SunQM-6s10: {N,n} QM Field Theory, S/RFs-force, Nuclear Force, Spin-spin Interaction, and the Possible Origin of the Weak-Force and Beta-Decay

Yi Cao

e-mail: yicaojob@yahoo.com. ORCID: 0000-0002-4425-039X

Abstract

In articles of SunQM-6, -6s1, -6s2, 6s3, and -6s4, I had established the frame work of a brand new {N,n} QM field theory. In the rest SunQM-6 series articles, I added more detailed developments on the {N,n} QM field theory. In the current article, I added some new developments on the S/RFs-force. 1) A ^{4}He nucleus is constituted with two same neutron-proton binaries that are doing the “face-to-face plus face-opposite-face two-level orbital motion”. Within each one binary, the neutron and proton are doing the “face-to-face tidal-locked orbital binary motion” with the parallel nuclear spin ⇑⇑↑. Between the two binaries, they are doing the “face-opposite-face locked binary orbital motion” in φ-1D bi-direction with the anti-parallel nuclear spin ⇑⇑↑⇓⇓↓, that eventually transformed to be a θ-1D orbital uni-directional motion. Meanwhile, the nuclear proton-1 and atomic electron-1 (in a ^{4}He atom) are paired to do the “face-to-face tidal-locked orbital binary motion”, and so does the proton-2 and electron-2 pair. The same model can be used to explain the dynamic structure of the multi-nucleons inside the nuclides of ^{1}H, ^{2}H, ^{3}H, ^{3}He, and α particle. 2) A neutron is formed with two sub-structures, one “u-d” binary and one “d” singlet, and they are also doing the “face-to-face plus face-opposite-face two-level orbital motion”. A proton is also formed with two sub-structures, one “u-d” binary and one “u” singlet, and they are again doing the “face-to-face plus face-opposite-face two-level orbital motion”. The Weak Interaction may be the spin-spin interaction (↑↑ vs. ↓) between the two sub-structures (that made of the three quarks inside a nucleon) with a “face-to-face plus face-opposite-face two-level orbital motion” in the θ-1D uni-direction; the β decay (in a neutron) may be caused by the crash of the two sub-structures after the disruption of this θ-1D uni-directional motion and goes back to the φ-1D bi-directional motion. 3) The “face-to-face plus face-opposite-face two-level orbital motion” may be one of the common dynamic structures in the *N*-body motion under the E/RFe-force, S/RFs-force, and even the G/RFg-force fields. 4) The “face-to-face tidal-locked (spin ↑↑) binary orbital motion” is the root for the “face-opposite-face locked (spin ↑↓) binary orbital motion”, for the “single-face tidal-locked binary orbital motion”, for the “proton-electron mirror-coupled orbit” model, for the parallel spin of the “mother”, the “daughter” and the “newborn” in the “|nL0> Elliptical/Parabolic/Hyperbolic Orbital Transition Model”, and, for the “π-bond” spin-spin interaction model in the arm of a galaxy. Therefore, it is also one of the many nature attributions of the QM. 5) The “Fourier transformation” kind of analysis revealed that the “quasi ^{4}He nucleus” is the building block of the high Z# nucleus. The similar analysis revealed that the {N,n//6} QM (in our universe) naturally includes {N,n//2}, {N,n//3}, {N,n//4} and {N,n//6} modes, so it covers the maximum number of modes (for superposition), and q=6 is still a small integer number that does not damage the quantum character of the {N,n//q} QM. Finally, because of its completeness and self-consistence, I do believe that the {N,n} QM is qualified to be put into the “Feynman Pool” as one of the many co-existing QM theories.

Key Words: Quantum mechanics, {N,n} QM, S/RFs-force. Nuclear force, Weak force, β decay

Introduction

In August 2016, I discovered that the Solar system can be described by a brand new {N,n//6} quantum mechanical structure [1]. Based on that result, (during the 10 years of the closed-door research), I further (independently) 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 a citizen-scientist-leveled work). As part of the {N,n} QM development, I (independently) designed and developed a brand new {N,n} QM field theory [23] ~ [24], [26] ~ [33]. 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 form of a 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 a motion electron, see SunQM-6s2's Fig-2), the spherical 3D wave packet description (with each shell's diameter equivalent to about one wavelength of the matter wave), the dis-entanglement of the outmost shell of the 3D wave packet (i.e., the "general decaying" process, see SunQM-6s1, -6s2, -6s3), the "|nL0> elliptical/parabolic/hyperbolic orbital transition model" (see SunQM-6s2, -6s3), the seamless transformation between a quantum process and a continues process through moving the r_1 inward (see SunQM-5s2), 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, SunQM-6s1, etc.). So, the {N,n} QM is constituted with two parts: the Bohr-orbit-QM part (with {N,n} structure added), and the Schrodinger-equation-QM part (with RF, and {N,n} QM field theory added). In the current paper, I presented some detailed developments on the S/RFs-force and its spin-spin interaction in the new {N,n} QM field theory. (Note: I am neither a particle physicist, nor a nuclear physicist. I am a {N,n} QM scientist. All I did here is to develop a {N,n} QM field theory to describe the S/RFs-force and interactions, and the whole designing is based on the current text book knowledge that a nucleon is made of three quarks [34]. All these re-descriptions may belong to a citizen-scientist-leveled work).

Note: QM means Quantum Mechanics, RF means "RotaFusion", or rotation diffusion. For {N,n} QM nomenclature as well as the general notes, please see SunQM-1's sections VII & VIII. Note: The best reading sequence for the (34 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, 6s6, 6s7, 6s8, 6s9, and 6s10. 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: 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: |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 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. An idealized single point-centered S/RFs-force field (from a single quark, and that fits to the single point-centered E/RFe-force and the G/RFg-force fields)

First, with the more and more new knowledge that have been developed, let's re-describe the E/RFe, the G/RFg, and the S/RFs-forces in the {N,n} QM in a more accurate way. In SunQM-6, I re-named the electromagnetic force as the **E/RFe-force**, with the electric force (**E-force**) is the primary force that initially only exert in r-1D space (in nL0 mode, when a charge is in static), and the **RFe-force** is the orthogonal companion force of the E-force and initially only exert in θφ-2D space (in the complete RF of nLL mode, when it is in static). Then, the magnetic force is either the (partially de-RF) nLL mode of RFe-force (when a charge is in translation, and here we named it as the "**circular RFe-force**"), or the "**inversed RFe-force**" (in quasi nL0 mode, when the charge is in spinning, so that it produced a new force component in r-1D (together with some left-over residue force in θφ-2D), here we named it as the "**quasi-r-1D**"). (Note: Sorry, due to my poor English, I might have miss used word "quasi" vs. "pseudo" time-upon-time in the SunQM papers). Similarly, the gravitational force and the "Dark matter" was paired and re-named as the **G/RFg-force**, with the **G-force** is the primary force that initially only exert in r-1D space (in nL0 mode, when it is in static), and the **RFg-force** is the orthogonal companion force of the G-force and initially only exert in θφ-2D space (in the complete RF of nLL mode, when it is in static), and the Dark matter is either the (partially de-RF) nLL mode of RFg-force (when an object is in translation, i.e., the "**circular RFg-force**"), or the "**inversed RFg-force**" in quasi nL0 mode (that exert in the quasi-r-1D space, when an object is in spinning). Similarly, the Strong-force and the Weak-force was paired and re-named as the **S/RFs-force**, with the **S-force** is the primary force that initially only exert in r-1D space (in nL0 mode, when it is in static), and the **RFs-force** is the orthogonal companion force of the S-force and initially only exert in θφ-2D space (in the complete RF of nLL mode, when it is in static), and the Weak-force is either the (partially de-RF) nLL mode of RFs-force (when a quark is in translation, i.e., the "**circular RFs-force**"), or the "**inversed RFs-force**" in quasi nL0 mode (that exert in the quasi-r-1D space, when a quark is in spinning). (Also see Appendix A for the discussion of the bound state).

Note: For the simplicity, many times we simply call the magnetic force as the "RFe-force", although it really is either a "circular RFg-force", or a "inversed RFe-force". Also for the Weak-force, we simply called it as "RFs-force", although it really is either a "circular RFs-force", or a "inversed RFs-force". Also for the "Dark matter force", we simply called it as "RFg-force", although it really is either a "circular RFg-force", or a "inversed RFg-force". (Note: Due to my poor English, here both the "inversed $\vec{\mathbf{E}}$ vector" and the "reversed $\vec{\mathbf{E}}$ vector" means the same thing). Thus, in the {N,n} QM field theory, an idealized single point-centered S/RFs-force may should be described in the same way as that for a single point-centered E/RFe-force (in SunQM-6s8's section III-b):

1) Like that of E/RFe-force field, the idealized S/RFs-force field (from a single quark in a rθφ-3D space) may can also be described by the Schrodinger equation/solution, i.e., the QM state of |n,*l*,m>, in the form of either the **Born probability (BP)** 3D density map, or the **non-Born probability (NBP)** 3D density map.

2) Again, in {N,n} QM field theory, it is impractical to use the combination of multiple n(s) of |n,*l*,m> QM states (see SunQM-6's Table 2 and eq-1) to describe the QM mode of S-force (also named as "**$\vec{\mathbf{S}}$ vector**", notice that it is the up-case S, not the low-case s, the low-case s vector is for the spin vector direction) and RFs-force (also names as "**$\overrightarrow{\mathbf{RFs}}$ vector**"). So now we use only a single n of QM state to describe the QM mode of $\vec{\mathbf{S}}$ vector (i.e., S-force) and $\overrightarrow{\mathbf{RFs}}$ vector (i.e., RFs-force). As usual, for the $\vec{\mathbf{S}}$ vector's and $\overrightarrow{\mathbf{RFs}}$ vector's translational speed, the spin-speed, or the RFs-RFs interaction intensity, we use the low n to describe the ground state (means the zero speed, or the minimum intensity), and use the high n to describe the excited state (means the high speed, or the high intensity, like that shown in SunQM-6s8's Fig-2).

3) Again, even for a single n of |n,*l*,m>, it still contains many superpositioned QM states (because for each n that greater than 2, *l* = 0…n-1, m = -*l*, … +*l*). For the simplest and the most characteristic description (i.e., the Eigen description), we would like to use the two ends of the series QM states for the description, that is, the **nLL mode**, and the **nL0 mode**. For the simplicity, I quite often use n=2, that is, the nL0 mode |2,1,0> and the nLL mode |2,1,±1> for the description.

4) Again, like that shown in SunQM-6s8's section I-a, for a (self) spinning S/RFs-force field, the vector decomposition of $\vec{\mathbf{S}} = \overrightarrow{\mathbf{S}_r} + \overrightarrow{\mathbf{S}_\varphi}$ also gives $\overrightarrow{\mathbf{S}_r}$ correlating to nL0 mode, and $\overrightarrow{\mathbf{S}_\varphi}$ correlating to nLL mode.

5) Again, although a single quark's spinning motion should be described with nLL QM mode, its spin vector $\vec{\mathbf{s}}$ should be described with nL0 mode (e.g., |2,1,0> state). In BP density, we can use the un-covered top-half-part of the |2,1,0> state to represent the spin ↑ (like in SunQM-6s5's Fig-1j), and use the un-covered bottom-half-part to represent the spin ↓ (like in SunQM-6s5's Fig-1q). In NBP density, we can directly use the top-positive wave function of |Y(1,0)|^2 to represent the spin ↑ (like in SunQM-6s5's Fig-1m), and use the bottom-positive wave function of |Y(1,0)|^2 to represent the spin ↓ (like in SunQM-6s5's Fig-1t).

