interacting with the neighboring orbital moving objects in the same *l* sub-shell is considered. Even for this, I was still unable to deduce the analytical formula. Note-2: Similarly, I had a bad luck in figuring out the $V_{\theta\varphi}$ value (under $V_{\theta\varphi} < 0$) when I was working on SunQM-4s1 to figure out how to calculate accretion process of a ring-shaped mass to form a planet (or a moon) in a circular 1D QM orbit). So, here I used an over simplified (or a citizen scientist-leveled) method to estimate the $V_{elec\text{-}elec}$ in each *l* sub-shell (where $l > 0$): suppose that there are j number (with the integer number $j > 1$) electrons in one *l* sub-shell, then for any specific one electron in *l* sub-shell, the $V_{elec-elec,l}$ (it subjected) is simplified by supposing that all the rest j-1 electrons are at the center of the atom, (see the similar "citizen-scientist leveled calculation" that used in SunQM-3's Fig-1b):

$$V_{elec-elec,l} \approx +\frac{(j-1)e^2}{4\pi\varepsilon_0}\frac{1}{r} \qquad \text{eq-19}$$

Because $l = 1$ sub-shell (p state) has maximum $j = 6$ electrons, and $l = 2$ sub-shell (d state) has maximum $j = 10$ electrons,

$$V_{elec-elec,l=1} \approx +\frac{5e^2}{4\pi\varepsilon_0}\frac{1}{r} \qquad \text{eq-20}$$

$$V_{elec-elec,l=2} \approx +\frac{9e^2}{4\pi\varepsilon_0}\frac{1}{r} \qquad \text{eq-21}$$

For $l = 0$ sub-shell (s state)'s two electrons, they most likely separated by $\frac{1}{2r}$, so it is much easier and more accurate to use

$$V_{elec-elec,l=0} \approx +\frac{e^2}{4\pi\varepsilon_0}\frac{1}{2r} = +\frac{1}{2}\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r} \qquad \text{eq-22}$$

For each n shell (of orbital electrons), there are l = 0, 1, … (n-1) sub-shells (of orbital electrons). Here I approximated that $r_{n=3,l=0} \approx r_{n=3,l=1} \approx r_{n=3,l=2} \approx r_{n=3}$ in eq-20, eq-21, and eq-22 (this is a citizen-scientist leveled approximation). I also approximated that for each specific l sub-shell, $V_{elec\text{-}elec} \approx V_{elec\text{-}elec,l}$ (and ignored the neighboring sub-shells' affect). Because for each l sub-shell's $V_{elec\text{-}elec,l}$, we only consider the electrons in the same l sub-shell, and practically it exists only in θφ-2D space, then I renamed it as $V_{elec\text{-}elec,l} = V_{\theta\varphi}$. Then I also renamed $V_{prot\text{-}elec} = V_r$ (because it only exists in r-1D space).

Now let's review the whole calculation from the very beginning: I tried to use Schrodinger equation/solution for the H-atom (Z=1) to explain the Z > 1 atom's result. In eq-3, I modified the potential V as $V_{total} = V_{r\theta\varphi} = V_r + V_{\theta\varphi}$, and thus the eq-3 becomes

$$\frac{-\hbar^2}{2m}\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial\psi}{\partial r}\right)+\frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial\psi}{\partial\theta}\right)+\frac{1}{r^2\sin^2\theta}\left(\frac{\partial^2\psi}{\partial\varphi^2}\right)\right]+(V_r+V_{\theta\varphi})\psi=E\psi \qquad \text{eq-23}$$

where $V_{\theta\varphi} = V_{elec\text{-}elec,l}$ is the electron-electron Coulomb interaction within the same l sub-shell. Then, by approximation, I treated $V_{\theta\varphi}$ to be a small perturbation of V_r , so that I can force $V_{\theta\varphi}$ to be a function in r-1D, and eliminated its function in θφ-2D, (see eq-19 through eq-22). Therefore, eq-23 can be further simplified to be a r-1D only Schrodinger equation

$$\frac{1}{R}\frac{d}{dr}\left(r^2\frac{dR}{dr}\right)-\frac{2mr^2}{\hbar^2}\left[(V_r+V_{\theta\varphi})-E\right]=l(l+1) \qquad \text{eq-24}$$

(Note: See Appendix B for a different treatment on eq-23). Then, for a Z =28 atom, inside the n=3 shell, after putting eq-20,eq-21, eq-22 into eq-17, and after shielding, a single electron in either one of the l = 0, 1, or 2 sub-shell will have $V_{total} = V_{prot\text{-}elec} + V_{elec\text{-}elec} = V_r + V_{\theta\varphi}$ =

$$V_{total,n=3,l=0} = V_r + V_{\theta\varphi} \approx -\frac{Z'e^2}{4\pi\varepsilon_0}\frac{1}{r}+\frac{1}{2}\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r} = -\left(Z'-\frac{1}{2}\right)\left(\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r}\right) = -\left(Z'-\frac{1}{2}\right)\left|V''_{n,l}\right| \qquad \text{eq-25}$$

$$V_{total,n=3,l=1} = V_r + V_{\theta\varphi} \approx -\frac{Z'e^2}{4\pi\varepsilon_0}\frac{1}{r}+5\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r} = -(Z'-5)\left(\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r}\right) = -(Z'-5)\left|V''_{n,l}\right| \qquad \text{eq-26}$$

$$V_{total,n=3,l=2} = V_r + V_{\theta\varphi} \approx -\frac{Z'e^2}{4\pi\varepsilon_0}\frac{1}{r}+9\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r} = -(Z'-9)\left(\frac{e^2}{4\pi\varepsilon_0}\frac{1}{r}\right) = -(Z'-9)\left|V''_{n,l}\right| \qquad \text{eq-27}$$

, where

$$\left|V''_{n,l}\right| = \frac{e^2}{4\pi\varepsilon_0}\frac{1}{r} \qquad \text{eq-28}$$

is the absolute value of a "Hydrogen atom"-like atom's potential energy, and here we treat it as one unit.

To solve eq-24 (that containing eq-25, eq-26, and eq-27), let's consider the following two possible cases:

Case-1:

If $r_{3s} > r_{3p} > r_{3d}$ is correct (as shown in Figure 1), then as shown in Table 1, for a single electron at r_{3s}, Z' = 28 – $[((1s)^2(2s)^2(2p)^6(3d)^{10}(3p)^6] = 2$, $V_{total,n=3,l=0} \approx -1.5\left|V''_{n,l}\right|$; for a single electron at r_{3p}, Z' = 28 –$[((1s)^2(2s)^2(2p)^6(3d)^{10}] = 8$, $V_{total,n=3,l=1} \approx -3\left|V''_{n,l}\right|$; for a single electron at r_{3d}, Z' = 28 –$[((1s)^2(2s)^2(2p)^6] = 18$, $V_{total,n=3,l=2} \approx -9\left|V''_{n,l}\right|$. Thus, the result is

$$V_{total,n=3,l=0} > V_{total,n=3,l=1} > V_{total,n=3,l=2} \qquad \text{eq-29}$$

Then, according to the H-atom's QM result in the section I-b (see eq-14), we may can use $|V_{total,n,l}|$ as the unit to present the relative value of the $E_{n,l}$ at the same n shell but at the different l sub-shell.

$$E_{n,l} = -a_{n,l}\left|V_{total,n,l}\right| = -a_n\left|V_{total,n,l}\right| \quad \text{eq-30}$$

(Note: Because the electron is in bound state, so both V_{total} and $E_{n,l}$ are always negative values). We may further assume that the coefficient $a_{n,l}$ (that is set to be > 0) is degenerated for different *l*(s), so it only depends on n, not on *l* (note: this is a citizen scientist leveled assumption, but I don't have much choice). The key point of eq-30 is, for each single n state, we present the $E_{n,l}$ by using $\left|V_{total,n,l}\right|$ as the unit, and the value of this unit varies upon the *l* state. Therefore, for the same n=3 state but different *l* = 0, 1, 2, because eq-29, we (most likely) will have

$$E_{n=3,l=0} > E_{n=3,l=1} > E_{n=3,l=2} \text{ , or } E_{3s} > E_{3p} > E_{3d} \quad \text{eq-31}$$

This result doesn't match the Z > 1 atom's spectrum experimental data of $E_{3s} < E_{3p} < E_{3d}$. So, $r_{3s} > r_{3p} > r_{3d}$ must be incorrect (according to this citizen-scientist leveled deduction) for an atom with Z=28.

Table 1. Based on $r_{3s} > r_{3p} > r_{3d}$ to estimate $V_{total,n,l}$ gave an incorrect answer

$r_{3s} > r_{3p} > r_{3d}$	Z'=	V_r	$V_{\theta\phi}$	$V_{total} = V_r + V_{\theta\phi}$
		unit=$\lvert V''_{n,l}\rvert$	unit=$\lvert V''_{n,l}\rvert$	unit=$\lvert V''_{n,l}\rvert$
r_{3s} (outmost)	$= 28 - [(1s)^2(2s)^2(2p)^6(3d)^{10}(3p)^6] = 2$	-2	0.5	-1.5
r_{3p} (middle)	$= 28 - [(1s)^2(2s)^2(2p)^6(3d)^{10}] = 8$	-8	5	-3
r_{3d} (inner)	$= 28 - [(1s)^2(2s)^2(2p)^6] = 18$	-18	9	-9

Table 2. Based on $r_{3s} < r_{3p} < r_{3d}$ to estimate $V_{total,n,l}$ gave a correct answer

$r_{3s} < r_{3p} < r_{3d}$	Z'=	V_r	$V_{\theta\phi}$	$V_{total} = V_r + V_{\theta\phi}$
		unit=$\lvert V''_{n,l}\rvert$	unit=$\lvert V''_{n,l}\rvert$	unit=$\lvert V''_{n,l}\rvert$
r_{3s} (inner)	$= 28 - [(1s)^2(2s)^2(2p)^6] = 18$	-18	0.5	-17.5
r_{3p} (middle)	$= 28 - [(1s)^2(2s)^2(2p)^6(3s)^2] = 16$	-16	5	-11
r_{3d} (outmost)	$= 28 - [(1s)^2(2s)^2(2p)^6(3s)^2(3p)^6] = 10$	-10	9	-1

Case-2:

If $r_{3s} < r_{3p} < r_{3d}$ is correct (that is opposite of what shown in Figure 1), then as shown in Table 2, the calculation showed

$$V_{total,n=3,l=0} < V_{total,n=3,l=1} < V_{total,n=3,l=2} \quad \text{eq-32}$$

Then, following the same deduction, we obtained

$$E_{3s} < E_{3p} < E_{3d} \quad \text{eq-33}$$

It matches the Z > 1 atom's spectrum experimental data of $E_{3s} < E_{3p} < E_{3d}$. Therefore, $r_{3s} < r_{3p} < r_{3d}$ is more correct (in comparison with $r_{3s} > r_{3p} > r_{3d}$) for an atom with Z=28. Thus, for atoms with Z > 1, based on spectrum experimental data of $E_{3s} < E_{3p} < E_{3d}$, we can directly calculate out (at least semi-quantitatively) $r_{3s} < r_{3p} < r_{3d}$ from the Schrodinger equation/solution.

(Note: The key contribution of this section is that we treat a rθφ-3D space as two sub-spaces of r-1D and θφ-2D, and this is the first time to introduce the concept of $V_{\theta\varphi}$ to explain the result of Schrodinger equation and solution. This idea comes from the study in SunQM-6s10 (that was worked out and was drafted in the Jan. 2020)).

III. Using the same Schrodinger equation for H-atom (but with $V_{\theta\varphi} < 0$) to (semi-quantitatively) explain the pre-Sun ball's quantum orbital energy level configuration

We should be able to use the similar method in section II to solve the H-atom's Schrodinger equation with $V_{\theta\varphi} < 0$ (at least qualitatively) to determine the l sequential of $r_{n,l}$ or $E_{n,l}$. Based on the previous result, I guessed that it should be $r_{n=3,l=0} > r_{n=3,l=1} > r_{n=3,l=2}$ and $E_{n=3,l=0} > E_{n=3,l=1} > E_{n=3,l=2}$, or, $r_{3s} > r_{3p} > r_{3d}$ and $E_{3s} > E_{3p} > E_{3d}$. (Note: here we still want to use "s" for $l = 0$, "p" for $l = 1$, and "d" for $l = 2$, etc., even it is not an atom's QM, but either a pre-Sun ball's QM or a Jupiter mass ball's QM). If we had known the $V_{\theta\varphi} < 0$ values for the attractive objects in each l sub-shells, then we would have been able to give the semi-quantitative estimation (similar as that in section II's eq-25 through eq-27). Unfortunately, by far, I was not able to do a semi-quantitative calculation for the $V_{\theta\varphi} < 0$ (as what I had did in the Table 1 and Table 2 for the $V_{\theta\varphi} > 0$).

Inside a pre-Sun ball, in the θφ-2D space of the same l sub-shell, the matter objects exert the mutual attractive force on each other (see SunQM-3's Figure 1b), and thus $V_{\theta\varphi} < 0$. Therefore, I believed that the H-atom's Schrodinger equation with $V_{\theta\varphi} < 0$ is (nearly) a perfect simplest solution for the pre-Sun ball's QM structure determination. Notice that in SunQM-3 series papers, I used the H-atom's Schrodinger equation/solution directly for the pre-Sun ball's QM structure determination, and it is reasonable. Because the mutual attractive force in the θφ-2D space is very weak (in comparison with the r-dimensional attractive force), so that $V_{\theta\varphi} = 0$ becomes an acceptable approximation. However, there is one thing we need to address: for H-atom's Schrodinger equation with either $V_{\theta\varphi} = 0$ or $V_{\theta\varphi} < 0$, even they have the similar $r_{3s} > r_{3p} > r_{3d}$, the $V_{\theta\varphi} = 0$ one may produce $E_{3s} = E_{3p} = E_{3d}$, and $V_{\theta\varphi} < 0$ one may produce $E_{3s} > E_{3p} > E_{3d}$. For the pre-Sun ball's QM, we should use the $V_{\theta\varphi} < 0$ one's $E_{3s} > E_{3p} > E_{3d}$ (rather than the $V_{\theta\varphi} = 0$ one's $E_{3s} = E_{3p} = E_{3d}$).

Then, do we have the experimental data to confirm that "$r_{3s} > r_{3p} > r_{3d}$ is the correct configuration for the pre-Sun ball {N,n} QM structure"? The answer is "most likely yes". I believed that Jupiter's surface atmosphere bands are the key evidence. It can be (nearly) perfectly explained as: the |5,4,m> zonal bands are embedded in the background of |400> QM state "ball" (see SunQM-3s3's Fig-3b and Fig-4), and the whole explanation fits to $r_{4,3} < r_{4,2} < r_{4,1} < r_{4,0} < r_{5,4} < r_{5,3} < r_{5,2} < r_{5,1} < r_{5,0}$ (see SunQM-3s3's Fig-1a and Fig-1d). If it were $r_{5,4} > r_{5,3} > r_{5,2} > r_{5,1} > r_{5,0}$, then those |5,4,m> sub-shell zonal bands at the out edge of the Jupiter's atmosphere (outside of |5,3,m> sub-shell) maybe interfere with the inner |5,3,m> band pattern, and may show a very different band pattern. Therefore, I believed that the Jupiter's surface atmosphere bands proved (or at least supported) that "$r_{3s} > r_{3p} > r_{3d}$ is the correct configuration for the pre-Sun ball {N,n} QM structure".

To the end, our major purpose for this work is "Is it correct to use Schrodinger equation/solution for H-atom with $r_{3s} > r_{3p} > r_{3d}$ for the pre-Sun ball {N,n} QM structure"? Now we have the answer: Yes.

The next "drama" result is, in the earlier SunQM papers, I happened to use H-atom's Schrodinger equation/solution (with $r_{3s} > r_{3p} > r_{3d}$, because that was the only radial wave function I learned) to explain the pre-Sun ball's {N,n} QM structure configuration, and it happened to be correct, and the whole thing was by an accident! It was so lucky that I did not use the Z > 1 atom's ground state electron configuration $r_{3s} < r_{3p} < r_{3d}$ for the pre-Sun ball, because that would have led me to the wrong conclusion. Cheers! (Note: In Chinese, this is called "歪打正着", means "Lucky hit").

IV. Based on the known atomic electron (E/RFe-forced ground state) configuration, a brand new nuclear proton (E/RFe-forced ground state) configuration is hypothesized to have a mirror-coupled configuration with that of electron

(Note: I am not a nuclear physicist. I am a {N,n} QM scientist. All I did here is to develop a {N,n} QM field theory to re-describe the E/RFe-force inside a nucleus. All these re-descriptions may belong to a citizen scientist leveled work). Can we use the above knowledge to figure out the nuclear proton's E/RFe-force produced orbital configuration inside a nucleus? After many trying, I believed it is "yes".

IV-a. A guessed solution for the Schrodinger equation with the point-centered repulsive force

There are some major differences between a nucleus-electron system and a multi-protons system: 1) Inside a nucleus, the proton-proton E/RFe-force interaction is repulsive, not attractive; 2) Inside a nucleus, it is not a point-centered force field. So a proton's Coulomb potential energy inside a nucleus may be something like

$$V_{prot}(r) = \sum_{i,j} \frac{q^2}{4\pi\varepsilon_0}\frac{1}{r_{i,j}} \qquad \text{eq-34}$$

For an atom with Z > 1, we may can simplify the model by assuming that all Z-1 protons are at the point center, and only one proton at the surface of the nucleus. Then, this surface proton's Coulomb potential energy may can be approximately expressed as under a pseudo point-centered force field

$$V_{prot}(r) = \frac{(Z-1)q^2}{4\pi\varepsilon_0}\frac{1}{r} \qquad \text{eq-35}$$

Then, we still try to use the same method as that in the section II, i.e., using the Schrodinger equation/solution for H-atom to study a single nuclear proton that located at the surface of the nucleus, with the assumption that all the rest (Z-1) nuclear protons in the same nucleus can be simplified as a single (Z-1) positive point charge at the very center of the nucleus. Because of the positive-positive repulsive Coulomb interaction, it must have $V_r > 0$ for this surface nuclear proton (relative to the Z-1 protons at the center). (Note: although the electric potential $V_r > 0$ intended to push this outmost proton away to the infinity distance, according to the known nuclear physics, a much stronger S/RFs-force retained this proton to be in a bound state. Here we only study E/RFe-force interaction, not the S/RFs-force interaction). Therefore, we may still can use eq-5 and eq-6 to describe this single surface proton's QM state. (Note: In this method, only the V_r is counted, the $V_{\theta\varphi}$ is completely ignored, because all other Z-1 protons are counted as at the center of the nucleus (although we know that the positive-positive repulsive Coulomb interaction in the same *l* sub-shell produced $V_{\theta\varphi} > 0$). So this method is a lowest level approximation).

Put eq-35 into eq-2 kind of Schrodinger equation that for one surface proton in a nucleus (that contains Z-1 protons at the very center of the nucleus), we have

$$E_{prot}\psi_{prot} = -\frac{\hbar^2}{2m}\nabla^2\psi_{prot} + \frac{(Z-1)q^2}{4\pi\varepsilon_0}\frac{1}{r}\psi_{prot} \qquad \text{eq-36}$$

Notice that this pseudo point-centered force field is valid (approximately) only for a single nuclear surface proton. As a citizen scientist, I don't have the ability to solve this equation (see Appendix C). However, from the general physics, we know that this surface proton must have the property that the further away from the central protons (or the larger the r), the lower the potential energy (and also the total E/RFe-orbital energy E_n). And, the vice versa. Based on this property, when I forced myself to follow Bohr's famous formula of H-atom (i.e., $r_n = r_1 n^2$ and $E_n \propto \frac{E_1}{n^2}$), and also by following Griffiths' eq-4.52 through eq-4.70, I guessed out a solution of eq-36 that may look like

$$E_{n,prot} \propto \frac{E_{1,prot}}{n^2} \quad \text{(where } n^2 = \frac{r_n}{r_1} < 1\text{, and n} \propto 1, ½, 1/3, \ldots \text{ from ground state to excited state)} \qquad \text{eq-37}$$

where $E_{1,prot} > 0$. After many tries, I guessed that in eq-37, the most reasonable answer is that the real n value is a fractional integer, i.e., something like 1/n", where n" = 1, 2, 3 … is the integer number. (Note: Here we use n" rather than n' because in the {N,n} QM, n' usually means the high-frequency multiplier n' quantum number). Thus, the "n = 2" QM state (with the real quantum number value of n = 1/2 in eq-37) should be said as the n" = 2 QM state, the "n = 3" QM state (with the real quantum number value of n = 1/3 in eq-37) should be said as the n" = 3 QM state, and so on so forth. Using Bohr formula $r_n = r_1 n^2$, this will also cause $r_n < r_1$.

Alternatively, if we don't want force ourselves to follow Bohr-QM's and Schrodinger-QM's famous formula of $E_n \propto \frac{E_1}{n^2}$ and $r_n = r_1 n^2$, then we can directly use n" for eq-37 so that it becomes eq-38

$E_{n",prot} \propto (n")^2 E_{1,prot}$ (where n" ≈ 1, 2, 3, etc., and $r_1 \propto r_{n"} (n")^2$) eq-38

Notice that the eq-38 is the same as eq-37, although it is re-written by using $n" = \frac{1}{n}$. Here I prefer to use eq-37 than eq-38, simply because the whole {N,n} QM is based on the Bohr-QM and the Schrodinger-QM, so I want to follow the format of Bohr-QM's famous formula as much as I can.

I believe that eq-37 is correct because: 1) Both $E_{n,prot} > 0$ and $E_{1,prot} > 0$, so it fits to eq-35 where $V_{prot}(r) > 0$, thus this surface proton is in unbound state (or E > 0) under the E/RGe-force field; 2) At n = 1, r_1 is the largest radius, so a surface proton (of a nucleus) has the lowest $E_{n,prot}$ (= E_1); 3) As n" = 1/n quantum number increasing (that means the r_n value is decreasing), the (repulsive energy) $E_{n,prot}$ increases for a proton that sits in the inner of the nucleus.

However, eq-37 does give us some difficulty to write in the {N,n//q} format (because the n is the fraction number). For example, for n =1/2, it is very ambiguous (or too messy) if we write it as {N,1/2//6}, or as {N,(1/2)//6}. To minimized this problem, here I made a new definition: (in comparison with the {N,n//q} format we used for the attractive force field), **for the repulsive force field, we use the {N,n"//q} format to represent the {N,n//q}**, where n = 1/n". For example, {N,2"//6} = {N,(1/2)//6}, {N,3"//6} = {N,(1/3)//6}, etc., see examples in Figure 2d. For this reason, in the current paper, I quite often use n" for the description whenever is needed. Then, for the n=1, {N,1"//q} = {N,1//q}, so (even in the repulsive force field), I usually don't write {N,1"//q}, but use {N,1//q} directly (see examples in Figure 3b). Also, in the description of nuclear proton orbital "$1s^1 2s^2 2p^6 3s^2 3p^6 3d^{10}$…", all the "nuclear orbital n number" of 1, 2, 3 are actually the numbers of n".

I need to emphasize again that eq-37 (and/or eq-38) is valid only under a point-centered repulsive force field. For the protons inside an atomic nucleus, only a single surface protons may can be treated as roughly satisfy this condition, all the inner protons are absolutely not satisfying this condition. Even under the S/RFs attractive force field, all the inner protons are unlikely to satisfy this condition.

IV-b. The new "proton-electron mirror-coupled orbit" model

According to eq-37, after many tries, I was able to construct the nuclear proton's E/RFe-force orbital configuration (by coupling with the electron's E/RFe-force orbital configuration) at the ground state for atoms with Z# = 1, 2, 3 and 7 (see in Figure 2). Here I used the interior {N,n} QM description with the n = 1 atomic electron orbit as the r_1, so it is the e1{N,n} QM description. (Note: Here is a brief (reviewing) explanation on the {N,n} QM nomenclature by using example of: e1{0,1} = e1{0,1//6} = Sun{-12,1//6} = {-12,1//6} = {-12,1}. e1{0,1} means using atomic electron's n=1 orbit-r as the r_1. The 1st equal sign (in the above long sequential equations) means that in {N,n//q} QM, if q=6, we often omit q and write it as {N,n}. The 2nd equal sign means that if using the Sun core's r as r_1, (or, in the standard Sun{N,n//6} QM structure), the n=1 electron orbit-r equals to Sun{-12,1//6}. The 3rd equal sign means that if we use the Sun{N,n//q} QM structure, we usually omit the prefix "Sun". The 4th equal sign means that if we use Sun{N,n//q} QM structure, we usually also omit the q=6, so it become {N,n}. In other words, if we see {N,n} without any specification, it usually means Sun{N,n//6} that using Sun core as r_1. Also see detailed explanation in SunQM-5's section II-a). To avoid the confusing, we use the "**nuclear orbit 1s**" for the nuclear proton. If we mention 1s without any specification, it (generally) means the (traditional) atomic electron's orbit (or QM state). Of course, (in this paper), both the atomic "1s" and nuclear "1s" are orbits that generated by E/RFe-force only. Nothing to do with either S/RFs-force or G/RFg-force.