6) Following figures (that used to describe the character and behavior of E/RFe-force) are also can be used to describe the character and behavior of a (single point-centered) S/RFs-force: SunQM-6s8's Fig-2, Fig-3, Fig-6, and SunQM-6's Fig-1, Fig-3, Fig-4, Fig-5, Fig-7, and Fig-8.

According to the text books knowledge, a single quark is impossible to be isolated, so that a single point-centered S-force field is impossible to be obtained. Therefore, the description in this section is impossible to be confirmed. Also, the S-force strength in r-1D may have deviated from the relationship of $\propto \frac{1}{r^2}$, and the potential strength in r-1D may have deviated from the relationship of $\propto \frac{1}{r}$. (Note: I believed that the degeneration of 3D space to a spherical 2D space is needed to explain the "color force" and the "color confinement", see SunQM-7s1's section I-g. I also guessed that the color force (i.e., the S-force that degenerated into to spherical 2D space) may can be described by Schrodinger equation/solution in spherical 2D space).

(Note: For the S/RFs-force formed three quarks' dynamic structure (inside a proton/neutron), it was moved backward to the section V, because it needs to use the result in sections II, III, and IV).

II. Using nuclear force (the residue S/RFs-force) to construct the dynamic structure of the four nucleons inside a ^{4}He nucleus

(Note: following descriptions are cited as "description-1" through "description-15").

1) According to the text book knowledge, and according to the SunQM-7's Table-1, inside a ^{4}He nucleus (with the size of {-15,2//6}), there are four nucleons (each with the size of {-15,1//6}). All these four nucleons are doing the orbital motion within the {-15,1//6}o orbital shell space. The nuclear force (that forms the ^{4}He nucleus) is from each of four nucleons' "**residue-S-force**".

2) In SunQM-6s6, I proposed the "proton-electron mirror-coupled orbit" model. In SunQM-6s7, I proposed that the "face-to-face tidal-locked binary orbital motion" may be the origin of the electron spin and proton spin. Based on these two models, (after many tries), I guessed that two of the four nucleons (inside a ^{4}He nucleus) formed a (face-to-face tidal-locked orbital moving) binary. Because of the face-to-face tidal-locked orbital motion, both two nucleons (in the same binary) must have the same spin direction ⇑ (for the residue S/RFs-force), or a combined spin of ⇑⇑ for each (nucleon-nucleon) binary. Similarly, I guessed that rest two of the four nucleons (inside the same ^{4}He nucleus) also formed another one (face-to-face tidal-locked orbital moving) binary with the spin of ⇑⇑. The formation of the ⇑⇑ (rather than ⇑⇓) spin configuration (within one nucleon-nucleon binary) comes from the orthogonal companion force of the residue S-force, named here as the **residue RFs-force**, (or, more accurately, the "**residue (inversed) RFs-force**").

3) More explanations for a (face-to-face tidal-locked orbital moving) nucleon binary's spin:
3a) ⇑ represents a nucleon's spin that is caused by S/RFs-force field, ↑ represents a proton's spin that is cause by E/RFe-force field, so that a proton's spin should be ⇑↑ while a neutron's spin is only ⇑;
3b) According to the Pauli exclusion principle, the two protons inside a ^{4}He nucleus should have the anti-parallel ↑↓ spin direction (in the case that if the residue S/RFs-force does not overcome the E/RFe-force);
3c) In the averaged distance between two nucleons, the residue S/RFs-force, if has not been consumed (meaning it has been used to pair with another nucleon, see description-5), is always stronger than the E/RFe-force.

4) Then, for each (nucleon-nucleon) binary, we need to determine whether it is paired with (the homo-sexual) neutron-neutron, or (the hetero-sexual) neutron-proton. There are two possibilities here:
4a) Possibility-1: The binary is always neutron-proton paired with the spin of either ⇑⇑↑ or ⇓⇓↓. It satisfied all above conditions;

4b) Possibility-2: One binary is proton-proton paired with the spin of either ⇑↑⇑↑ or ⇑↑⇓↓. For ⇑↑⇑↑, the ↑↑ violates the Pauli exclusion principle (for E/Rfe-force); and for ⇑↑⇓↓, the ⇑⇓ violates that the S/RFs-force is stronger than the E/RFe-force. So this possibility is unfavored and discarded.

5) The most possible result is: in a ^{4}He nucleus, the four nucleons always form two binaries, each binary is always neutron-proton paired, with the spin of ⇑⇑↑. These two binaries further form the relative anti-parallel spin ⇑⇑↑⇓⇓↓ configuration (as shown in Figure 1a). (Note: Then, why not form ⇑⇑↑⇑⇑↑ spin configuration for the two binaries in ^{4}He nucleus? The advantage of ⇑⇑↑⇑⇑↑ is that all four nucleons S/RFs-force spins are in parallel ⇑⇑⇑⇑, so that they are in the S/RFs-force spin energy favored minimum state. However, the ↑↑ makes these two protons in ^{4}He nucleus to be E/RFg-force spin energy unfavored maximum state. As I have pointed out in SunQM-6s7's section VII-d, "*although the RFs-RFs interaction is stronger than the RFe-RFe interaction, the RFs-RFs interaction is already consumed by the two nucleons (within one neutron-proton pair)'s* ⇑⇑ *spin-spin interaction, so the leftover RFs-force (we named it as the* "**consumed residue RFs-force**"*) of the neutron-proton-pair-1 that can be used to interact with the "consumed RFs-force" of the neutron-proton-pair-2 become weak, and it is guessed even weaker than the RFe-RFe interaction force between the two pairs of neutron-proton (because that the RFe-force of each pair of neutron-proton has not been consumed). In this case, the RFe-RFe interaction force overcome the residue RFs-force, and caused* (⇑⇑↑)(⇓⇓↓) *spin configuration for the four nucleons inside an alpha particle*". This is the first reason for the ⇑⇑↑⇓⇓↓ configuration. The second reason is that this configuration perfectly fits to the ^{4}He atom's two electrons spin configuration (see description-9)).

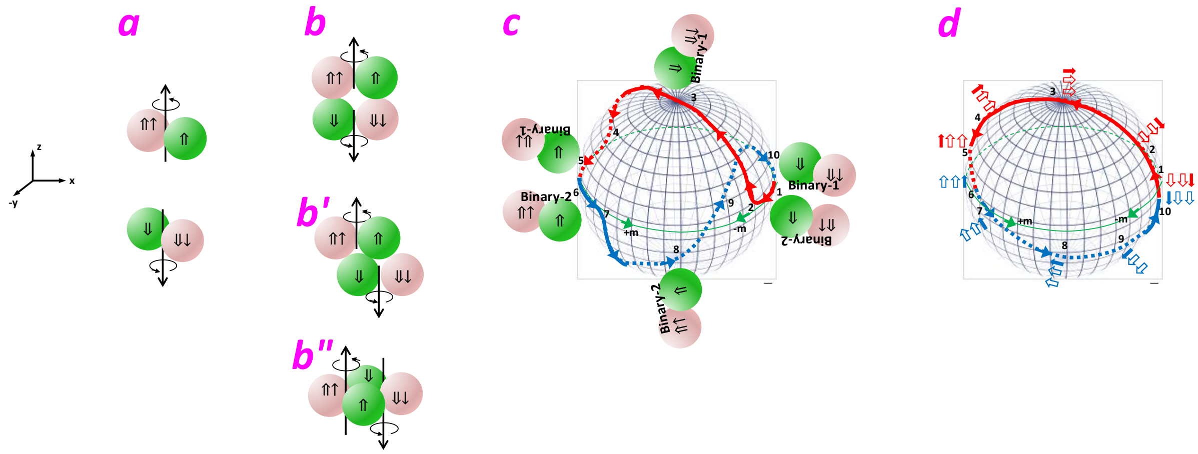

Figure 1a. Illustration of a neutron-proton binary with spin either ⇑⇑↑ or ⇓⇓↓. The pink ball represents the proton, the green ball represents the neutron.
Figure 1b. Illustration of a two neutron-proton binary structure inside a ^{4}He nucleus with ⇑⇑↑⇓⇓↓ spin configuration. (Figure 1b' and 1b" are the alternative possibilities).
Figure 1c. Illustration of two of the neutron-proton binaries (with spin either ⇑⇑↑ or ⇓⇓↓) that are doing the "face-opposite-face locked binary orbital motion" in bi-direction inside a ^{4}He nucleus.
Figure 1d. Illustration of two of the neutron-proton binaries (with spin either ⇑⇑↑ or ⇓⇓↓) that are doing the "face-opposite-face locked binary orbital motion" in bi-direction that eventually transformed into a θ-1D uni-directional orbital motion inside a ^{4}He nucleus.

6) Then, how these two neutron-proton binaries move inside the ^{4}He nucleus? First, I assumed that these two binary entities are doing circular (or near circular) orbital motion around their (four nucleons) reduced mass center inside the ^{4}He nucleus i.e., (within the size of {-15,2//6}, in the xy 2D-plane, as shown in Figure 1c). According to the Schrodinger equation's solution (i.e., the NBP, or the Y(l,m) function, e.g., by comparing Y(l=1,m=1) = $-\sqrt{\frac{3}{8\pi}}e^{im\varphi}\sin\theta$, with, Y($l$=1,$m$=-1) =

$\sqrt{\frac{3}{8\pi}}e^{-im\varphi}\sin\theta$), I guessed that these two anti-parallel spinning binaries should be doing orbital rotation in opposite directions, (meaning, one in +m direction, one in -m direction, both in φ-1D, see the section III for more detailed explanation). In Figure 1c, I assumed that the first binary with spin ⇓⇓↓ (named as **binary-1**) is moving in -m (or -φ in a rθφ-3D coordinate space, or from +x axis to -y axis in a xyz-3D coordinate space) direction, and the second binary with spin ⇑⇑↑ (named as **binary-2**) is moving in +m (or +φ) direction.

7) In Figure 1c, the blue line represents the orbital rotation trajectory of the binary-2 that moving in +m direction (from -x axis to -y axis, or from position-6 to position-7), and the red line represents the orbital rotation trajectory of the binary-1 that moving in -m direction (from +x axis to -y axis, or from position-1 to position-2). If they are continues moving like this (along the equator of the {-15,2//6} sized shell), they will collide at the -y axis position. However, the E/RFe repulsive force of these two binaries (from the two protons) will not only prevent this collide, but also will keep the farthest distance in between these two binaries. Then one of these two binaries has to go through the north pole (let's assuming it is the red binary-1, from the position-1, to 2, 3, 4, 5), and the second one has to go through the south pole (let's assuming it is the blue binary-2, from position-6 to 7, 8, 9, 10). This is the explanation for Figure 1c, and it is also named as the "**face-opposite-face locked binary orbital motion**".

8) Because the E/RFe repulsive force (between the two protons in the two binaries) is so strong, the distance (between the two binaries) smaller than the half circumference is not allowed at any time during the orbital rotation, so that the movement (of the binary-1 from position-1 to position-2 in -m direction in φ-1D, and the movement of the binary-2 from position-6 to position-7 in -m direction in φ-1D) in Figure 1c is not allowed (because the resulted distance between position-2 to position-7 is smaller than the half circumference). So, even at the beginning, the two binaries' ±m φ-1D orbital movement (along the equator) has to be along longitude line (in θ-1D), as shown in Figure 1d. Thus, an original φ-1D bi-directional orbital rotation is now transformed into a θ-1D uni-directional orbital rotation. After carefully tracing (see in Figure 1d), we will find that both binary spin vectors (one is downward at the initial position-1, and one is upward at the initial position-6) will have to keep overlapping with the longitude line of the {-15,1//6}o orbital sphere and pointing in the opposite direction (of the circular tangential) at all time during the orbital movement. This is perfect to keep spin ⇑⇑↑⇓⇓↓ anti-parallel for these two binaries at all time. And it is also perfect to keep a half circumference distance between these two binaries at all time during the orbital movement. Finally, a pure φ-1D orbital bi-directional rotation (in ±m opposite directions) for a pair of spin ⇑⇑↑⇓⇓↓ anti-parallel binaries (with the spin vectors perpendicular to the orbital moving direction), under the repulsion (in θφ-2D), it is transformed into a pure θ-1D orbital uni-directional rotation (with the both spin vectors lying within the orbital moving direction).

9) Notice that Figure 1c (for the two of anti-parallel spinning neutron-proton binaries in a ^{4}He nucleus within the {-15,1//6}o orbital shell space) is very similar as that in SunQM-6s7's Fig-5b (for the two anti-parallel spinning electrons in a ^{4}He atom within the {-12,1//6}o orbital shell space). After pairing the nucleon binary-1 (in Figure 1d) to the electron-1 (in SunQM-6s7's Fig-5c), we can find that the proton (in binary-1) may be doing the face-to-face tidal-locked binary orbital motion with the electron-1, (notice that when proton-electron is doing the face-to-face tidal-locked binary orbital motion, they have the parallel physical spin ↑↑, but in the anti-parallel electric spin ↑↓ due the their opposite charge). It also fits to the pairing of the nucleon binary-2 (in Figure 1d) to the electron-2 (in SunQM-6s7's Fig-5c). Therefore, in this description,

9a) Following pairs are all match to the Pauli principle of E/RFe-force ↑↓ pairing: Proton-1 pairs to electron-1 with electric ↑↓, proton-2 pairs to electron-2 with electric ↑↓, electron-1 pairs with electron-2 with ↑↓, proton-1 pairs to proton-2 with ↑↓;

9b) Following pairs are all doing the face-to-face tidal-locked binary orbital motion: Neutron-proton pair in binary-1, neutron-proton pair in binary-2, proton-1 and electron-1 pair, proton-2 and electron-2 pair, (or may be the electron is doing the "single-face tidal-locked" motion relative to nucleus, see section III);

9c) Following pairs are all doing the face-opposite-face locked binary orbital motion: electron-1 vs. electron-2, (neutron-proton) binary-1 vs. (neutron-proton) binary-2;

9d) Following pairs fit to the "proton-electron mirror-paired orbit" model: Proton-1 and electron-1 pair, proton-2 and electron-2 pair.

10) Then, what is the most possible geometry shape that these four nucleons will form in a ^{4}He nucleus? For the four nucleons to form a smallest total volume (of ^{4}He nucleus), the initial guess is either tetrahedron shape, or diamond/square shape. Because the residue S/RFs-force has been consumed by the two nucleons within each neutron-proton binary, the consumed residue S/RFs-force between the two binaries is assumed to be weaker than the E/RFe-force between the two binaries (or between the two protons), thus, the E/RFe repulsive force must make these two protons to stay as far as possible from each other. Therefore, a diamond/square shape with the two protons sits at the two far ends (as illustrated in either Figure 1b, or Figure 1b', or Figure 1b") is the most possible geometric shape for the four nucleons in a ^{4}He nucleus. I guessed that Figure 1b conformation maybe is better for the θ-1D uni-directional orbital rotation (see in Figure 1d), and Figure 1b" conformation maybe is better for the φ-1D bi-directional orbital rotation (see in Figure 1c). Then, Figure 1b (or Figure 1b', or Figure 1b") is further doing rotation along -y axis (for the θ-1D uni-directional orbital rotation).

11) Finally, with all above descriptions, now I developed a {N,n} QM description for the ground state ^{4}He nucleus (under the nuclear force (i.e., the residue S/RFs-force) and E/RFe-force): it contains two of neutron-proton binaries, within each binary, neutron-proton is doing the face-to-face tidal-locked binary orbital motion around its (two nucleons) reduced mass center with spin ⇈↑, and two binaries further formed an anti-parallel spin ⇈↑⇊↓ configuration, and doing the "face-opposite-face locked binary orbital motion" (in bi-direction, around its four nucleons' reduced mass center) that eventually transformed into a θ-1D uni-directional orbital motion (with the spin direction oppositely lined-up to the orbital direction, see Figure 1d, also see section III).

12) The above descriptions (that for a ^{4}He nucleus) should also be suitable for an α particle.

13) Before working on this paper, I glanced some online information (see below) without much understanding. After I finished above analysis, I found that my {N,n} QM based result matched to those online information quite well:
13a) Wiki "Nuclear force" said, "*If two particles are the same, such as two neutrons or two protons, the force is not enough to bind the particles, since the spin vectors of two particles of the same type must point in opposite directions when the particles are near each other and are (save for spin) in the same quantum state. ... For fermion particles of different types, such as a proton and neutron, particles may be close to each other and have aligned spins without violating the Pauli exclusion principle, and the nuclear force may bind them (in this case, into a deuteron), since the nuclear force is much stronger for spin-aligned particles …*".
13b) Wiki "Nuclear magnetic resonance" showed that deuterium ^{2}H has the nuclear spin =1, tritium ^{3}H has total nuclear spin = 1/2, so does ^{1}H nucleus (the proton).
13c) Wiki "Helium-3", "*helium-4 has an overall spin of zero, making it a boson, but with one fewer neutron, helium-3 has an overall spin of one half, making it a fermion*".

14) Based on the dynamic structure of the four nucleons in the ^{4}He (in Figure 1), I further constructed the dynamic structure of the nucleons in the nuclides of ^{1}H, ^{2}H, ^{3}H, and ^{3}He.
14a) For a hydrogen ^{1}H, the single proton's spin is truly in φ-1D uni-direction, it is face-to-face tidal-locked to the electron's orbital motion and spin, the spin vector is perpendicular to the φ-1D motion, see SunQM-6s7's Fig-5a. The nuclear spin is ⇑↑ =1/2.
14b) For a deuterium ^{2}H, its neutron-proton pair is doing the pure "face-to-face tidal-locked orbital binary motion" in φ-1D uni-direction (without the θ-1D motion). The total nuclear spin is ⇈↑ = ½ + ½ = 1, and the spin vector is perpendicular to the φ-1D motion. Because both neutron and proton have the size of {-15,1//6} = {-16,6//6}, and their mass ratio is 1:1, I assumed that both neutron and proton are doing the orbital motion around their reduced mass center in the ^{2}H nucleus's {-16,7//6}o orbital shell, and thus **the neutron-proton binary may form an effective size at around {-16,8//6}**. Notice that this size is significantly smaller than a ^{4}He nucleus's size {-15,2//6} = {-16,12//6}. In the atom, this neutron-proton nucleus and the atomic electron may be further doing the "face-to-face tidal-locked orbital binary motion", (or maybe the electron is doing "single-face tidal-locked" motion relative to the nucleus, see section III), in φ-1D uni-direction (in the very different orbital shells, one in the {-16,7//6}o orbital shell, and one in the {-12,1//6}o orbital shell, see SunQM-7's Table-1).

14c) The nucleus of a triduum ^{3}H (with the total nuclear spin = ½) is composed with two sub-structures: a neutron-proton binary (that is doing "face-to-face tidal-locked orbital binary motion" around the two nucleons' reduced mass center, with nuclear spin ⇑⇑↑ =1), plus a neutron singlet (with nuclear spin ⇓ = - ½). These two sub-structures are further doing the "face-opposite-face locked binary orbital motion" in φ-1D bi-direction with the anti-parallel nuclear spin ⇑⇑↑⇓ that eventually transformed to be a θ-1D orbital uni-directional motion (around the three nucleons' reduced mass center), with the final nuclear spin vector pointing to the θ-1D motion direction. Because the mass ratio between the two sub-structures (a neutron-proton binary vs. a singlet neutron) is 2 : 1, then I assumed that inside a ^{3}H nucleus (that has a size of {-15,2//6} = {-16,12//6}), the singlet neutron sub-structure (that has a size of {-15,1//6} = {-16,6//6}) is doing the orbital motion in the ^{3}H nucleus's {-16,11//6}o orbital shell, and the neutron-proton binary sub-structure (that has a size of {-16,8//6}) is doing the orbital motion in the ^{3}H nucleus's {-16,8//6}o orbital shell (around the three nucleons' reduced mass center), so that they formed a {-16,12//6} = {-15,2//6} sized ^{3}H nucleus. (Note: The estimated n=8 in {-18,8//6}o orbit and n=11 in {-16,11/6}o orbit is based on, at the reduced mass center of two sub-structures, $r_{neu-pro}m_{neu-pro} = r_{neu}m_{neu} \rightarrow r_{neu-pro}/r_{neu} = m_{neu}/m_{neu-pro} = ½$, so that $r_{neu-pro,n=8}/r_{neu,n=11} = (r_1 \times 8^2) / (r_1 \times 11^2) = 64/121 \approx ½$).
14d) The nucleus of a ^{3}He (with the total nuclear spin = ½) is composed with two sub-structures: a neutron-proton binary (that is doing "face-to-face tidal-locked orbital binary motion", with nuclear spin ⇑⇑↑ =1), plus a proton singlet (with nuclear spin ⇓↓ = - ½). And, these two sub-structures are further doing the "face-opposite-face locked binary orbital motion" that eventually transformed to be a θ-1D orbital motion (around the three nucleons' reduced mass center). The final total nuclear spin ⇑⇑↑⇓↓ = ½, with the spin vector is pointing to the θ-1D motion direction. Because the mass ratio between the two sub-structures (a neutron-proton binary vs. a singlet proton) is 2 : 1, then I assumed that inside a ^{3}He nucleus (that has a size of {-15,2//6} = {-16,12//6}, see SunQM-7's Table-1), the singlet proton sub-structure (that has a size of {-15,1//6} = {-16,6//6}) is doing the orbital motion in the ^{3}He nucleus's {-16,11//6}o orbital shell, and the neutron-proton binary sub-structure (that has a size of {-16,8//6}) is doing the orbital motion in the ^{3}He nucleus's {-16,8//6}o orbital shell (around the three nucleons' reduced mass center), so that they formed a {-16,12//6} = {-15,2//6} sized ^{3}He nucleus.
14e) The nucleus of a ^{4}He (with the total nuclear spin = 0) is composed with two same sub-structure: the neutron-proton binary (that is doing "face-to-face tidal-locked orbital binary motion" around the two nucleons' reduced mass center, with nuclear spin ⇑⇑↑ =1 for the first binary, and ⇓⇓↓ = -1 for the second binary). These two same sub-structures are further doing the "face-opposite-face locked binary orbital motion" in φ-1D bi-direction that eventually transformed to be a θ-1D orbital uni-directional motion (around the four nucleons' reduced mass center). The final total nuclear spin ⇑⇑↑⇓⇓↓ = 0. Because the mass ratio between the two sub-structures (a neutron-proton binary vs. a second neutron-proton binary) is 1:1, then I assumed that inside a ^{4}He nucleus (that has a size of {-15,2//6} = {-16,12//6}), both sub-structures (that have sizes of {-16,8//6}) are doing the orbital motion in the ^{4}He nucleus's {-16,11//6}o orbital shell (around the four nucleons' reduced mass center), so that they formed a {-16,12//6} = {-15,2//6} sized ^{4}He nucleus.