From Figure 2, we see that in contradicting with that of the electron's orbits (where the most inner one has the lowest energy), the nuclear protons have their outmost orbit to have the lowest energy. For example, in a nitrogen atom with Z=7, because the n" = 2 in e1{-3,2"//6} has the actual of n = 1/2, the nuclear orbit 2s has the e1{-3,2"//6} = e1{-3,(1/2)//6} orbit, and it is at the inner of the nuclear orbit 1s that has the e1{-3,1"//6} = e1{-3,1//6} orbit (see Figure 2c). Also see Figure 2d, although both nuclear 2s and nuclear 2p share the same e1{-3,2"//6}o orbital n shell, the nuclear 2p orbit is at the inner of

the nuclear 2s orbit. In Figure 2e, I showed the pair-wised nuclear proton orbital (ground state) configuration and the atomic electron orbital (ground state) configuration for a Z=36 element. So the key feature of Figure 2 is: the nuclear proton's orbital energy level configuration may be oppositely paired to that of electron. Therefore, for a high Z# atom, (if this model is correct), its most inner $1s^2$ two orbital electrons match to its most outer $1s^2$ two nuclear protons with the shortest distance Δr in between, its 2^{nd} most inner $2s^2$ two orbital electrons match to its 2^{nd} most outer $2s^2$ two nuclear protons with the 2^{nd} shortest distance in between, its 3^{rd} most inner $2p^6$ six orbital electrons match to its 3^{rd} most outer $2p^6$ six nuclear protons with the 3^{rd} shortest distance in between, and so on so forth. I showed this new feature by using the green lines in Figure 2d. I also showed this new feature in Figure 3a.

From this result, I hypothesized that there should be a mutual mirror effect between the E/RFe-force generated nuclear proton orbital configuration (a set of $1s^12s^22p^63s^23p^63d^{10}$… at the ground state, (note: all nuclear orbits using n" number)) versus the same E/RFe-force generated atomic electron configuration (a set of $1s^12s^22p^63s^23p^63d^{10}$… at the ground state, (note: all atomic electron orbits using the real n number)), with a 2D spherical surface mirror in between these two sets of $1s^12s^22p^63s^23p^63d^{10}$… orbitals. To me, this is a completely new feature, and I have never seen any this kind of feature in any text book. Let's name this new model as the **"proton-electron mirror-coupled orbit" model**.

(Note: Based on the famous Bohr formula $r_n = r_1 n^2$, if we plot the r-1D axis as the sqrt(r) from the center of the nucleus to the out edge of the atom, in theory, as the n increasing linearly, we should see the linear increasement for the nuclear r_n as well as for the atomic r_n . However, in reality, due to the "5 of {-15,2//6} particles" non-linear effect (that caused by the S/RFs-force, see SunQM-7's section I-d), the sqrt-linear relationship of the nuclear r_n has been messed-up. Never the less, if we plot the radius as sqrt(r) , or as the log(r), we will be more easily to see where the spherical mirror located (than that if we plot with the linear r)). In Figure 3b, when plotting as sqrt(r), with our previous knowledge of {N,n} QM, I guessed that the location of the spherical mirror is located somewhere in between the e1{-2,1} and e1{-1,1} for the low-Z# atoms (e.g., H-atom), and is moved outward to very close to e1{-1,1} for the high-Z# atoms (e.g. Og-118). (Note: This is because when atoms increases Z#, the r_1 value of e1{0,1} decreases with $r'_1 = r_1 /Z$, see SunQM-5's Table-2 for details). In SunQM-5's section II-a Table 2 and discussion-3, I mentioned that the theoretical maximum atom has the pseudo Z# $\approx$ 1870 and it has the size of Sun{-10,1//6}. Relative to the shrunken inner-most 1s electron shell e1{0,1} = e1{-1,6//6}, its nuclear 1s proton orbital has a size more than e1{-1,5//6} and it is very close to the size of e1{-1,6//6}. So, in this extreme case, the spherical mirror is almost at e1{-1,6//6} = e1{0,1}. Therefore, in summary, as the Z# increasing from 1 to 1870, due to the shrinking of e1{0,1}, the location of the spherical mirror (between the nuclear proton orbitals and the atomic electron orbitals) will shift from below e1{-1,1} to around e1{-1,1}, then to infinitely close to e1{0,1}. (Note: See the usage of this information in section IV-f for explaining the gravity collapse from a {-2,1//6} star to a {-3,1//6} star).

In section II, for the Z > 1 atom, we attributed the atomic electron's reversed *l* sub-shell sequence $r_{3s} < r_{3p} < r_{3d}$ completely to the $V_{\theta\varphi} > 0$ for the electron-electron's repulsive interaction in the same *l* sub-shell. However, under the new "proton-electron mirror-coupled orbit" model, the nuclear proton's $r_{3s} > r_{3p} > r_{3d}$ sequence is also expected to make an important contribution to the electron's $r_{3s} < r_{3p} < r_{3d}$, because of the mirror-coupling effect.

(Note: This "proton-electron mirror-coupled orbit" effect (in the point-centered E/RFe-force field) may can also be explained in the same way as the "binary mirror-paired mutual orbiting" effect of the two objects (in the point-centered G/RFg-force field): the small mass object (apparently) is circling around the large mass object (actually is around the reduced mass center) at a large orbital-r, and this caused a "paired-mirroring" effect that forces the large mass object to (apparently) circling around the small mass object (actually is circling around the reduced mass center at a small orbital-r)).

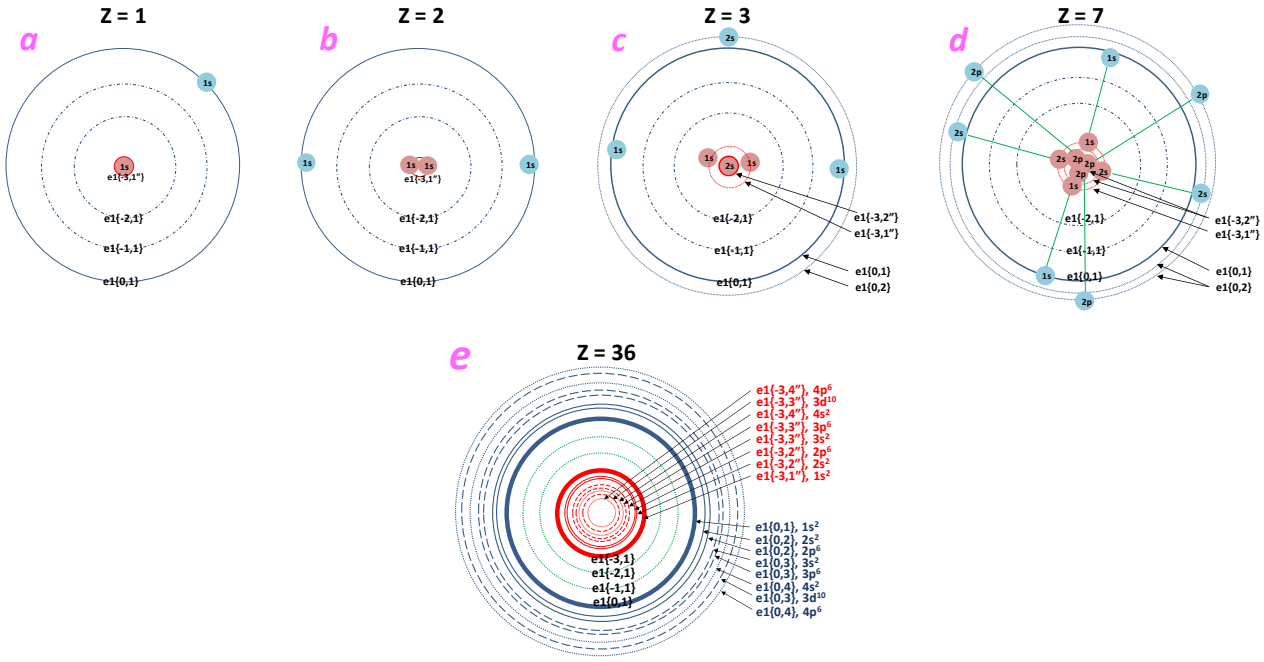


Figure 2 (a, b, c, d). Illustration of the "proton-electron mirror-coupled orbit" model for atoms with Z# = 1, 2, 3 and 7. The red ball (and red circular line) represents the proton (and orbit), the blue ball (and blue circular line) represents the electron (and orbit). The green lines in Figure 2d illustrated the pair-matching between the nuclear proton and atomic electron that have the same orbital quantum number of *n* and *l*, and (transiently) in pair. Note: the orbital radius is not on scale.
Figure 2e. Illustration of a pair-wised nuclear proton orbital (ground state) configuration and the atomic electron orbital (ground state) configuration for a Z=36 element under the {N,n//6} QM structure format.

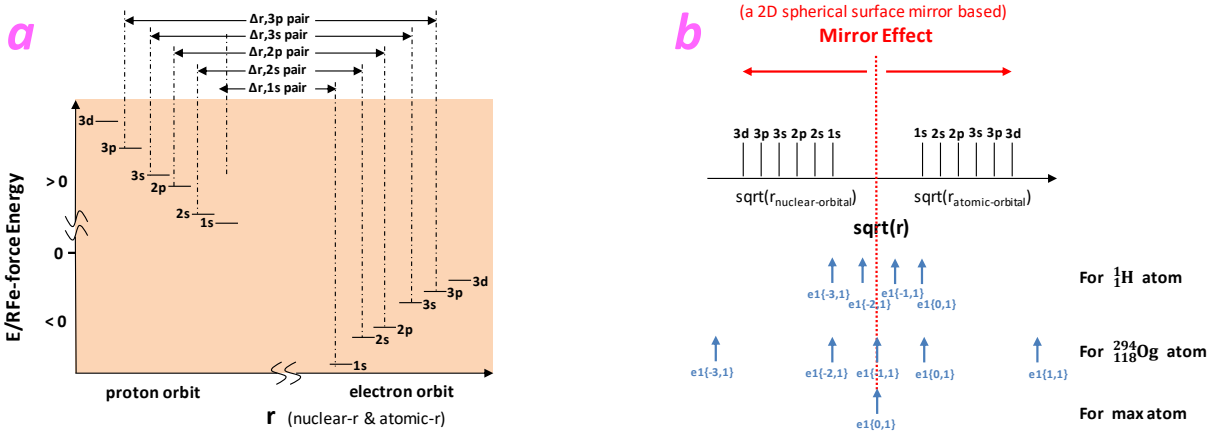


Figure 3a. Illustration of the (relative) Δr distances between the pair-matched nuclear protons and atomic electrons (with the same orbital quantum number of *n* and *l*).
Figure 3b. To illustrate the mirror effect between the E/RFe-force generated nuclear proton orbital configuration of $1s^1 2s^2 2p^6 3s^2 3p^6 3d^{10}$ versus the same E/RFe-force generated atomic electron configuration of $1s^1 2s^2 2p^6 3s^2 3p^6 3d^{10}$.

With the above information of radius vs. quantum state, we can further draw the possible 3D structures for those nuclides. In Figure 4 (a', b', c', d', e'), I illustrated the possible 3D structures for the nuclides of $^{4}_{2}$He, $^{7}_{3}$Li, $^{9}_{4}$Be, $^{11}_{5}$B, $^{12}_{6}$C (in

the possible minimum volume (e.g., at 0 K°), and by using a cube as the possible core structure). Based on that, in Figure 4 (a, b, c, d, e), I re-drew the (possible) 3D structures at ~ 300 K° with the (random) thermal vibration, and added the information of the nuclear orbital radius vs. quantum state for the nuclear protons. We see that the two nuclear $1s^2$ protons are always at the outmost edge of the nucleus (with the lowest E/RFe-force potential), the two nuclear $2s^2$ protons are always at the 2nd outmost edge of the nucleus (with the 2nd lowest E/RFe-force potential), and the highest nuclear *n*, *l* orbital protons are always at the core of the nucleus (with the highest E/RFe-force potential). Although far from accurate, the diagram does provide some vivid view on how these nuclear protons are arranged based on their QM state.

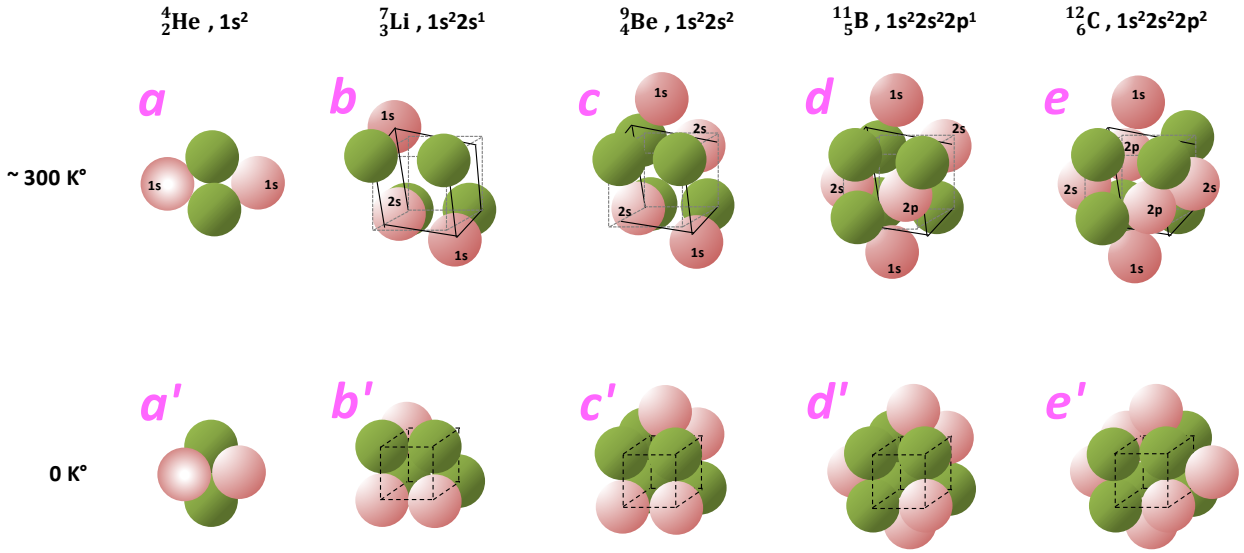


Figure 4 (a, b, c, d, e). Illustrating the possible 3D structure for the nuclides of $^4_2$He, $^7_3$Li, $^9_4$Be, $^{11}_5$B, $^{12}_6$C (at ~300 K° with the normal thermal motion), and by using a cube as the possible core structure. The green ball represents the neutron, the pink ball represents the proton.

Figure 4 (a', b', c', d', e'). Illustrating the possible 3D structure for the nuclides of $^4_2$He, $^7_3$Li, $^9_4$Be, $^{11}_5$B, $^{12}_6$C (at 0 K° with the minimum thermal motion), and by using a cube as the possible core structure.

IV-c. Hypothesis: the γ decay may can be attributed to the nuclear proton's pure E/RFe-force energy level de-excitation

As wiki "Gamma ray" mentioned: "*Typically, gamma rays are the products of neutral systems which decay through electromagnetic interactions (rather than a weak or strong interaction)*". Based on the previous result of nuclear proton's configuration (of energy level, structure, etc.), here I hypothesized that maybe the gamma decay can be explained by purely using nuclear proton's E/RFe-force energy level transition (without involving the S/RFs-force). If this hypothesis is correct, then, can we directly use eq-37 to estimate the proton's nuclear orbital QM states for a γ decay? The answer is "No". Because eq-37 is only correct under a condition that all protons inside a nucleus are in a strict point-centered force field, and we knew that this condition is not satisfied for all the protons that located at the inner of the nucleus. However, in principle, we may still can use eq-37 to evaluate a γ decay that caused by the transition from an inner nuclear proton orbit to a surface nuclear proton orbit (see Figure 5c). The rest part of this section is to build up a model to do some real estimative calculations.

Now the task become: we need to figure out a way to calculate out two nuclear orbital energy levels (that can be used to calculate out the γ decay energy by using the Coulomb equation eq-35). After many tries, I further simplified the model for the nuclear proton's E/RFe-energy configuration by assuming that there are only two levels of E/RFe-energy level

inside a nucleus: the low-energy level (or **low-E**, equivalent to n = n" = 1 QM state) that is formed by all nuclear surface protons, and the high-energy level (or **high-E**, equivalent to n = ½ or n" = 2 QM state) that is formed by all sub-surface protons. Under this model, if we can estimate out the r_n value, then we can estimate the energy E_n level at each (of the two) n:

$$E_n = K_n + V_n = \frac{1}{2}m_p v_n^2 + \frac{(Z-1)q^2}{4\pi\varepsilon_0}\frac{1}{r_n} = \left(\frac{n\hbar}{r_n}\right)^2 \frac{1}{2m_p} + \frac{Z'q^2}{4\pi\varepsilon_0}\frac{1}{r_n} \qquad \text{eq-39}$$

where m_p is the mass of the proton. For $K_n = \frac{1}{2}m_p v_n^2$, I used Bohr's angular momentum formula [32], $(L = mv_n r_n = n\hbar) \rightarrow \left(v_n = \frac{n\hbar}{mr_n}\right)$, so that $K_n = \frac{1}{2}m_p v_n^2 = \left(\frac{n\hbar}{r_n}\right)^2 \frac{1}{2m_p}$. (Note-1: Although a nuclear surface proton is repelled by the (approximated) point-centered nuclear E/RFe-force, combined with the S/RFs-force, the total force field it subjected may can be approximated as a point-centered attractive force field. Note-2: This nuclear surface proton only does the random thermal motion, it does not do the circular orbit movement around the nucleus. However, under the (approximately) point-centered attractive total force field (of S/RFs-force plus E/RFe-force), there is a matter wave mode (that equivalent to a single one nuclear surface proton at any one time, but can be carried by different protons at any different time), and it is doing the circular orbit movement around the center of the nucleus. This is similar as what I have described in SunQM-2's section III, "*… inside the Sun it is the collection of matter waves (of all atoms) that doing the RF. For a specific atom, at the end of its free path it collides with a 2nd atom, the 1st atom's original motion is stopped, but its matter wave is transferred to the 2nd atom, and the 2nd atom carries this matter wave (now it is a virtual matter wave) on its free path until it collides with the 3rd atom and transfer this virtual matter wave to the 3rd atom. The Sun has countless of atoms, and each atom carries (and transfers) several matter wave modes simultaneously (to different direction)*". Note-3: Thus, I may can (approximately) use the Bohr's angular momentum formula $L = mv_n r_n = n\hbar$ to describe. Note-4: Because the atomic electron is doing the true (near) circular orbital movement, while the paired nuclear proton is only doing the thermal motion, not the true (near) circular orbital movement, thus, the pair between the nuclear proton and the electron is not "one-to-one" fixed, and must be dynamically changed all the time. For example, for any one of the $1s^22s^2$ four nuclear surface protons, at any one time, it picks one closest $1s^22s^2$ electron to pair transiently, and at the next time, it picks another one closest $1s^22s^2$ electron to pair transiently). The n^2 in eq-39 is obtained by using $n^2 = \frac{r_{n"=2}}{r_{n"=1}} < 1$ (see eq-37). (Note: In eq-39 and eq-7, using (Z-1) is more like using the classical physics (because it can choose a single proton as the surface proton), using Z' is more like using the QM (because it has to choose all protons at the n=1 nuclear energy level as the surface proton). See Table 3 and Table 5 for how to choose the value of Z'). In Table 3 (also in Table 5, and also in SunQM-6s9's Table 1), I used eq-39 (with (Z-1) replaced by Z') to estimate the de-excitation ΔE (for the possible γ decay).

In Figure 5a, I copied a diagram of nuclear potential from a text book [33]. The total nuclear potential (see Figure 5a) can be separated into two parts: the nuclear potential that caused by the S/RFs-force of the total nucleons (see Figure 5b), and the nuclear potential that caused by the E/RFe-force of the total protons (see Figure 5c). In Figure 5c, notice that besides that the all surface nuclear protons are at the low-E QM state (with n" = 1), I was forced to treat all inner protons and the core protons to have the same energy level as that of the sub-surface protons so that they are all at the high-E QM state (with n" ≈ 2), because this is the only way that I can use the Coulomb formula to (semi-quantitatively) calculate the de-excitation energy ΔE between the two energy levels of the nuclear protons (for the possible γ decay). See in Figure 5b, nuclear force's S/RFs (attractive force) part causes inner nucleons at low-E and surface nucleons at high-E (both E < 0, short range); See in Figure 5c, nuclear force's E/RFe (repulsive) force part caused all sub-surface protons to have the same leveled high-E and caused the surface protons to have low-E (both E > 0, long range). According to Figure 5a, at the (nuclear) ground state, the combined final nuclear force caused the inner nucleons to have low-E and the surface nucleons to have high-E (both E < 0), and at the outside of nuclear surface to have E > 0 for protons.

In the rest part of this section, I only discuss the nuclear proton caused E/RFe-force nuclear orbital potential (i.e., Figure 5c), and how it may affect the nuclear proton's orbital energy level configuration (for both the ground state and the excited states, see Figure 2e and Figure 3a), and how it may affect the nuclear proton's structural configuration inside a nucleus (for both the ground state and the excited states, see Figure 6 and Figure 7). For the S/RFs-force caused nuclear potential, it may will be described in the future paper SunQM-6s9.

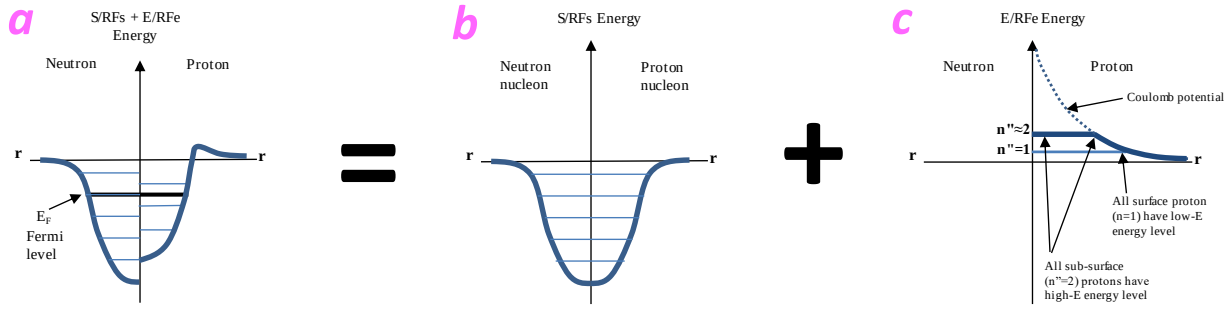
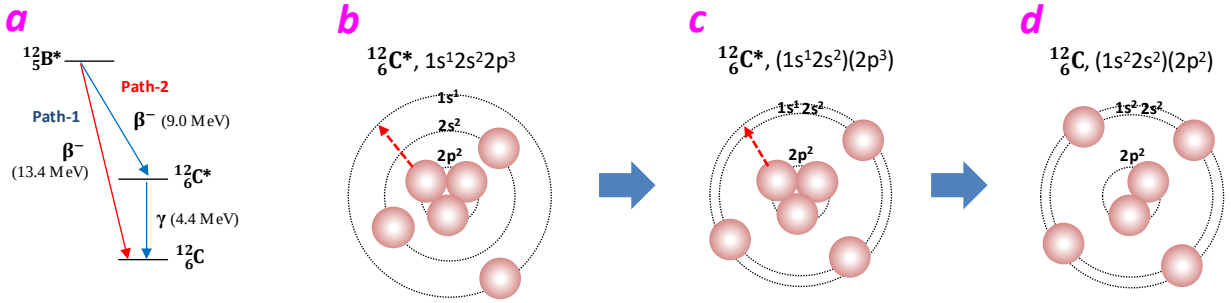


Figure 5a. Illustration of nuclear potential produced by the S/RFs-force plus E/RFe-force. Note: Figure 5a was drawn by coping: Stephen T. Thornton & Andrew Rex, Modern Physics for Scientists and Engineers, 3rd ed. 2006. p439. Fig-12.7.
Figure 5b. Illustration of nuclear potential produced by the S/RFs-force.
Figure 5c. Illustration of nuclear potential produced by the nuclear protons' E/RFe-force. Notice that in this model, only between n" = 1 and n" ≈ 2, we can use the Coulomb potential to estimate ΔE. All inner and core protons have the same E/RFe-energy level as that of the n" ≈ 2. (Note: I know this estimation is far from perfect, but it should not be too far away from the true value. In my mind, a semi-quantitative description is much better than a pure qualitative description).