15) One new knowledge I learned from the above analysis is: for a binary of nucleon inside a nucleus, only the hetero-sexual binary of neutron-proton is preferred, the homo-sexual binary of either neutron-neutron or proton-proton is unfavored.

III. The "face-to-face tidal-locked (spin ↑↑) binary orbital motion" is the root of the "face-opposite-face locked (spin ↑↓) binary orbital motion", and it is also the root for several other models (that I have proposed before), so it is one of the nature attributions of the QM

In SunQM-6s7's section VII-a, I hypothesized that the "face-to-face tidal-locked" state is the Eigen state (or the global energy minimum state) for a binary's φ-1D orbital motion. In this φ-1D orbital motion, because it is face-to-face tidal-locked, the two objects' spin must be in parallel with each other (↑↑), and the ↑↑ spin direction must be perpendicular to the φ-1D orbital motion direction. It is equivalent to say, in the global energy minimum state, each (φ-1D orbital motion) object's spin direction is in parallel to its orbital-rotation angular momentum vector's direction. Let's name this as the "**parallel rotation-spin principle**", (notice that in {N,n} QM, rotation always means orbital-rotation, and spin always means self-spin).

This means that, it is "the face-to-face tidal-locked state is the global energy minimum state for a binary orbital motion" that produced the "parallel rotation-spin principle". This principle is suitable for G/RFg-force, like the Pluto-Chiron binary orbital motion, the planet Earth and the Australia continent "quasi binary" (if we can treat the spinning planet Earth as the reduced mass entity of a binary, and treat the Australia continent as one of two objects in this binary), etc. This principle is also suitable for E/RFe-force, like a proton-electron binary's φ-1D orbital motion in a H-atom (note: electron's physical spin, not the electric spin).

Surprisingly, when the two objects that are doing φ-1D orbital bi-directional motion (around their reduced mass center) with the anti-parallel spin ↑↓ configuration, the hypothesis that "the face-to-face tidal-locked state is the global energy minimum state" still holds for each object. In other words, for a "face-opposite-face locked orbital binary motion" in the global energy minimum state, each (φ-1D orbital motion) object's spin direction is still in parallel to its orbital-rotation angular momentum vector's direction. In this case, (using the two binaries in a ^{4}He nucleus as the example, as shown in Figure 1c), binary-1 with spin ↓ at position-1 will have to move in the -m direction because it is face-to-face tidal-locked orbital motion (i.e., the orbital rotation's angular momentum direction in parallel to the object's spin direction). Similarly, binary-2 with spin ↑ at position-6 will have to move in +m direction, also because it is face-to-face tidal-locked (i.e., the orbital rotation's angular momentum direction in parallel to the object's spin direction). The same explanation also holds for the SunQM-6s7's Fig-5b for the two $1s^2$ electrons' φ-1D orbital bi-directional motion in a ^{4}He atom (notice that it only works for the object's physical spin, and electron's electric spin is opposite of the physical spin due to its negative charge). (Note: In an alternative explanation, suppose that the reduced mass of the two binaries formed two (virtual) balls superpositioned at the orbital center, with one virtual ball spins in -m, one virtual ball spins +m, and total spin of the two virtual balls is zero. Then one binary (of the two) that doing +m orbital motion is face-to-face tidal-locked to the +m spinning virtual ball (that at the orbital center), and the second binary (of the two) that doing -m orbital motion is face-to-face tidal-locked to the -m spinning virtual ball (that at the orbital center)).

Under the G/RFg-force, the "parallel rotation-spin principle" means that a retrograde moon should have its spin direction in parallel to its orbital-rotation angular momentum direction. For example, in the Saturn-moon system, while all the prograde moons are expected to have spins (say, in ↑) in same direction (as their orbital-rotation angular momentum's direction ↑, also as the spin of Saturn that also in ↑), the only (major) retrograde moon Phoebe is expected to have the spin in opposite direction (i.e., spin in ↓, because its orbital-rotation around the Saturn is retrograde).

During the {N,n} QM development, there are several fundamental questions that had caused my deep thinking for many years. One question is: for a single (steady state) positive charge's E-force field (or the E-force lines), does it have many lines that radiating to all 4π in the spherical 3D simultaneously, or does it have only one line that radiating to a single direction and then the RF motion of this positive charge that makes its E-force line to spread all over 4π in the spherical 3D (as a time averaged effect)? Whatever it is, at least for a H-atom's proton-electron pair, the proton's E-force field may can be explained as that: it has only one E-force line that radiating to a single direction to the electron, and then the (synchronized) RF motion of both proton and electron makes this E-force line to spread all over 4π directions (as a time averaged effect). This thinking led me to propose the hypothesis that the face-to-face tidal-locked state is the global energy minimum state for a binary orbital motion. (Note: however, I still don't know the answer for how a single (steady state) positive charge radiates its E-force line).

A similar question (that I was wondering for many years) is, in the solution of Schrodinger equation (for H-atom), what is the meaning of a simultaneous opposite ±m (or ±φ) directions motion in φ-1D for a matter wave? For example, in the NBP, (i.e., in the Y(l,m) function), by comparing Y(l=1,m=1) = $-\sqrt{\frac{3}{8\pi}}e^{im\varphi}\sin\theta$, with, Y($l$=1,$m$=-1) = $\sqrt{\frac{3}{8\pi}}e^{-im\varphi}\sin\theta$, the matter wave must move simultaneously in both opposite ±m (or ±φ) directions. For matter waves, it is not difficult to understand that a simultaneous ±φ motion means a steady state wave. But, for two physical objects, how to explain the simultaneous ±φ motion as the NBP? With the better understanding of the face-opposite-face locking, now I may can give a better answer. As I mentioned in SunQM-6s7's Fig-2e, in the solution of Schrodinger equation (for H-atom) Re[Y(l'=7,m'=4)] , for a matter wave with a pair of positive/negative peaks in θφ-2D, the positive peak may can be used to represent the spin ↑ object in an (circular) orbital motion binary, and the negative peak may can be used to represent the spin ↓ object in the same (circular) orbital motion binary. Then, the face-opposite-face locked orbital motion told us that if the spin ↑ object (i.e., the positive peak of the matter wave) moves in one direction in a (circular) orbit (for example, in φ-1D, in

+φ direction), then the spin ↓ object (i.e., the negative peak of the matter wave) must move in the opposite direction in the same (circular) orbit (in φ-1D, in -φ direction). Or, in the same SunQM-6s7's Fig-2e, if the spin ↑ object moves in θ-1D in +θ direction, then the spin ↓ object must move in θ-1D in -θ direction. Or, in any circular orbit in θφ-2D space (as shown in SunQM-7's Fig-3a, the red dotted line), if the spin ↑ object moves in one direction, then the spin ↓ object must move in the opposite direction in the same (circular) orbit. In the micro-world, this process (a spin ↑↓ binary orbits in ±m directions, or the face-opposite-face locked orbital bi-directional motion in φ-1D) is transformed to be a pure θ-1D orbital uni-directional rotation (with the both spin vectors lying in the orbital moving direction), but still retains the connotation of the simultaneous ±m orbital bi-directional motion in φ-1D. However, in the macro-world, this simultaneous ±m orbital bi-directional motion in φ-1D process may have to be broken, the object has to choose only one motion, either in +m direction, or in -m direction, and in the global energy minimum state, it must choose the orbital motion direction in parallel with the spin direction, (i.e., it must be in face-to-face tidal-locked). The example of this is: in the Saturn's planet-moon system, all the major moons choose the prograde orbital motion (with spins in parallel to Saturn's spin ↑, so they are in ↑↑↑ spin configuration), and the only (major) retrograde moon Phoebe is expected to have the spin anti-parallel to Saturn's spin ↑ (so it is in ↑↓ spin configuration). (Note: as a citizen scientist, I am not able to find the information (from online) that Phoebe's spin is ↑↓ or ↑↑ to Saturn's spin).

In the global energy minimum state (of a mutual orbiting binary), the rule of "face-to-face tidal locked orbital motion binary" makes each object (of the binary) to have the orbital rotation angular frequency equals to its own spin angular frequency, (see SunQM6s7's eq-27 for the micro-world, and eq-28 for the macro-world). On the other hand, in the macro-world, we find many examples that in a binary (or a "quasi-binary") mutual orbiting motion, only one (minor) object is "**single-face tidal-locked**" to another (major) object (e.g., in the Earth-Moon binary, the Moon is single-face tidal-locked to the Earth, with the period $T_{\text{Moon orbital rotation}} = T_{\text{Moon spin}} = 1$ month (to the Earth), while the Earth is not face-tidal-locked to the Moon, with $T_{\text{Earth-Moon orbital rotation}} = 1$ month, and $T_{\text{Earth spin}} \approx 1$ day (to the Moon); Also for the Sun-Mercury "quasi-binary", right now the Mercury is roughly single-face tidal-locked to the Sun; Also for the Sun-Venus "quasi-binary", the Venus is also roughly single-face tidal-locked to the Sun). So, this must be a "**half global energy minimum state**". Relative to the "face-to-face tidal locked" "global energy minimum state", the "single-face tidal-locked" binary can be treated as the excited QM state. After enough long time (and under some kind of "friction"), the "single-face tidal-locked" "half global energy minimum state" binary should de-excite to the "face-to-face tidal locked" "global energy minimum state" binary. For example, if we could remove all outside force (from the Solar system), then after a long time, the Earth-Moon binary would reach the global energy minimum state, and would have $T_{\text{Moon orbital rotation}} = T_{\text{Moon spin}} = T_{\text{Earth-Moon orbital rotation}} = T_{\text{Earth spin}}$. For a second example, for the Sun-Earth "quasi-binary", the current Earth is not single-face tidal-locked to the Sun at all, so that the Sun-Earth "quasi-binary" mutual orbital motion is not even the "half global energy minimum". After a long enough time (billions of years?), the physics of the global energy minimization for the Sun-Earth "quasi-binary" mutual orbital motion will slow down Earth's spin to $T_{\text{Earth spin}} = 1$ year, so that it will become the "half global energy minimum" binary with single-face tidal-locked to the Sun, (like both the Sun-Venus "quasi-binary", and the Sun-Mercury "quasi-binary" have done today). (Note: In the micro world, as mentioned before, in atoms of ^3H, ^3He, or ^4He, the atomic electron may be also doing the "single-face tidal-locked" binary motion (rather than the true "face-to-face tidal locked orbital motion binary") relative to the nuclear proton inside a "neutron-proton" binary).

Note: For a high Z# atom, the "face-opposite-face locked binary orbital motion" happens not only for the $1s^2$ electron binary, but also for the $2s^2$, $2p^2$, $3s^2$, $3p^2$, $3d_2$, ... electron binaries (that paired with the spin ↑↓) that is doing the orbital rotation (in the same QM state orbit) around a nucleus. Similarly, the "face-opposite-face locked binary orbital motion" happens for all the $1s^{2,}$ $2s^2$, $2p^2$, $3s^2$, $3p^2$, $3d^2$, ... nuclear proton binaries (that paired with the spin ↑↓) that is doing the orbital rotation (in the same QM state orbit) inside a nucleus.