IV-d. Example-1: gamma decay of $^{12}_{6}C^{*} \xrightarrow{\gamma,4.4\ MeV} {}^{12}_{6}C$ explained by using the pure nuclear proton orbital transition

Copied from [34], Figure 6a showed the energy level of a β^- decay of $^{12}_{5}B \xrightarrow{\beta,13.4\ MeV} {}^{12}_{6}C$, with a γ decay step of $^{12}_{6}C^{*} \xrightarrow{\gamma,4.4\ MeV} {}^{12}_{6}C$ in the path-2. Now we try to explain this γ decay as the pure E/RFe force field effect (not including S/RFs) that caused by a single nuclear proton's de-excitation from a high E/RFe energy level (n" ≈ 2) to a low E/RFe energy level (n" = 1). Figure 6b through Figure 6c showed the detailed description:

1) In Figure 6b, I described the six protons (in the $^{12}_{6}C^{*}$ excited state) in a $1s^1 2s^2 2p^3$ nuclear orbital configuration;
2) In Figure 6c, I assumed that the nuclear orbital 1s2s are degenerated. Thus, after re-grouping it as $(1s^1 2s^2)(2p^3)$, we simplified the $^{12}_{6}C^{*}$ nuclear orbital configuration to contain only two energy levels: the high-energy level state $2p^3$ contains three protons at the core, and the low-energy level state $1s^1 2s^2$ contains three protons at the surface of the nucleus (also see Figure 6e).
3) From Figure 6c to Figure 6d, a proton from 2p nuclear orbit de-excited to $1s^1 2s^2$ nuclear orbit, and emitted a γ photon. Thus all four protons at $1s^2 2s^2$ state have the same (E/RFe-force) low energy level (also see Figure 6f). Notice that this transition can be treated as 2p → 1s, so that it satisfies the selection rule of $\Delta l = \pm 1$ (see [35]).



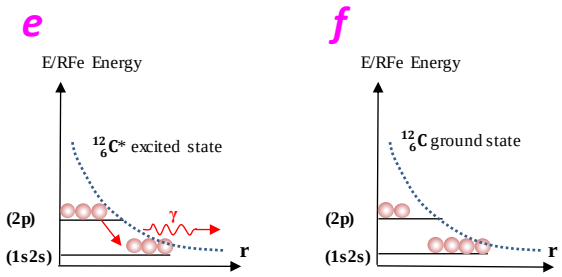


Figure 6a. The energy level of a β^- decay of $^{12}_{5}\mathrm{B} \xrightarrow{\beta,13.4\ \mathrm{MeV}} {}^{12}_{6}\mathrm{C}$ (copied from Giancoli's text book p1116, Fig-41-9 with the minor modifications).
Figure 6b, 6c, 6d. The (possible) nuclear orbital configurations for $^{12}_{6}\mathrm{C}^*$ $(1s^1 2s^2)(2p^3)$ and $^{12}_{6}\mathrm{C}$ $(1s^2 2s^2)(2p^2)$.
Figure 6e, 6f. Illustration of the E/RFe-energy level de-excitation from the high-E state (n" ≈ 2 state, or the real nuclear 2p state) to the low-E state (n" = 1 state, or the real nuclear 1s2s state), that may cause the γ decay.

In Figure 7 (a, b, c, d, e), I detailed the above description by constructing a series of (possible) 3D structural dynamic changes for all 12 nucleons inside the nucleus of $^{12}_{5}\mathrm{B}$, $^{12}_{6}\mathrm{C}^*$, and $^{12}_{6}\mathrm{C}$ (note: all of them using a cube as the possible core structure). We started with a possible 3D (ground state) structure for the stable (non-isotopic) $^{11}_{5}\mathrm{B}$ shown in Figure 7a. By adding one more neutron, Figure 7b showed the isotopic $^{12}_{5}\mathrm{B}$ in the ground state with the nuclear orbital configuration of $(1s^2 2s^2)(2p^1)$. (Note: Although in theory, the two nuclear orbital $1s^2$ protons are always at the most outer edge and the two nuclear orbital $2s^2$ protons are always at the 2nd most outer edge of the nucleus, for the all high Z# nuclides, I guessed that the nuclear orbital $1s^2$ protons and nuclear orbital $2s^2$ protons are always degenerated into the same nuclear orbital energy level, so we grouped them as $(1s^2 2s^2)$ by adding a parenthesis. I guessed all nuclear orbital 2p protons are always having the significantly high nuclear orbital energy level than that of $(1s^2 2s^2)$, so we grouped them as $(2p^1)$ here). I also assumed that the β^- decay starts at the excited state of $^{12}_{5}\mathrm{B}^*$ with the initial nuclear proton configuration of $^{12}_{5}\mathrm{B}^*$ $(1s^1 2s^2)(2p^3)$, as shown in Figure 6c. (Note: from $^{12}_{5}\mathrm{B}$ (in Figure 6b) to $^{12}_{5}\mathrm{B}^*$ (in Figure 6c), a nuclear 1s (low-E) surface proton is moved to the core of the nucleus to become a nuclear 2p (high-E) proton, probably by switching the position with a neutron). Then, in the first part of the path-2 decay $^{12}_{5}\mathrm{B}^* \xrightarrow{\beta,9.0\ \mathrm{MeV}} {}^{12}_{6}\mathrm{C}^*$, a core neutron β^- decayed into a nuclear 2p proton (as shown from Figure 6c to Figure 6d). In the second part of the path-2, $^{12}_{6}\mathrm{C}^* \xrightarrow{\gamma,4.4\ \mathrm{MeV}} {}^{12}_{6}\mathrm{C}$, the γ decay become the (pure) result of the de-excitation of a nuclear orbital 2p proton (high-E, at the core) to be a nuclear orbital 1s proton (low-E, at the surface of the nucleus). Notice that this become be a pure E/RFe-force orbital energy level de-excitation (without S/RFs-force involved).

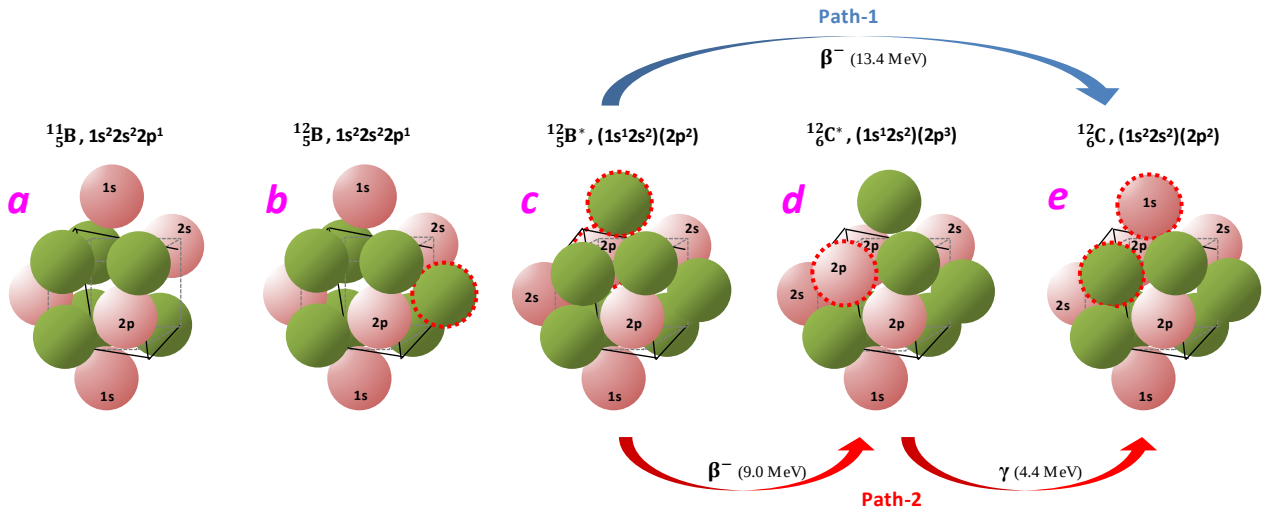


Figure 7. The illustration of the (possible) 3D structures for all 12 nucleons inside the nuclides of $^{12}_{5}$B , $^{12}_{6}$C*, and $^{12}_{6}$C for the β^- decay process of $^{12}_{5}\mathrm{B} \rightarrow {}^{12}_{6}\mathrm{C}$. The green ball represents the neutron, the pink ball represents the proton.

With these (possible) 3D structures, I can further estimate the (pure E/RFe-force caused de-excitation) energy difference between a nuclear orbital 2p proton and a nuclear orbital 1s proton (see Table 3). To simplify the calculation, I first approximated a pseudo point-centered E/RFe-force field with the two 2p protons in $^{12}_{6}$C (see Figure 7e) at the center (or, Z' = 2). Then, the third 2p proton (or the excited n" = 2 proton) in $^{12}_{6}$C* (see Figure 7d) was approximated to have a radius r_n = 1.45E-15 meters to the pseudo E/RFe-force field center. (Note: It was calculated as: for a cubic core in Figure 7d, the eight nucleons locate at [x, y, z] = [±1r, ±1r, ±1r], where r ≈ r_{proton} = 8.4E-16 meters. The distance from the third 2p proton to the core center = $\sqrt{r^2 + r^2 + r^2} = \sqrt{3}$r = 1.73 × 8.4E-16 = 1.45E-15 meters). Then, all the nuclear 1s2s protons (or the ground state proton) in $^{12}_{6}$C (see Figure 7e) was assumed to have a radius $r_{n=1}$ = 3.13E-15 meters to the pseudo E/RFe-force field center. (Note: It was calculated as the radius of the core proton plus two times of r_{proton} , or, = 1.45E-15 + 2×0.84E-15 = 3.13E-15 meters. Notice that this value (3.13E-15 meters) is pretty close to SunQM-5's Table 2's carbon atom's r_{nuc} = 2.86E-15 meters). Then, according to eq-37, for the ground state 1s2s, n=1, $n^2 = \frac{r_{1s}}{r_{1s}} = 1$; for the excited nuclear state 2p (or n" = 2), $n^2 = \frac{r_{2p}}{r_{1s}} = \frac{1.45\mathrm{E}{-15}}{3.13\mathrm{E}{-15}} = 0.463$, or n = $\sqrt{0.463}$ = 0.681 (notice that it is pretty close to n = ½ in eq-37). Then, I used eq-39 to calculate the $E_n = K_n + U_n$ energy level for a proton at either nuclear 2p or nuclear 1s2s state. The final result was: the proton at nuclear 2p state has E_{2p} = 6.57 MeV, at nuclear 1s2s state has E_{1s2s} = 3.04 MeV, and the difference of $\Delta E_{2p \rightarrow 1s2s}$ = 3.52 MeV. This value is pretty close to the experimental value (4.4 MeV) for the γ decay (see Figure 6a). Therefore, I believed that this semi-quantitative estimation may support the hypothesis that the γ decay may be a pure E/RFe-force de-excitation (without the S/RFs involvement).