Note: Here is a special case: based on the "proton-electron mirror-paired orbit" model, inside a ^4He atom, a proton-electron binary is doing either the "face-to-face tidal-locked binary orbital motion" (the physical spin ↑↑), or the "single-face locked binary orbital motion". After the K-capture, one 1s electron is merged with one 1s proton to become one neutron, and this neutron is still can be treated as a (closely contacted) proton-electron binary, and they are still doing the face-to-face tidal-locked binary orbital motion. This is like that the planet Earth and the Australia continent can be treated as a (closely contacted) binary that is doing the face-to-face tidal-locked binary orbital motion (around their reduced mass center).

Based on the above analysis, I further hypothesized that in the "|nL0> Elliptical/Parabolic/Hyperbolic Orbital Transition Model", if both the "mother" particle/object and the "daughter" particle/object are in the "global energy minimum" face-to-face tidal-locked binary orbital motion (relative to the center particle/object), then the spun-off "newborn" particle/object must have its spin in parallel with the spins of both "mother" and "daughter". This hypothesis fits to all examples in the SunQM-6s3's Table-2 "*A list of the general "decay" process in both micro- and macro-world*", (including: photon's cosmic red-shift, photon's emission (in H-atom, electron spin-off its outmost shell as a photon), α decay, β decay, γ decay, Triton captured by Neptune and spun-off a G-photon, merge of binary black holes and spin-off many G-photons, black hole and companion star binary that emitting X-ray, astrophysical jet, etc.). For example, when an H-atom spins-off a 656.1 nm photon, this emitted photon (i.e., the "newborn"), the n=3 electron (before transition, i.e., the "mother"), the n=2 electron (after the transition, i.e., the "daughter"), and the nuclear proton (the "center particle"), all of them may have the spins in parallel with each other (see in SunQM-6s5).

For another example, during the formation of a galaxy's arms, as shown in SunQM-6s8's Fig-10, under the "|nL0> Elliptical/Parabolic/Hyperbolic Orbital Transition Model", all of the spun-off "newborns" (such as gas. dust, stars, etc., as the outmost shells of the pre-SMC (SuperMassiveCenter)'s 3D wave packets) have the spins in parallel with each other, so that the parallel spin-spin interaction (that belongs to the "inversed-RFg" to "inversed-RFg" interaction) between the neighboring gas molecules/dusts/stars provided a "π-bond" kind of secondary force to further stabilize the arm structure (as a chain structure), (besides the r-1D G-force (actually is the residue force of the G-force) between the neighboring gas molecules/dusts/stars that provided a "σ-bond" kind of primary force to stabilize the arm structure (as a chain structure)). Note: for a "quasi-binary" between the pre-SMC and each newborn (a gas molecule/a dust/a star), it may or may not exactly in the face-to-face tidal-locked binary orbital motion, but on average, all of each newborn (a gas molecule/a dust/a star) are at least doing the "single-face tidal-locked binary orbital motion" to the pre-SMC, thus they are in a "half global energy minimum" QM state for each of the quasi-binary orbital motion.

From the above analysis, I realized that the "face-to-face tidal-locked binary orbital motion" is the root of several other models (that I have proposed). For example, the "face-to-face tidal-locked binary orbital motion" is the root of the "face-opposite-face locked (spin ↑↓) binary orbital motion"; it is also the root of the "single-face tidal-locked binary orbital motion"; it is also the root of the "proton-electron mirror-coupled orbit" model; it is also the root of the parallel spin of the "mother", the "daughter" and the "newborn" in the "|nL0> Elliptical/Parabolic/Hyperbolic Orbital Transition Model"; and it is also the root of the "π-bond" spin-spin interaction in the arm of a galaxy.

Therefore, I believed that the "face-to-face tidal-locked binary orbital motion" is also one of the many nature attributions of the QM (or even in the classical physics). Similarly, because the RF (RotaFusion, or rotation diffusion) is the root of many other physical process, so I believed that the RF is also one of the many nature attributions of the QM (see SunQM-3s11). Also, because the "general decay" is the root of the cosmic red-shift, so I believed that the cosmic red-shift is also one of the many nature attributions for a propagating photon (see SunQM-6s3). Some of the other known nature attributes of QM are: the particle-wave duality, uncertainty principle, the superposition, Simultaneous-Multi-Eigen-Description (SMED, see SunQM-7), the holographic effect (see SunQM-7), etc.

IV. The "face-to-face plus face-opposite-face two-level orbital motion" may be one of the common dynamic structures in the *N*-body motion under the E/RFe-force, G/RFg-force, and S/RFs-force fields

Besides both the "face-to-face tidal-locked (spin ↑↑) binary orbital motion" and "face-opposite-face locked (spin ↑↓) binary orbital motion" are the two standard dynamic structures in the QM (or even in the classical physics), the combination of "face-opposite-face locked (spin ↑↓) binary orbital motion" on top of "face-to-face tidal-locked (spin ↑↑) binary orbital motion" may also be one of the standard dynamic structures for the multiple-body (or *N*-body, with $N \geq 3$) motion in QM (or even in the classical physics). Here I name it as the "**face-to-face plus face-opposite-face two-level orbital motion**" model. Although we hypothesized that this is the common case in the micro-world, (e.g., the four nucleons inside a ^{4}He, the three nucleons inside a ^{3}H or ^{3}He, and also the three quarks inside a proton/neutron (see section V), etc.), it is impossible to be viewed directly by our eye. If this hypothesis is correct, then we should see this kind of dynamic structure with our eye in the macro-world. In the macro-world, so far we only see the "face-to-face tidal-locked (spin ↑↑) binary orbital motion" as shown in the Pluto-Chiron binary. I predict that we should be able to find the 3-body (or *N*-body) orbital motion in the "face-to-face plus face-opposite-face two-level orbital motion" model in the macro-world (like that three nucleons inside a ^{3}He, but with three celestial fragments, or three stars, or three galaxies, or even three galaxy clusters, etc.). So now we need astronomists to find it. (Note: in {N,n} QM, the "|nL0> Elliptical/Parabolic/Hyperbolic Orbital Transition Model" is the primary model for the binary motion in both micro-world and macro-world).

V. Using S/RFs-force to construct the dynamic structure of the three quarks inside a nucleon (based on the "face-to-face plus face-opposite-face two-level orbital motion" model)

After many tries and struggles, I found that in the {N,n//q} QM, it is best to use the nuclear dynamic models of either ^{3}He or ^{3}H to build the three quarks' dynamic model for a neutron/proton. In this case, a "proton" inside a nucleus is equivalent to a "up-quark" inside a nucleon, and a "neutron" inside a nucleus is equivalent to a "down-quark" inside a nucleon. (Note: up-quark is abbreviated as "**u-quark**" or even as "**u**", and down-quark is abbreviated as "**d-quark**" or even as "**d**"). Inherited from the previous knowledge (that for a binary of two nucleons inside a nucleus, only the hetero-sexual binary of neutron-proton is preferred, the homo-sexual binary of either neutron-neutron or proton-proton is unfavored), let's assume that for a binary of two quarks inside a nucleon, only the hetero-sexual binary of "u-d" is preferred, the homo-sexual binary of either "u-u" or "d-d" is unfavored. According to the {N,n//6} QM structure table (SunQM-7's table-1), a u-quark has a size of {-17,2//6}, a d-quark has a size of {-17,3//6}, a nucleon has a size of {-15,1//6} = {-16,6//6}. The mass ratio of u-quark to d-quark is 1:4. Based on these information, I assumed that under the S/RFs-force, a u-quark and a d-quark usually forms a "u-d" binary that is doing the "face-to-face tidal-locked binary orbital motion" around their reduced mass center to form a {-16,1//6} = {-17,6//6} sized sub-structure, with the {-17,3//6} sized d-quark is doing the orbital motion in the {-17,3//6}o orbital shell (around the reduced mass center of the "u-d" binary), and the {-17,2//6} sized u-quark is doing the orbital motion in the {-17,5//6}o orbital shell (around the same reduced mass center of the "u-d" binary). (Note: The estimated n=3 in {-17,3//6}o orbit and n=5 in {-17,5/6}o orbit was calculated as, at the reduced mass center of "u-d" binary, $r_{u-d}m_{u-d} = r_d m_d \rightarrow r_{u-d}/r_d = m_d/m_{u-d} = 1/4$, so that $r_{u-d,n=3}/r_{d,n=5} = (r_1 \times 3^2) / (r_1 \times 5^2) = 9/25 \approx 1{:}3 \approx ¼$). In this way, inside a nucleon (either neutron or proton) that has a size of {-15,1//6} = {-16,6//6}, **a "u-d" binary formed a {-16,1//6} sized sub-structure**. According to the text book, quarks have many strange physical properties (that beyond my knowledge). In this model construction, I used only one property: "*All quarks have spin ½*" [35]. Because of the face-to-face tidal-locked, the S/RFs-force formed "u-d" binary must have the parallel spin with the total quark spin ↑↑ = ½ + ½ = 1.

Based on the above result, I hypothesized that the dynamic structure of the three quarks (inside a nucleon) also follows the "face-to-face plus face-opposite-face two-level orbital motion" model.

For a neutron, under the S/RFs-force, the three quarks (udd) are divided into two sub-structures: a "u-d binary" sub-structure (that is doing the "face-to-face tidal-locked binary orbital motion" (around the reduced mass center of the two quarks "u-d"), with the size of {-16,1//6}), and a "d" singlet sub-structure (with the size of {-17,3//6}). Because the final spin of a neutron is ½, then the "u-d" binary with spin ↑↑ =1 has to anti-parallel to the "d" singlet's spin ↓. With this information, I assumed that under the S/RFs-force, the "u-d" sub-structure and the "d" sub-structure are further formed a binary that is doing the "face-opposite-face locked (↑↑)(↓) binary orbital motion" around their reduced mass center, initially in φ-1D bi-direction, and then transformed to be θ-1D uni-direction (around the reduced mass center of the three quarks "udd"). Because the mass ratio of these two sub-structures is, "u-d" : "d" = 5 : 4, we can treat it as roughly 1:1. Then, I assumed that both "u-d" sub-structure (with the size of {-16,1//6}) and "d" sub-structure (with the size of {-17,3//6}) are doing the orbital rotation around their reduced mass center in the same {-16,5//6}o orbital shell. In this way, we constructed a neutron (with the size of {-16,6//6} = {-15,1//6}) by using the two sub-structures "u-d" and "d" (that are doing the orbital rotation inside the neutron's {-16,5//6}o orbital shell around their reduced mass center, and under the S/RFs-force).

For a proton, under the S/RFs-force, the three quarks (udu) are also divided into two sub-structures: a u-d binary sub-structure (that is doing the "face-to-face tidal-locked binary orbital motion" (around the reduced mass center of the two quarks "u-d")), with the size of {-16,1//6}), and a "u" singlet sub-structure (with the size of {-17,2//6}). Because the final spin of a neutron is ½, then the "u-d" binary with spin ↑↑ =1 has to anti-parallel to the "u" singlet's spin ↓. With this information, I assumed that under the S/RFs-force, the "u-d" sub-structure and the "u" sub-structure are further formed a binary that is doing the "face-opposite-face locked (↑↑)(↓) binary orbital motion" around their reduced mass center, also initially in φ-1D bi-direction, and then transformed to be θ-1D uni-direction (around the reduced mass center of the three quarks "udu"). Because the mass ratio of these two sub-structures is, "u-d" : "u" = 5 : 1, then I assumed that only the "u" sub-structure (with the size of {-17,2//6}) is doing the orbital rotation around their reduced mass center in the {-16,5//6}o orbital shell, while the "u-d" sub-structure (with the size of {-16,1//6}) is doing the orbital rotation in (roughly) the {-16,2//6}o orbital shell. (Note: The estimated n=5 in {-16,5//6}o orbit and n=2 in {-16,2/6}o orbit was calculated as, at the reduced mass center of two sub-structures, $r_{u-d}m_{u-d} = r_u m_u \rightarrow r_{u-d}/r_u = m_u/m_{u-d} = 1/5$, so that $r_{u-d,n=2}/r_{d,n=5} = (r_1 \times 2^2) / (r_1 \times 5^2) = 4/25 \approx 1{:}6 \approx 1/5$). In this way, we constructed a proton (with the size of {-16,6//6} = {-15,1//6}) by using the two sub-structures "u-d" and "u" (that "u" is doing the orbital rotation inside the proton's {-16,5//6}o orbital shell, and "u-d" is doing the orbital rotation in the proton's {-16,2//6}o orbital shell, both around their reduced mass center, and under the S/RFs-force).

In a neutron, first, within a single u-d binary, under the S/RFs-force field, the u-quark and the d-quark not only use the S-force to interact directly with each other to form the "σ-bond" kind of binding, but also use the (inversed) RFs-force to interact with each other to form the "π-bond" kind of binding (as the parallel spin-spin interaction). Second, between the "u-d" sub-structure and the "d" sub-structure, the "u-d" and the "d" not only use the S-force to interact directly with each other to form the "σ-bond" kind of binding, but also use the (inversed) RFs-force force to interact with each other to form the "π-bond" (or the "anti-π-bond"?) kind of binding (as the anti-parallel spin-spin interaction). This is also true for the proton.

According to the text book knowledge, the nuclear force is the residue force of the strong-force that leaked out to the outside of a nucleon (see wiki "Nuclear force", section of "*The nuclear force as a residual of the strong force*"). To fit to this knowledge, for a neutron, maybe it is the wobbling of the two sub-structures in the orbital rotation (produced by the uneven mass ratio 5:4, although both in {-16,5//6}o orbit) that caused the strong-force to leak out (to the outside of the neutron). Similarly, for a proton, maybe it is the wobbling of the two sub-structures in the orbital rotation (one at {-16,5//6}o, one at {-16,2//6}o orbit) that caused the strong-force to leak out (to the outside of the proton). If this guess is correct, then, because it may wobble more and leak out more, a proton may have stronger nuclear force than that of a neutron. If this guess is correct, then a tetraquark particle with "u-d" "u-d" and (↑↑)(↓↓) spin (see wiki "tetraquark", and see SunQM-7's Table-1 at the {-16,6//6}o orbit. Note: Although {-16,6//6} = {-15,1//6}, {-16,6//6}o ≠ {-15,1//6}o, because {-15,1//6}o = {-16,n=6..11//6}o, also see Appendix B) may have zero nuclear force (because it may have zero wobble and zero leak), and thus, it can't be used as a nucleon component for an atomic nucleus.

VI. The possible origin of the weak force and the β decay (in view of {N,n} QM)

Wiki "Nuclear force" said, "*The weak force plays no role in the interaction of nucleons, though it is responsible for the decay of neutrons to protons and vice versa*". The weak force (or the Weak interaction) is either the "circular RFs-force" or the "inversed RFs-force" of each quark, ranges at 1E-18 meters [36], i.e., within {-17,n=1..3//6}o orbital shell range, (see SunQM-1s2's Table-1, using the proton-r track, {-17,1//6} has r = 6.48E-19 meters. {-17,2//6} has r = 4×6.48E-19 = 2.6E-18 meters. {-17,3//6} has r = 9×6.48E-19 = 5.83E-18 meters. {-17,4//6} has r = 16×6.48E-19 = 10.0E-18 meters). For a neutron (u-d, d), a weak force range (that within a {-17,n=1..3//6}o orbital shell range) means that it must be either within the "d" singlet alone, or within the "u-d" binary alone. Because the "u-d" binary got the extra stability from the parallel spin ↑↑, its d-quark is less possible to β decay into u-quark. Then, it is more likely that the weak force acts only on the "d" singlet sub-structure itself, and caused the β decay to become a "u" singlet sub-structure.

Based on above analysis, I proposed an explanation for the β decay (in a neutron): The (circular/inversed) RFs-force (i.e., the weak force) of each of three quarks (u, d, d) formed spin-spin interaction of ↑↑ vs. ↓ that transformed a φ-1D bi-directional orbital motion into a θ-1D uni-directional orbit motion. Then, this normal spin-spin interaction between the two sub-structures (↑↑ vs. ↓) is accidently severely disturbed, so that the θ-1D uni-directional motion is messed up, and goes back to the true φ-1D bi-directional motion, and "u-d" and "d" crashed at the -y axis position (see Figure 1c). This kind of orbital rotation disruption (i.e., the θ-1D uni-directional motion accidently goes back to the φ-1D bi-directional motion) can happen for the three quarks in both neutron and proton, but the accident crash of the two sub-structures can only happen for a neutron, because they (u-d and d, mass ratio 5:4) are running in the same {-16,5//6}o orbital shell. It will never happen for a proton because its two sub-structures (u-d, u, mass ratio 5:1) are running in the two very different orbital shells, one in {-16,2//6}o, and another in {-16,5//6}o. Alternatively, a β decay may can be described as a "d" singlet sub-structure (with the rest-mass energy level of {-17,2//6}o in SunQM-7's Table 1) decayed into a "u" singlet (with the rest-mass energy level of {-17,1//6}o in SunQM-7's Table 1) in the {-16,5//6}o orbit (around the three quarks' reduced mass center), plus a "u-d" binary sub-structure de-excited from the {-16,5//6}o orbit to a {-16,2//6}o orbit (around the same three quarks' reduced mass center).

Also based on above analysis, I proposed a second (or the alternative) explanation for the same β decay: using the "|nL0> Elliptical/Parabolic/Hyperbolic Orbital Transition Model", inside a neutron, the "d" singlet sub-structure can be treated as it is doing the circular/elliptical orbital motion around the "u-d" binary sub-structure (that at a "quasi-center"), under a (circular/inversed) RFs-RFs interaction (or spin-spin interaction) force field. Relative to the "quasi-center", a "d" singlet sub-structure has the longer (circular) orbital radius than that of a proton's "u" singlet sub-structure (because in a neutron, both "u-d" and "d" running in the same {-16,5//6}o orbital shell, so the distance between them is 5^2 +5^2 = 50× of r_1. but for a proton, only "d" in the {-16,5//6}o orbit while "u-d" in {-16,2//6}o orbit, so the distance between them is 5^2 +2^2 = 29× of r_1). Thus, the "d" singlet sub-structure (in the neutron) is at a higher energy level (of the (circular/inversed) RFs-RFs interaction (or spin-spin interaction) force field) relative to that of the "u" singlet sub-structure (in a proton), (and it just like that in a H-atom under the E/RFe-force field, the n=3 electron vs. the n=2 electron has orbital radius of 3^2 = $9r_1$ vs. 2^2 = $4r_1$). Then, in a rare case that the "d" singlet sub-structure goes to an extreme high eccentric orbit, at the perihelion site, the "d" singlet sub-structure (the "mother") will spin-off its outmost shell of the 3D wave packet (as the "newborn", i.e., $e^- + \overline{\nu}$), and the rest part become a "u" singlet sub-structure (the "daughter") and de-excited to the lower energy level (of the spin-spin interaction force field), and with the shorter distance to the "u-d" binary sub-structure (at the spin-spin interaction force field "quasi-center"). In this explanation, we can clearly see that a neutron can be treated as the high-energy state (or the "excited state") of a proton (i.e., a relatively low-energy state, or the "ground state").

In the above two explanations for the β decay, I guessed that both "quasi-central" force fields come from the (circular/inversed) RFs-RFs interaction (or spin-spin interaction), not come from the S-force. Therefore, they produce neither bound state nor binding energy (see Appendix A). The only difference is: in the first explanation, the two sub-structures are doing the orbital rotation around their reduced mass center; and in the second explanation, the small mass sub-structure is supposed to do the orbital rotation around the large mass sub-structure.

Under the "face-to-face plus face-opposite-face two-level orbital motion", the three quarks inside a neutron (u-d, d, with spin ↑↑ vs. ↓) formed a final nuclear spin of ½ ⇑, and according to Figure 1d, this neutron's nuclear spin ⇑ direction is always doing (the up-down-up) rotation in the xz-2D plane (if we fix the xyz-coordinate, or fix the neutron as a whole entity in the xyz-coordinate). Then, after adding a strong external magnetic field to fix the nuclear spin ⇑ direction in one direction, then the neutron (as a whole entity) will be force to do the opposite (up-down-up) rotation in the xz-2D plane, and this may increase the probability of messing up the three quarks' (↑↑ vs. ↓) high-level rotation in θ-1D, make it more often to accidently go back to the true φ-1D bi-directional rotation, and then crashed at the -y axis position to make the β decay. If this guess is correct, then under the extreme strong external magnetic field, we should see the increased probability of β decay in the reactions (like that shown Figure 5a).

In summary, the **Weak Interaction** may be the spin-spin interaction (↑↑ vs. ↓) between the two sub-structures (that made of the three quarks inside a nucleon) with a "face-to-face plus face-opposite-face two-level orbital motion" in the θ-1D uni-direction; the **β decay** reaction may be caused by the crash of the two sub-structures after the disruption of this θ-1D uni-directional motion and goes back to the φ-1D bi-directional motion.

VII. Using "Fourier transformation" to analyze a high Z# nucleus to find the sub-stable building blocks, and it correlates to the answer of "why Solar system has {N,n//q} QM structure with q=6?"

Using the concept of the Fourier transformation (that transformed a wave amplitude analysis from a time "space" into a frequency "space"), for the sub-structural stability analysis of a nucleus (especially the high Z# nucleus, note: Z# is the atomic number), we can also transform the analysis from the Z# "space" into a n_{nuc} "space". (Note: See SunQM-5's Table 2 for the n_{nuc} definition). Figure 2a showed a nuclear stability analysis in Z# "space", and Figure 2b illustrated a nuclear stability analysis in n_{nuc} "space". (Note: As a citizen scientist, I don't know how to deduce out the mathematic formula, or how to calculate out the accurate value for Figure 2b. So, Figure 2b is purely from my scientific guess, or from my "first principle thinking", because I believed that it should be similar as the SVD, PCA, etc., in which the first principal component vector must point to $\Delta n_{nuc} = 1$, and the second principal component vector must point to $\Delta n_{nuc} = 2$, see SunQM-5's section II-b). As usual, I always like to put some (purely scientifically guessed) values to give myself a better understanding: let's guess that the $n_{nuc} = 1$ sub-structure may contribute the nuclear stability by ~99%, the $n_{nuc} = 2$ sub-structure may contribute the nuclear stability by ~1%, the $n_{nuc} = 3$ sub-structure may contribute the nuclear stability by ~0.01%, the $n_{nuc} = 4$ sub-structure may contribute the nuclear stability by ~0.0001%, etc. Now, let's translate the meaning of Figure 2b's result back to the Figure 2a, it means:

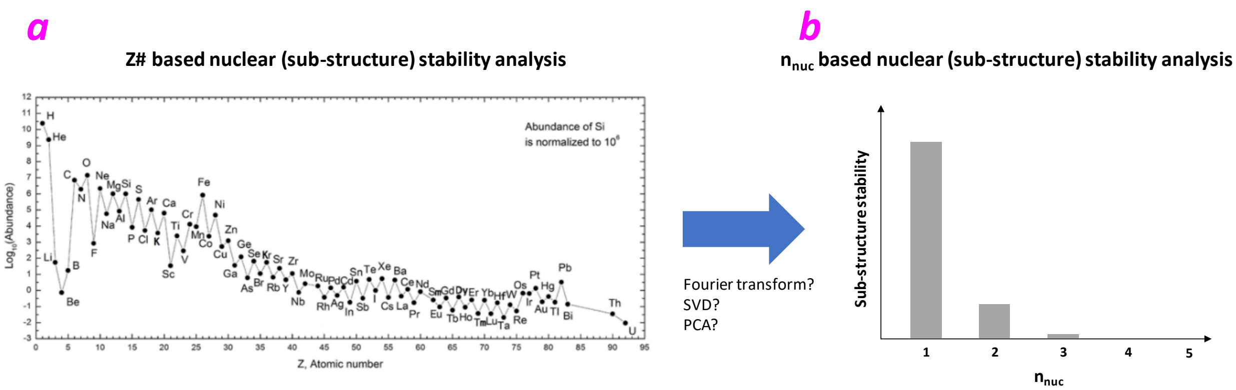

Figure 2a. Z atomic number based nuclear (sub-structure) stability analysis. Copied from wiki "chemical element". Author: Ken Croswell. Copyright: CCBY-SA 3.0.
Figure 2b. n_{nuc} based nuclear (sub-structure) stability analysis (with the guessed values, not on scale), it is obtained by my imagination of a "Fourier transformation" on the Figure 2a.