Table 3. For C* → C gamma decay, calculate (by estimation) a proton's (E/RFe) energy level difference between the nuclear 2p state and the nuclear 1s2s state (inside a C atomic nucleus).

	n" = 1, (or n=1s2s)	**n" = 2,** (or n=2p)
$r_{n"=2} = r_{n"=1} - b*(r_{proton})$, **b=**		**2**
r_n =	3.13E-15	1.45E-15
$n^2 = r_n / r_1$	1	0.463
n =	1	0.681
$K_n = (1/2)\, m\, v_n^2 = (n\, h/(2\pi r_n))^2/(2m)$, J	3.39E-13	7.32E-13
K_n =(MeV)	2.12	4.58
Z' =	2	2
$U_n = Ze^2/4\pi\varepsilon_0 / r_n$ = (J)	1.47E-13	3.18E-13
U_n = (MeV)	0.92	1.99
$E_n = K_n + U_n$ = (MeV)	**3.04**	**6.57**
ΔE = (MeV)		**2p → (1s2s)**
		3.52

Note: Here we treat the four ($1s^2 2s^2$) protons to have the degenerated QM states, so they have the same energy level and the same r_n = 3.13E-15 meters, so that the de-excited proton at r_n of 1s orbital still see two (2p) protons at the center (of this pseudo point-centered E/RFe force field). Note: In this kind of semi-quantitative calculation, there are two major uncertain variables: the first one is the r_n, we usually use a value of $\Delta r_n = 2\times r_{proton} = 2\times 8.4E\text{-}16 = 1.68E\text{-}15$ meters for the radial difference between the high-energy level orbit and the low-energy level orbit; the second one is the effective center charge number Z', and it is estimated roughly case by case (see Table 3, Table 5 and SunQM-6s9's Table 1).

If we use eq-37 (or eq-38) for the calculation, then $E_{n"=1}$ = 3.04 MeV, $E_{n"=2} = (n")^2\, E_{n"=1}$ = 4 * 3.04 = 12.16 MeV, $E_{n"=3} = 3^2$ * 3.04 = 27.36 MeV, and the minimum transitional energy is $\Delta E_{2\text{-}1}$ = 3* 3.04 = 9.12 MeV. The result is worse than that in Table 3 (although both results are too rough to compare).

See the similar calculation (as the Example-2) in the Appendix D (for $^{203}_{81}\mathrm{TI}^* \xrightarrow{\gamma,\ 279\ \mathrm{keV}} {}^{203}_{81}\mathrm{TI}$). Also see the similar calculation (as the Example-3) in SunQM-6s9's Table 1 (for $^{24}_{12}\mathrm{Mg}^{**} \xrightarrow{\gamma,2.76\ \mathrm{MeV}} {}^{24}_{12}\mathrm{Mg}^* \xrightarrow{\gamma,1.38\ \mathrm{MeV}} {}^{24}_{12}\mathrm{Mg}$).

By using the simple harmonic oscillator potential well for the S/RFs-force, and the Coulomb potential hill for the E/RFe-force (mainly for the radius change vs. the energy level change for each nucleon in the β^- decay process of $^{12}_{5}\mathrm{B}^* \rightarrow {}^{12}_{6}\mathrm{C}$), Figure 8 showed another way to explain the (possible) 3D structural changes in Figure 7 (for the path-2 only). Figure 8a represents the 3D structure of $^{12}_{5}\mathrm{B}$ (in Figure 7b) at zero thermal motion (or at 0 K°, similar as that in Figure 4d'). Figure 8b represents the same 3D structure of $^{12}_{5}\mathrm{B}$ with very high thermal motion (>> 300 K°). Then, all 11 nucleons transfer their high (thermal?) energy to the very center single neutron and make this neutron excited to the high S/RFs energy level, and all 11 nucleons move to the low thermal energy state (see Figure 8c, for the explanation of Figure 7c). Then, the excited (central) neutron β^- decayed to be a (central) proton, and thus de-excited its S/RFs energy level (see Figure 8d). Then, this new (central) proton added a new Coulomb (repulsive) interaction with all other nuclear protons (see Figure 8e), and this new (central) proton slide down the hill of this Coulomb (repulsive) potential to the lowest point it can get (by emitting a γ photon, and also by moving its position from the center to the edge of the nucleus, see Figure 8f). Meanwhile, to accommodate this position change, all the rest 11 nucleons also slightly changed their position by moving inward a little bit (also see Figure 8f). Finally, all 12 nucleons in the $^{12}_{6}\mathrm{C}$ nucleus are settled down (with the low thermal motion) and with the newly formed proton sits at the surface of the nucleus (see Figure 8g).

Similarly, Figure 9 showed the same way to explain the (possible) 3D structural changes in Figure 7 (for the path-1 only). In this case, a surface neutron (not a central neutron) is excited to the high S/RFs energy level (by collected all the rest 11 nucleons' high thermal energy), and then de-excited to the low S/RFs energy level (by emitting β^- particles), but without changing its (radial) position in the nucleus, and with no γ decay.

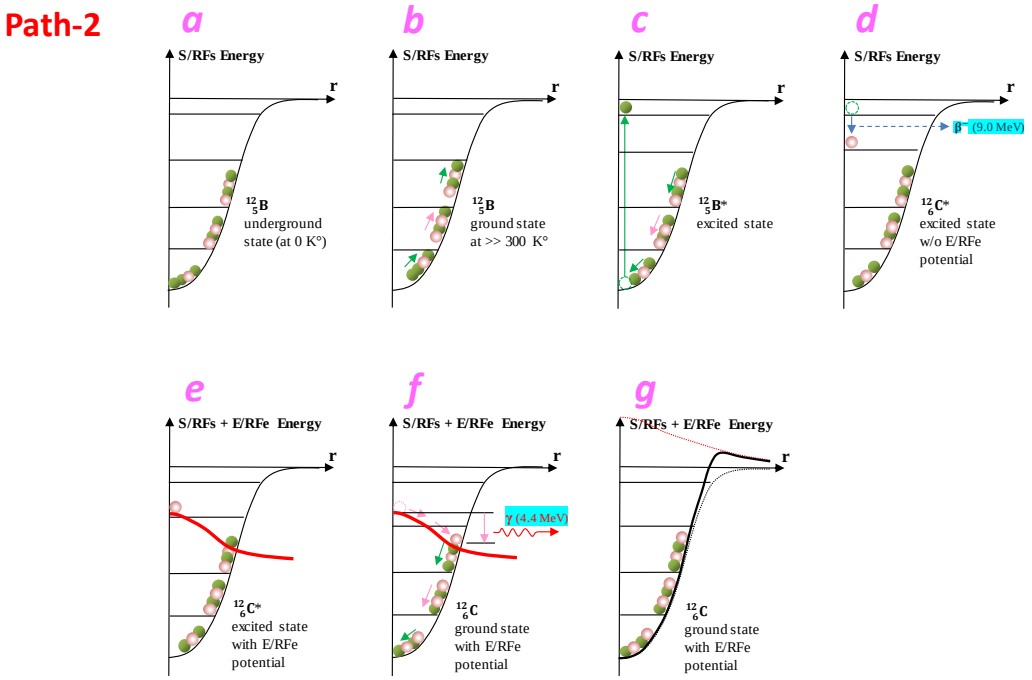


Figure 8. Illustration of the changes of the nuclear orbital radius vs. the energy level for each of 12 nucleons in the β^- decay process of $^{12}_{5}\mathrm{B}^* \rightarrow {}^{12}_{6}\mathrm{C}$ (path-2 only), by using the simple harmonic oscillator potential well for the S/RFs-force, and the Coulomb potential hill for the E/RFe-force.

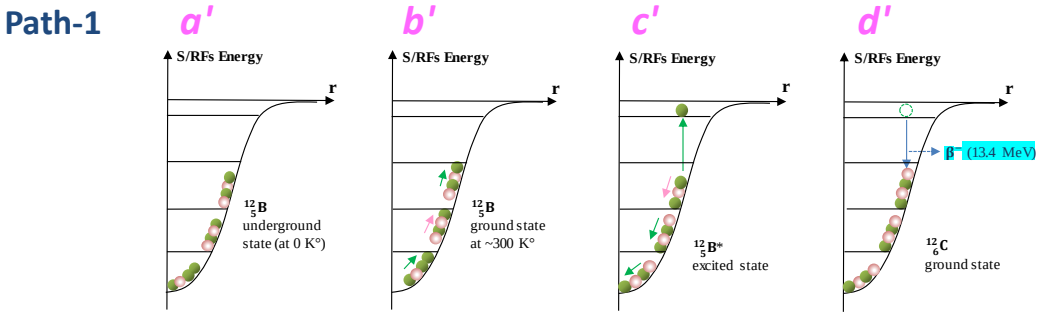


Figure 9. Illustration of the changes of the nuclear orbital radius vs. the energy level for each of 12 nucleons in the β^- decay process of $^{12}_{5}\mathrm{B}^* \rightarrow {}^{12}_{6}\mathrm{C}$ (path-1 only), by using the simple harmonic oscillator potential well for the S/RFs-force, and the Coulomb potential hill for the E/RFe-force.

IV-e. Using the "proton-electron mirror-coupled orbit" model to explain the K-capture

After developed "proton-electron mirror-coupled orbit" model, I started to looking for more supportive materials. In wiki "internal conversion", it mentioned: *"In the quantum model of the electron, there is non-zero probability of finding the electron within the nucleus. In internal conversion, the wavefunction of an inner shell electron (usually an s electron) penetrates the nucleus. When this happens, the electron may couple to an excited energy state of the nucleus and take the*

energy of the nuclear transition directly, without an intermediate gamma ray being first produced. The kinetic energy of the emitted electron is equal to the transition energy in the nucleus, minus the binding energy of the electron to the atom. Most IC electrons come from the K shell (the 1s state), as these two electrons have the highest probability of being within the nucleus. However, the s states in the L, M, and N shells (i.e., the 2s, 3s, and 4s states) are also able to couple to the nuclear fields and cause IC electron ejections from those shells (called L or M or N internal conversion)". To me, this is a strong evidence that may support the pair-matching between the nuclear proton's $1s^22s^22p^63s^2$… QM states to the atomic electron's $1s^22s^22p^63s^2$… QM states (in the same atom). Actually, not only the atomic electron's (E/RFe-forced) wave function extended inward to $r \to 0$ (to the nuclear region), the nuclear proton's (E/RFe-forced) wave function also extended outward to $r \to \infty$ (to the electron orbital region), the mutual coupling and the mutual modulation between this two wave functions may be the driving force that causing the result of "proton-electron mirror-coupled orbit".

According to wiki "Electron capture", a K-capture and/or a L-capture "*is a process in which the proton-rich nucleus of an electrically neutral atom absorbs an inner atomic electron, usually from the K or L electron shells … The resulting daughter nuclide, if it is in an excited state, then transitions to its ground state. Usually, a gamma ray is emitted during this transition, but nuclear de-excitation may also take place by internal conversion … Electron capture is sometimes included as a type of beta decay, because the basic nuclear process, mediated by the weak force, is the same* ". Based on the "proton-electron mirror-coupled orbit" model, I further guessed that there might be a one-to-one relationship between the proton and the electron in a K-capture (or a L-capture): in a K-capture, the 1s electron can only (or mainly?) be captured by the 1s proton; in a L-capture, the 2s electron can only (or mainly?) be captured by the 2s proton, and the 2p electron can only (or mainly?) be captured by the 2p proton, etc. (Note: Again, this is a completely citizen scientist leveled guess).

IV-f. Using the "proton-electron mirror-coupled orbit" model to explain the gravity collapse (that forms the white dwarf and the neutron star)

Here I switched to use the interior {N,n} QM description with the n=1 nuclear proton orbit as the r_1, so it is the prot{N,n//6} QM description. (See SunQM-5's section IV for detailed explanation. Note: Here is a brief review on the {N,n} QM that related to prot{N,n}: prot{0,1} = prot{0,1//6} = Sun{-15,1//6} = {-15,1//6} = {-15,1}, or prot{0,1//6} = e1{-3,1//6}, or e1{0,1//6} = prot{3,1//6}).

From SunQM-7's Table 1, (depends on the Z#), we see that the size of nuclides take the {N,n} orbital space from {-15,1//6} size to {-15,36//6} = {-14,6//6} = {-13,1//6} size, or from prot{0,1//6} size to prot{0,36//6} = prot{1,6//6} = prot{2,1//6} size; while the size of atoms take the {N,n} orbital space from {-12,1//6}o orbital space to {-12,7//6}o orbital space, or from {-12,2//6} size to {-12,8//6} size (due to the 100% electron occupancy, and due to the rule of "all mass between r_n and r_{n+1} belong to orbit n"), or from about e1{0,2//6} size to about e1{0,8//6} size, or from about prot{3,2//6} size to about prot{3,8//6} size. From the point view of a nucleus (that based on protons), why an atom has a size about $\Delta N \approx +3$ (or $\Delta N \approx +2$, or $\Delta N \approx +1$, depends on the Z#) larger than the size of a nucleus is that, it is the electron shell that makes the size of the atom. The size of the electron shell is mainly supported by the repulsive E/RFe-force between the electrons in the same shell (i.e., the $V_{\theta\varphi} > 0$, see the section II in this paper). So, when a Sun collapsed from the size of {0,2//6} to a white dwarf with the size of {-1,1//6}, it may can be explained as its electron shell collapsed size by $\Delta N \approx -1$.