1) For any nucleus (especially for a high Z# nucleus), its ~99% stability is come from those single nucleon sub-structure (that has $n_{nuc} = 1$), that means, each nucleon is the fundamental sub-structure (or the building block) of the nucleus.

2) Beyond that, its ~1% stability is come from those four nucleons-grouped sub-structure (that has $n_{nuc} = 2$, and has a ^{4}He nucleus' composition, i.e., two protons plus two neutrons), and we had named these sub-structures as the "**quasi ^{4}He nucleus**" or the "**virtual α-particles**" in SunQM-7's section II-c. This result revealed that inside a (high Z#) nucleus, many "quasi ^{4}He nucleus" or the "virtual α-particles" sub-structures are formed dynamically, and these "quasi ^{4}He nuclei" are the second most important sub-structures for the nuclear stability. This result also explains why all Z = even number atoms have higher abundancy (that equals to the high stability) than their neighboring Z = odd number atoms (in Figure 2a), it is because every Z = even number nucleus contains a integer number (= Z/2) of "quasi ^{4}He nucleus", so these nuclides are in the comfortable state and have the relative high nuclear stability, while for every Z = odd number nucleus, after you grouped all protons, there is always one extra proton left. Thus, the odd Z number nuclides are not comfortable with this extra proton, so that they have the relative low nuclear stability (or abundancy). So, for a high odd Z number nucleus, besides containing many "quasi ^{4}He nucleus", it also contains (at least) one "quasi ^{3}H nucleus". Notice that in the {N,n} QM description, we supposed that all four (or three) nucleons in the "quasi ^{4}He nucleus" (or in the "quasi ^{3}H nucleus") are doing the "face-to-face plus face-opposite-face two-level orbital motion".

3) For every $\Delta Z = +2$ you added into a nucleus, you actually added two neutron-proton binaries, i.e., a complete "quasi ^{4}He nucleus" sub-structure to the previous nucleus. Similarly, the α particle emission can be simply explained as that one of the "quasi ^{4}He nucleus" sub-structure block is excited to $n = \infty$, so that it changed state from a "virtual α-particle" to a "true α-particle". Also for this reason, we can use the "quasi ^{4}He nucleus" as the building block to construct the 3D structure of a nucleus (see the example in Figure 3).

4) For any nucleus (even the high Z# nucleus), the stability contribution for $n_{nuc} \geq 3$ sub-structures is practically zero. In other words, the probability to form $n_{nuc} \geq 3$ sub-structures is practically zero. (Note: Should we put the "neutron-proton binary" as one kind of the building blocks for the high Z# nucleus? No, because it violated the rule of $r_n = r_1 n^2$, thus it is unfavored by the {N,n} QM structural system).

This discussion brought me another very important (old) question: why in the Solar {N,n//q} QM structure, the q = 6? Also why our universe has the q = 6 for its {N,n//q} QM structure (from N = -17 to N = +10, see SunQM-1s2's Table 1)? From the previous {N,n} QM studies, we know that the body size of all eight primitive planets in our Solar system were originally formed in {N,n//2} QM structural format (see SunQM-1s3). Adding more mass to these {N,n//2} primitive planets will change their {N,n//q} QM format from q = 2 to q = 3. (For example, the current Saturn is a superposition of {N,n//3} QM structure with minorly in the {N,n//2} at the core, so Saturn is actually an under-massed planet for a perfect {N,n//3} QM planet; and the current Jupiter is a superposition of {N,n//3} QM structure (although only minorly for the ring structure) and {N,n//5} QM structure (mainly for the body and the surrounding moons), so Jupiter is actually an over-massed planet for a perfect {N,n//3} QM planet). This analysis may have revealed to us that the {N,n//2} with q=2 is the primary mode for an object (i.e., a celestial body, or maybe even a particle) to exist under the {N,n//q} QM structural format, and the {N,n//3} with q=3 is the secondary mode for an object to exist under the {N,n//q} QM structural format. When learning and studying the molecular structure (in the middle 1980s at Fudan university), I leaned the concept that something like: for a single chemical molecule, the more resonance modes (or the more Lewis structures?) it can have, the more stable this molecule will be (is it Linus Pauling's theory?). Using this concept, now I may can explain why our universe has q=6 for its {N,n//q} QM: for our universe's {N,n//q} QM, the q (integer number) needs to include as many (of the basic q-modes) as possible (for the QM state superposition), and simultaneously, the q integer number should also be as small as possible (to not damage the quantum character of the {N,n//q} QM). Therefore, $q = 2 \times 3 = 6$ must be a best minimum integer number, because it naturally includes both the primary mode {N,n//2} with q=2, and the secondary mode {N,n//3} with q=3. Remember that a {N,n//2} QM mode naturally equals to a {N,n//4} QM mode. Thus, a {N,n//6} QM naturally covers the {N,n//2} mode, the {N,n//3} mode, the {N,n//4} mode, and the {N,n//6} mode, so it includes the maximum number of modes (for superposition), and q=6 is still a small integer number that does not damage (or abolish) the quantum character of the {N,n//q} QM. (Also see SunQM-6s1's section III-c).

VIII. Construct a high Z# nuclear structure by using the "quasi ^{4}He nucleus" as the building block

In brief, the newly designed {N,n} QM field theory revealed that, inside a heavy nucleus, nucleons are grouped in multi-mode movement. The basic mode is the single nucleon ($n_{nuc} = 1$) movement mode. The second most stable n_{nuc} mode is the $n_{nuc} = 2$ mode in which four nucleons (two neutron-proton binaries) grouped as a "quasi ^{4}He nucleus" (or, "virtual α particle"). That is to say, there are around Mass# / 4 of virtual α particles randomly moving in a nucleus's energy well (that equals to a *N*-body problem, also see SunQM-7's section II-c). Based on this result, we may be able to use the "quasi ^{4}He nuclei" as the building block to construct the possible (low energy) geometry/configuration for any even Z# nucleus. For example, in Figure 3a, I constructed a nucleus of $^8_4$Be (with 4 protons and 4 neutrons) in a cubic geometry. It is formed by simply stacking two of the "quasi ^{4}He nuclei" (see Figure 1b) together. Once added the thermal motion, Figure 3a may can be illustrated by Figure 3b.

In Figure 3c, I showed one more example to use eight of "quasi ^{4}He nuclei" as the sub-structure to construct the geometry/configuration of the nucleus of $^{32}_{16}\mathrm{S}$. It was constructed as by using the $^{8}_{4}\mathrm{Be}$ nucleus's cube (that contains two "quasi ^{4}He nuclei") as the cubic core structure, then add one more "quasi ^{4}He nucleus" (total 6) to each of the 6 faces of the cubic core (see Figure 3d, again the thermal motion is ignored). I guessed that it is one of the lowest QM state energy geometry and configuration for the $^{32}_{16}\mathrm{S}$ nucleus.

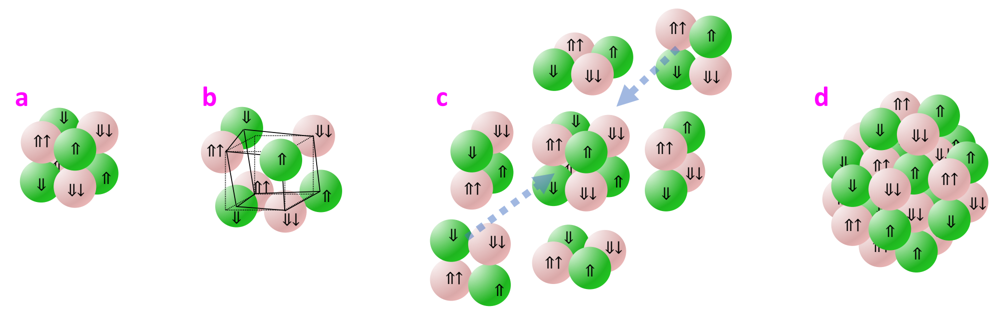

Figure 3 (a, b). A possible nucleon structure and spin configuration for a $^{8}_{4}\mathrm{B}$ nucleus by using two of the "quasi ^{4}He nuclei" as the building block. (Note: Although within each "quasi ^{4}He nucleus" it is in ⇑⇑↑⇓⇓↓ spin configuration, how to configure spin between the neighboring "quasi ^{4}He nuclei" is not clear yet. So Figure 3 is only a random guess on this issue). (Note: Although Figure 1b conformation is used to construct all high Z# nuclides structure in this paper (see Figure 3 and Figure 6), Figure 1b" conformation may also can be used).

Figure 3 (c, d). A possible nucleon structure and spin configuration for a $^{32}_{16}\mathrm{S}$ nucleus by using eight of the "quasi ^{4}He nuclei" as the building block.

IX. Adding the nuclear proton (E-force) orbital energy level to a nucleus (for the possible γ decay energy estimation)

In SunQM-6s6, I had developed a "proton-electron mirror-paired orbit" model, in which all the nuclear protons' (E-force) orbital energy levels can be assigned. Furthermore, there is a one-to-one relationship between the atomic electron (E-force) orbital energy level and the nuclear proton (E-force) orbital energy level, with the exactly mirrored configuration (see SunQM-6s6's Fig-2). Using that method, for a $^{32}_{16}\mathrm{S}$ nucleus (shown in Figure 3c), we can assign the nuclear proton's (E-force) energy level for total 2×8=16 protons (or 8 "quasi ^{4}He nuclei") as in $1s^22s^22p^63s^23p^4$ nuclear configuration (see Figure 4a). Notice that all four protons in the nuclear cubic core are assigned to have the highest (E-force) energy level $3p^4$, the two nuclear surface protons are assigned to have the lowest (E-force) energy level $1s^2$, the other two (near) surface protons are assigned to have the 2nd lowest (E-force) energy level $2s^2$. For a large Z# nucleus, I had assumed that all four surface protons at $1s^2$ and $2s^2$ are practically having the same (E-force) energy level, so we often regrouped them as (1s2s) energy level (see in SunQM-6s6's Fig-6d). In one way, we may also regroup all 16 protons into three (E-force) energy levels: ($1s^22s^2$), ($2p^63s^2$), and ($3p^4$), as shown in Figure 4b. Even more, if we further simplify the model to have only two (E-force) energy levels with the low-Energy of ($1s^22s^2$), and the high-Energy of ($2p^63s^23p^4$), we may be able to use the Coulomb potential equation to (semi-quantitatively) estimate the energy difference between these two (E-force) energy levels (as shown in SunQM-6s6's Fig-5c).