If using the model in SunQM-5s1's section I, "*White dwarf, neutron star, and black hole analyzed as the shrink of atom (or virtual atom), with the total number of atoms (in a Sun) unchanged*", and if using the H-atom (in the Sun) as the example, then

1) For a Sun (or any star that is greater than {0,1//6} in size), its 1s orbital electron of the H-atom is at e1{0,1//6}o orbital space (see Figure 10a);
2) For a white dwarf star (with the size of {-1,1//6} = {-2,6//6}), its 1s orbital electron of the pseudo "H-atom" is now compressed into the e1{-1,1//6}o orbital space (see Figure 10b);
3) For a {-2,1//6} = {-3,6//6} sized star (that take the {-3,n=1..5//6}o orbital space, and including a neutron star that take {-3,1//6}o orbital space, or with the size of {-3,2//6}), its 1s orbital electron of the pseudo "H-atom" is now further compressed into the e1{-2,1//6}o orbital space (see Figure 10c);

4) For a black hole (with the size of {-3,1//6} = {-4,6//6}), its 1s orbital (pseudo) electron of the pseudo "H-atom" is now completely compressed into the e1{-3,1//6} sized space, and merged with the proton (because a proton has size of e1{-3,1//6} = prot{0,1//6}, see Figure 10d).

This analysis supports (at least a part of) the particle Standard Model: particles may decay from the 3rd generation to 2nd generation to 1st generation (note: for the down-quark, the {N,n} QM result showed that it is from {-15,2//6}o orbit, to {-16,2//6}o orbit, to {-17,2//6}o orbit, or from {-15,3//6} size, to {-16,3//6} size, to {-17,3//6} size, see SunQM-5s2's Table 1), just like a star decays (or collapse) from the "zero" generation (with size {0,1//6} or above, like a Sun) to "-1" generation (with size {-1,1//6}, like a white dwarf star), then to "-2" generation (with size {-2,1//6}, like a neutron star or a {-2,1//6} sized star), then to "-3" generation (with size {-3,1//6}, like a black hole). Or, just like a H-atom "decay" (or "collapse") from the "zero" generation (with the r_1 size at e1{0,1//6}) to "-1" generation (with r_1 size at e1{-1,1//6}), then to "-2" generation (with the r_1 size at e1{-2,1//6}), then to "-3" generation (with the r_1 size at e1{-3,1//6}).

However, instead of shrinking the size of each H-atom, the real physical world used the nuclear fusion (by decreasing the total atom number while increasing the Z#). For a $^{294}_{118}$Og atom (suppose it is on the surface of a {-2,1} star, see SunQM-5s1's section I), when this {-2,1} star is further (gravitational) collapsed to be {-3,1} star, we may can simply explain it as: first the 1s electron and the 1s proton pair of this $^{294}_{118}$Og atom is merged, followed by the 2s orbital electron-proton pair merging, then the 2p electron-proton pair merging, then the 3s-pair, 3p-piar, 3d-pair merging, ... , until all 118 electrons are merged to their intrinsically coupled 118 protons. Thus, a $^{294}_{118}$Og atom become a $^{294}_{0}$Og virtual "atom". Without the electron shell, a $^{294}_{0}$Og virtual "atom" becomes a bared nucleus with 294 pure neutrons, and then it can easily fuse with all other same $^{294}_{0}$Og virtual "atoms", or bared $^{294}_{0}$Og nuclei, to become a single huge nucleus. And then, because of this, a {-2,1} star collapsed to be a {-3,1} star. Thus, in this case (and only in this case), we can directly use the same orbital-coupled electron-proton merge to explain the (gravitational) collapse of a {-2,1} star to a {-3,1}star. (Note: However, I found it is impossible to use the same method to explain the general fusion process, e.g., for twelve H-atoms that are fused into one C-atom, or from a {0,1} star collapse to a {-1,1} star, or from a {-1,1} star collapse to a {-2,1} star).

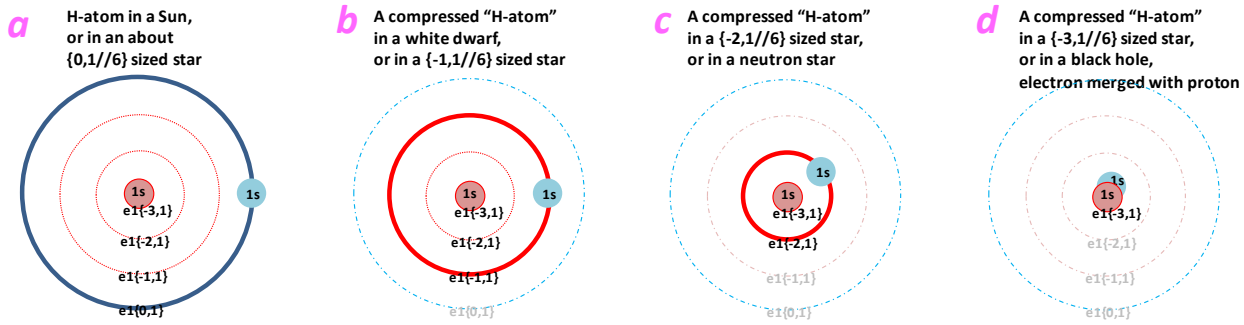


Figure 10. To illustrate the quantum collapse of a H-atom (or a compressed pseudo "H-atom") that correlates to the celestial body collapse from a {0,2} Sun to a {-1,1} white dwarf, then to a {-2,1} star, then to a {-3,1} black hole.

V. Summary of using the traditional Schrodinger equation with $V_{total} = V_r + V_{\theta\varphi}$

If we are able to extract a $V_{\theta\varphi}$ out of the V_{total} as either the mutual repulsion of electrons (or the mutual attraction of pre-Sun ball's fragmental objects) in the same *l* sub-shell, then we may be able to use $V = V_r + V_{\theta\varphi}$ in the traditional Schrodinger equation to directly determine the $r_{n,l}$ and $E_{n,l}$ for all n shells and all *l*(s) sub-shells in one step. In this case, eq-3 becomes eq-23. Although I am not able to solve eq-23, according to the above results, at least we now know some of the

solutions (qualitatively or even semi-quantitatively), and they were listed in Table 4. For the point-centered attractive force field ($V_r < 0$), the newly added $V_{\theta\varphi}$ in eq-24 (in comparison with eq-5) determines the *l* sequence of the $r_{n,l}$ and $E_{n,l}$ in a fixed n shell: when $V_{\theta\varphi} > 0$, it produces $r_{3s} < r_{3p} < r_{3d}$ and $E_{3s} < E_{3p} < E_{3d}$; when it is $V_{\theta\varphi} < 0$, it produces $r_{3s} > r_{3p} > r_{3d}$ and $E_{3s} > E_{3p} > E_{3d}$; when it is $V_{\theta\varphi} = 0$, it produces $E_{3s} = E_{3p} = E_{3d}$, although still $r_{3s} > r_{3p} > r_{3d}$ (because the bound state always has $V_r < 0$ (or $E < 0$)). On the other hand, eq-5 determines the n sequence of the $r_{n,l}$ and $E_{n,l}$ for different n shells. However, for the point-centered repulsive force field ($V_r > 0$), according to the result in section IV, I can only guess that $r_3 < r_2 < r_1$ and $E_3 > E_2 > E_1$ (for quantum number n"), I am unable to guess the relationship between r_{3s} and r_{3p} and r_{3d} , or between E_{3s} and E_{3p} and E_{3d} .

Table 4. A (uncompleted) list on how $V_r + V_{\theta\varphi}$ affect r_n , E_n , $r_{n,l}$, and $E_{n,l}$.

		r_n	E_n	$r_{n,l}$	$E_{n,l}$	Example
$V_r < 0$		$r_{n=3} > r_{n=2} > r_{n=1}$	$E_{n=3} > E_{n=2} > E_{n=1}$			
	$V_{\theta\phi} < 0$			$r_{3s} > r_{3p} > r_{3d}$	$E_{3s} > E_{3p} > E_{3d}$	pre-Sun ball's orbital
	$V_{\theta\phi} = 0$			$r_{3s} > r_{3p} > r_{3d}$	$E_{3s} = E_{3p} = E_{3d}$	H-atom's electron orbital
	$V_{\theta\phi} > 0$			$r_{3s} < r_{3p} < r_{3d}$	$E_{3s} < E_{3p} < E_{3d}$	Z > 1 atom's ground state electron configuration
$V_r > 0$		$r_{n=3} < r_{n=2} < r_{n=1}$	$E_{n=3} > E_{n=2} > E_{n=1}$			
	$V_{\theta\phi} < 0$			?	?	?
	$V_{\theta\phi} = 0$			?	?	?
	$V_{\theta\phi} > 0$			?	?	?

Conclusion:

By using $V = V_r + V_{\theta\varphi}$ with $V_{\theta\varphi} > 0$ for the electron-electron's repulsive interaction in the same *l* sub-shell, we may be able to explain why a Z > 1 atom has a reversed sequence of *l* sub-shells (than the Schrodinger equation's solution for an H-atom). A brand new "proton-electron mirror-coupled orbit" model has been proposed for the nuclear proton's E/RFe-force energy level (inside the nucleus). The γ decay may can be attributed to the nuclear proton's pure E/RFe-force energy level de-excitation (without involving the S/RFs-force).

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[28] Yi Cao, SunQM-6s4: In {N,n} QM Field Theory, A Point Charge's Electric Field Can Be Represented by Either the Schrodinger Equation/Solution, Or A 3D Spherical Wave Packet, In Form of Born Probability. https://vixra.org/pdf/2306.0136v1.pdf (submitted on 2023-06-23)
[29] Yi Cao, SunQM-6s5: Using {N,n} QM Field Theory to Describe A Propagating Photon as A 3D Spherical Wave Packet with the Oscillation Among Three QM States. https://vixra.org/pdf/2307.0098v1.pdf (submitted on 2023-07-18)
[30] Douglas C. Giancoli, Physics for Scientists & Engineers with Modern Physics, 4th ed. 2009, p1005, eq-37-14.
[31] Douglas C. Giancoli, Physics for Scientists & Engineers with Modern Physics, 4th ed. 2009, p1004, eq-37-11.
[32] Douglas C. Giancoli, Physics for Scientists & Engineers with Modern Physics, 4th ed. 2009, p1004, eq-37-10.
[33] Stephen T. Thornton & Andrew Rex, Modern Physics for Scientists and Engineers, 3rd ed. 2006. P439, Fig-12.7.
[34] Douglas C. Giancoli, Physics for Scientists & Engineers with Modern Physics, 4th ed. 2009, p1116, Fig-41-9.
[35] David J. Griffiths, Introduction to Quantum Mechanics, 2nd ed., 2015, p362, eq-9.78, and Figure 9.6. Selection rule of $\Delta l = \pm 1$.

Note: A series of SunQM papers that I am working on:
SunQM-6s7: {N,n} QM Field Theory Development On the E/RFe-force … (drafted in Apr. 2023).
SunQM-6s8: {N,n} QM Field Theory Development On the G/RFg-force … (drafted in Apr. 2023).
SunQM-6s9: {N,n} QM Field Theory Development On the S/RFs-force … (drafted in May. 2023).
SunQM-6s10: Schrodinger equation and {N,n} QM ... (drafted in January 2020).
SunQM-4s4: More explanations on non-Born probability (NBP)'s positive precession in {N,n}QM.
SunQM-7s1: Relativity and non-linear {N,n} QM
SunQM-9s1: Addendums, Updates and Q/A for SunQM series papers.

Note: Major QM books, data sources, software I used for SunQM series papers study:
Douglas C. Giancoli, Physics for Scientists & Engineers with Modern Physics, 4th ed. 2009.
David J. Griffiths, Introduction to Quantum Mechanics, 2nd ed., 2015.
Stephen T. Thornton & Andrew Rex, Modern Physics for Scientists and Engineers, 3rd ed. 2006.
John S. Townsend, A Modern Approach to Quantum Mechanics, 2nd ed., 2012.
Wikipedia at: https://en.wikipedia.org/wiki/
(Free) online math calculation software: WolframAlpha (https://www.wolframalpha.com/)
(Free) online spherical 3D plot software: MathStudio (http://mathstud.io/)
(Free) offline math calculation software: R
Microsoft Excel, Power Point, Word.
Public TV's space science related programs: PBS-NOVA, BBC-documentary, National Geographic-documentary, etc.
Journal: Scientific American.

Note: I am still looking for endorsers to post all my SunQM papers (including the future papers) to arXiv.org. Thank you in advance!

Note: With my 30 of SunQM papers that have been posted out so far, I believe that the framework of the {N,n} QM has been fully established. It is clear now that the {N,n} QM description is not only suitable for the mass field, but also suitable for the force field (or potential field, or energy field, etc.). Thus, my (10 years of close-door) research phase on the {N,n} QM will be ended in about one year (most likely in the summer of 2024). After that, I will re-write the SunQM papers (~ 35 of them) in the form of a text book.

Appendix A. The particle (and the smaller r_1) equals to the continues process, the wave (and the larger r_1) equals to the quantum process?

(Note: This Appendix should be moved to SunQM-7 as Appendix-D's Example-6). According to the "magic" of the {N,n} QM theory (see SunQM-7's Appendix-D), we can move the r_1 inward "freely" so that the high-frequency n' becomes very big value, and when $r_1 \rightarrow 0$, $n' \rightarrow \infty$, this quantum description completely becomes a continuous description (or a classical physics description). (See in SunQM-6s3's Table-3, or SunQM-6s5's Table-1, for the example on how to move r_1 "freely"). Notice that in this operation, the original base-frequency n value (or the Eigen n value) does not change.

According to SunQM-6s3's Table-3, for a photon, the smaller the r_1, the smaller the core of this photon's 3D wave packet will be, thus the more particle physics (or the more particle mechanics, or, the more continues process) it will behave. On the other hand, the larger the r_1, the larger the outer shell of this photon's 3D wave packet will be, thus the more wave physics (or the more wave mechanics, or, the more quantum process) it will behave. According to SunQM-2's section IV, the QM effect is the matter wave interference (or resonance) effect. All of these perfectly explained the double-slit experiment (see SunQM-6s1's section III-d): "*a propagating photon uses its large size (but low density) NBP 3D peak (e.g., $r_{photon\text{-}surface} = b = 3.22$ meters) to detect the obstacle in the front of propagation. After this wave-front passing through a double-slit, this large size NBP 3D peak (wave) will interfere to make a new NBP peak (interfered) pattern, and this new NBP peak (interfered) pattern will guide the core part (or the particle part) of the photon to pass through one of the two slits, and to end on a screen as an interference pattern (based on the NBP probability)*". The key point of this discussion is: **the particle character (and the smaller r_1) is related to the continues process, and the wave character (and the larger r_1) is related to the quantum process**. Besides that, this description also strongly suggested that the wave-front of a propagating photon does propagate faster than the light speed c (maybe at 2c, see SunQM-6s5's Fig-8c); and, in the normal world, our view is limited (or "distorted") by the Einstein's relativity framework and unable to see it (see SunQM-6s5's Fig-8c); and, a one-directional-propagating photon does simultaneously propagate its (inversed) E/RFe force field to all 4π directions in the light speed c (see SunQM-6s1's Fig-3).

Notice that the above description for a photon is also mostly valid for an electron, or even for an object in the macro-world. The major difference is, the mass of the electron (or a macro object) limited the size of its outmost shell of the 3D matter wave packet (also see the similar description in SunQM-6s3 and in SunQM-6s2), so that the higher the mass, the smaller the outmost shell of the 3D matter wave packet, the less distance that can be used for its wave-front's interference, and thus more difficult to observe the double-silt effect.

Appendix B. An alternative treatment than eq-24

(Note: This is a citizen scientist leveled work, written here mainly for myself to read). In eq-23, if we treat $V_{\theta\varphi}$ as a θφ-2D only function, nothing in r-1D, then eq-23 may can be further separated into eq-5 in r-1D and eq-40 in θφ-2D,

$$\frac{1}{Y}\left[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\,\frac{\partial Y}{\partial\theta}\right)+\frac{1}{\sin^2\theta}\left(\frac{\partial^2 Y}{\partial\varphi^2}\right)\right]+V_{\theta\varphi}=-l(l+1) \qquad \text{eq-40}$$

As a citizen scientist, I don't have the ability to solve eq-40.

Appendix C. A peek of the repulsive force field formed Born probability density (or NBP) map

(Note: This is a citizen scientist leveled work, written here mainly for myself to read). For the Schrodinger equation under a point-centered repulsive force field (as shown in eq-36), I don't have the ability to solve it. However, according to the newly designed and developed {N,n} QM field theory, the Born probability density map's contour lines can be re-explained as the trajectory of the moving electron (see SunQM-6s2's Fig-2). Then, consequently and oppositely, we can also treat a trajectory of a moving particle as the contour line of the possible corresponding Born probability (or NBP) density map. This means, we can treat the scattering trajectory of a particle as the contour line of the possible NBP (or Born probability) density

map under the corresponding repulsive force field. Figure 11 showed a series trajectories of a positive charge that is scattered by a central positive charge (at the center of the coordinate) under different conditions. In Figure 11a, it started at the same initial xyx-3D position and in the same initial direction of $\vec{v}_{initial}$ (meaning the same potential energy V_n), but with different speed of $\vec{v}_{initial}$ (meaning different initial kinetic energy K_n). Then it gives different $E_n = K_n + V_n$, with the higher n, the higher E_n . We can imagine that these trajectories formed a set of contour lines for a NBP (or BP) probability density map, with the higher the n, the higher the probability density (for the high E_n QM state of the Schrodinger equation's solution). In Figure 11b, it started at the same initial xyx-3D position and the same initial speed of $\vec{v}_{initial}$ (meaning both the same initial V_n and the initial K_n , thus the same initial E_n), but in different direction of $\vec{v}_{initial}$. Unfortunately, it is beyond my ability to imagine a probability density map (for the Schrodinger equation's solution) using the trajectories of Figure 11b as the contour lines of a density map.

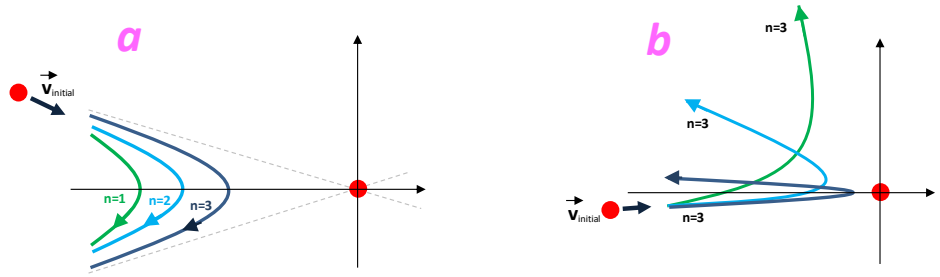

Figure 11. Using the trajectories of the scattering processes (as the contour lines of a probability density map) to imagine a repulsive force field formed Born Probability (or non-Born probability) density map. Note: all trajectories may be hyperbolic (or parabolic).

Appendix D. Gamma decay of $^{203}_{81}TI^* \xrightarrow{\gamma,279\ KeV} {}^{203}_{81}TI$ explained by using pure nuclear proton orbital transition

(Note: This is a citizen scientist leveled work, written here mainly for myself to read). From wiki "internal conversion", it showed a gamma decay process (following a beta decay): $^{203}_{80}Hg \xrightarrow{\beta,\ 214\ keV} {}^{203}_{81}TI^* \xrightarrow{\gamma,\ 279\ keV} {}^{203}_{81}TI$. The online encyclopedia mentioned: The excited TI "*can proceed to the ground state by emitting a 279.190 keV gamma ray, or by internal conversion*" (http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/radact2.html).

In Table 5, after many tries, I decided to choose Z' = 81 - 12 = 69 as the pseudo point center. It was calculated by assuming that 12 of the protons (in the nuclear orbital of $1s^22s^22p^63s^2$) were at the surface of the nucleus (and thus belongs to n" = 1 and have low-E), so the rest 69 protons ($3p^64s^23d^{10}4p^6\ldots5d^{10}6p^1$) were treated as the central charge (and thus belongs to n" ≈ 2 and have high-E). The calculation was done by manually looking for the b value (in the green cell of the Table 5) to make the ΔE (in the yellow cell of the Table 5) closely equal to 0.279 MeV. The result of b = 0.18 means, a proton that is only 0.18× r_{proton} inner than the very surface (1s2s) protons transits to the very surface (1s2s) protons and produced a 279 keV γ-photon.

Here is one possible explanation of the result in Table 5: Due to it is too close to the very surface of the nucleus, this nuclear E/RFe-force excited state proton must not be one of the Z' = 69 core protons ($3p^64s^23d^{10}4p^6\ldots5d^{10}6p^1$), and it must be one of the $1s^22s^22p^63s^2$ surface nuclear protons. According to the transition selection rule of $\Delta l = \pm1$ [35], it must be one of the six of 2p orbital protons. Therefore, we should change the ($1s^22s^22p^63s^2$)($3p^64s^23d^{10}4p^6\ldots5d^{10}6p^1$) configuration to be [($1s^22s^2$)($2p^63s^2$)]($3p^64s^23d^{10}4p^6\ldots5d^{10}6p^1$) configuration. It means, in comparison with the very high energy level ($3p^64s^23d^{10}4p^6\ldots5d^{10}6p^1$) QM state, the ($1s^22s^2$) and the ($2p^63s^2$) QM states have the (almost) same low energy level (so that the Z' = 69 can be used as the core for the calculation). However, , in comparison with the energy level of ($1s^22s^2$), the energy level of ($2p^63s^2$) is a little bit higher (so that a transition between 2p orbit to 1s orbit can produce a 279 keV γ decay). Thus, in this case, we treated the central 69 nuclear protons ($3p^64s^23d^{10}4p^6\ldots5d^{10}6p^1$) as the single high-E state, and treat all

12 surface and near surface nuclear protons ($1s^2 2s^2 2p^6 3s^2$) as the "single" low-E state. And even within the "single" low-E state, we may still can use Table 5 as the "perturbation" calculation to determine the minor change of the energy level.

Table 5. For TI* → TI gamma decay, calculate (by estimation) a proton's (E/RFe) energy level difference between the nuclear 2p state and the nuclear 1s2s state (inside a TI atomic nucleus).

	n" = 1, (or n=1s2s)	**n" = 2,** (or n=2p, 3s, 3p, ...)
$r_{n=2} = r_{n=1} - b*(r_{proton})$, **b=**		0.18
r_n =	7.36E-15	7.21E-15
$n^2 = r_n / r_1$	1	0.979
n =	1	0.990
$K_n = (1/2)\, m\, v_n^2 = (n\, h/(2\pi r_n))^2/(2m)$, J	6.14E-14	6.26E-14
K_n =(MeV)	0.38	0.39
Z' = 81 - 12 surface shell protons ($1s^2 2s^2 2p^6 3s^2$)	69	69
$U_n = Ze^2/4\pi\varepsilon_0 / r_n$ = (J)	2.16E-12	2.21E-12
U_n = (MeV)	13.52	13.80
$E_n = K_n + U_n$ = (MeV)	**13.90**	**14.19**
ΔE = (MeV)		**2p → (1s2s)**
		0.29

Appendix E. In the {N,n} QM, the meaning of N, n, *l*, m for the quantization:

(Note: This Appendix should be moved to SunQM-1). **N**: it quantizes r-1D space, for $0 < r < \infty$; **n**: it further quantizes Δr-1D space within each $\Delta N = 1$ super shell and for $0 < r_N < \infty$, (note: when used in traditional QM, it quantizes r-1D space, for $0 < r_n < \infty$); ***l***: it further quantizes Δr-1D space within each $\Delta n = 1$, and for $0 < r_{n,l} < \infty$, (note: when used in traditional QM, it quantizes r-1D space, for $0 < r_n < \infty$); **m**, it quantizes θ-1D space, for $0 < \theta < \pi$;