(Note: Inside a nucleus, we better to group two neighboring protons that have the same E/RFe-force energy level together to form a "quasi ^{4}He nucleus". However, if we use the two $1s^2$ protons in a $^{32}_{16}\mathrm{S}$ nucleus's $1s^22s^22p^63s^23p^4$ configuration to form a "quasi ^{4}He nucleus", then these two protons are too far away. So, after re-grouping $^{32}_{16}\mathrm{S}$ nucleus's $1s^22s^22p^63s^23p^4$ configuration into ($1s^22s^2$)($2p^63s^2$)($3p^4$), then use the $1s^12s^1$ to form a "quasi ^{4}He nucleus", it seems better. However, in Figure 6, I may have to use $1s^12p^1$ kind of pairing to form a "quasi ^{4}He nucleus").

In SunQM-6s6, I hypothesized that "*the γ decay may be the result of the pure E-force energy level de-excitation of a single proton from the high-energy nuclear orbit (at the core of the nucleus) to the low-energy nuclear orbit 1s (at the* *surface of the nucleus), with no S/RFs-force involved*". In that paper, I used two different β decay reactions, ${}^{12}_{5}B^* \xrightarrow{\beta,9.0\ \text{MeV}} {}^{12}_{6}C^* \xrightarrow{\gamma,4.4\ \text{MeV}} {}^{12}_{6}C$, and ${}^{203}_{80}Hg \xrightarrow{\beta,\ \ 214\ \text{keV}} {}^{203}_{81}TI^* \xrightarrow{\gamma,\ \ 279\ \text{keV}} {}^{203}_{81}TI$, to support this hypothesis. In the current paper, because we have obtained a possible nuclear proton (E-force) energy level configuration for ${}^{32}_{16}S$ nucleus (see Figure 4b), I tried to add one more (${}^{32}_{16}S$ related) γ decay reaction example to support this hypothesis. Unfortunately, I was not able to do it, simply because (as a citizen scientist) I did not know how to find the experimental γ energy value for a ${}^{32}_{16}S$ related γ decay. However, through online search, I did find a β decay reaction, ${}^{24}_{11}Na^* \xrightarrow{\beta,1.39\ \text{MeV}} {}^{24}_{12}Mg^{**} \xrightarrow{\gamma,2.76\ \text{MeV}} {}^{24}_{12}Mg^* \xrightarrow{\gamma,1.38\ \text{MeV}} {}^{24}_{12}Mg$, (see Figure 5a), that produces two steps of γ emission with the known energy values. Because the nuclear proton (E-force) energy level configurations between ${}^{24}_{12}Mg$ and ${}^{32}_{16}S$ are pretty similar, I decided to use the ${}^{24}_{12}Mg$ related γ decay as the substitution.

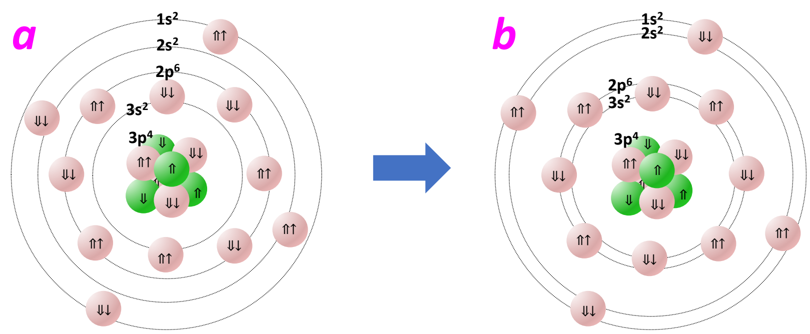

Figure 4a. The "standard" nuclear proton (E-force) energy level in $1s^2 2s^2 2p^6 3s^2 3p^4$ configuration for a ${}^{32}_{16}S$ nucleus.
Figure 4b. The re-grouped nuclear proton (E-force) energy level in $(1s^2 2s^2)(2p^6 3s^2)(3p^4)$ configurations for a ${}^{32}_{16}S$ nucleus.

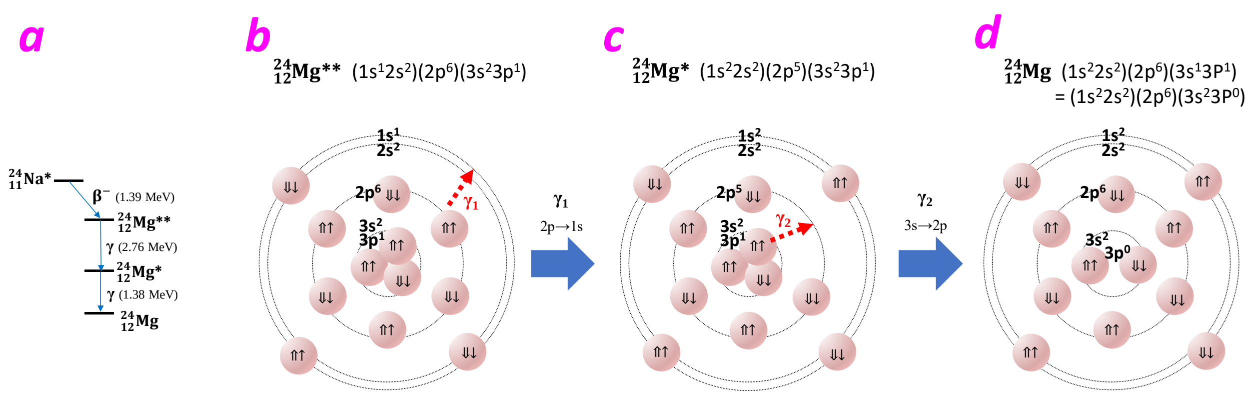

Figure 5a. β decay reaction followed by two γ decay reactions (with the known energy value of γ photons), ${}^{24}_{11}Na^* \xrightarrow{\beta,1.39\ \text{MeV}} {}^{24}_{12}Mg^{**} \xrightarrow{\gamma,2.76\ \text{MeV}} {}^{24}_{12}Mg^* \xrightarrow{\gamma,1.38\ \text{MeV}} {}^{24}_{12}Mg$. Copied from the online encyclopedia Britannica at (https://www.britannica.com/science/beta-decay).

Figure 5 (b, c, d). The possible nuclear proton (E-force) energy level transitions for the ${}^{24}_{12}Mg^{**} \xrightarrow{\gamma,2.76\ \text{MeV}} {}^{24}_{12}Mg^* \xrightarrow{\gamma,1.38\ \text{MeV}} {}^{24}_{12}Mg$ reaction process.

Before doing the semi-quantitative calculation, I first re-group the nuclear proton (E-force) energy level configurations of ${}^{24}_{12}Mg^{**}$ as $(1s^1 2s^2)(2p^6)(3s^2 3p^1)$, as shown in Figure 5b. (Note: We can't group it as ${}^{32}_{16}S$ nucleus's $(1s^2 2s^2)(2p^6 3s^2)(3p^1)$. If we do so, then the 3p → 2p transition will have zero central charge in a point center E-force field, and abolished this method). Then, I assigned ${}^{24}_{12}Mg^{**} \xrightarrow{\gamma, 2.76\ MeV} {}^{24}_{12}Mg^{*}$ γ decay reaction as one proton de-excited from 2p nuclear orbit to 1s nuclear orbit and emitted a γ photon (as shown in Figure 5b), and assigned ${}^{24}_{12}Mg^{*} \xrightarrow{\gamma, 1.38\ MeV} {}^{24}_{12}Mg$ γ decay reaction as (another) one proton de-excited from 3s nuclear orbit to 2p nuclear orbit and emitted a (second) γ photon (as shown in Figure 5c). Notice that with the re-grouped $(3s^2 3p^1)$, the 3p proton is now equivalent to a 3s proton, so after the 3s → 2p transitions and the (second) γ photon emitted, the leftover $(1s^2 2s^2)(2p^6)(3s^1 3p^1)$ is automatically become $(1s^2 2s^2)(2p^6)(3s^2 3p^0)$. Therefore, both the 2p → 1s and the 3s → 2p transitions satisfy the selection rule of $\Delta l = \pm 1$ [37], [38].

In Table 1, I did a semi-quantitative calculation to estimate the γ energy values for the two γ photons. In SunQM-6s6, I said that "*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 roughly estimated case by case*". Here is the detailed description on how the calculation was performed in Table 1 (and Table 2):

Table 1a. For a ${}^{24}_{12}Mg^{**} \xrightarrow{\gamma, 2.76\ MeV} {}^{24}_{12}Mg^{*}$ gamma decay, calculate (by estimation) a proton's (E-force) energy level difference between the nuclear 2p state and the nuclear 1s2s state (inside a Mg atomic nucleus).

	n = 1, (or n=1s2s)	n = 2, (or n = 2p)	n = 3, (or n = 3s3p)
n =	1	0.816	0.577
n^2 = r_n / r_1	1	0.667	0.333
r_n =	5.04E-15	3.36E-15	1.68E-15
K_n = (1/2) m v_n^2 = (n h/(2πr_n))^2 /(2m), J	1.31E-13	1.96E-13	3.93E-13
K_n =(MeV)	0.82	1.23	2.45
center Z	8	8	2
U_n = Ze^2/4πε$_0$ /r_n = (J)	3.66E-13	5.49E-13	2.75E-13
U_n = (MeV)	2.29	3.43	1.72
E_n = K_n + U_n = (MeV)	**3.11**	**4.66**	**4.17**
ΔE = (MeV)		**2p → (1s2s)**	**(3s3p) → 2p**
		1.55	-0.49

Table 1b. For a ${}^{24}_{12}Mg^{*} \xrightarrow{\gamma, 1.38\ MeV} {}^{24}_{12}Mg$ gamma decay, calculate (by estimation) a proton's (E-force) energy level difference between the nuclear (3s3p) state and the nuclear 2p state (inside a Mg atomic nucleus).

	n = 1, (or n=1s2s)	n = 2, (or n = 2p)	n = 3, (or n = 3s3p)
n =	1	0.816	0.577
n^2 = r_n / r_1	1	0.667	0.333
r_n =	5.04E-15	3.36E-15	1.68E-15
K_n = (1/2) m v_n^2 = (n h/(2πr_n))^2 /(2m), J	1.31E-13	1.96E-13	3.93E-13
K_n =(MeV)	0.82	1.23	2.45
center Z	2	2	2
U_n = Ze^2/4πε$_0$ /r_n = (J)	9.15E-14	1.37E-13	2.75E-13
U_n = (MeV)	0.57	0.86	1.72
E_n = K_n + U_n = (MeV)	**1.39**	**2.08**	**4.17**
ΔE = (MeV)		**2p → (1s2s)**	**(3s3p) → 2p**
		0.69	2.08

1) Assuming that in the β decay reaction ${}^{24}_{11}Na^{*} \xrightarrow{\beta, 1.39\ MeV} {}^{24}_{12}Mg^{**}$, a neutron at the core of ${}^{24}_{11}Na^{*}$ nucleus is mutated to be a proton (also at the core of the nucleus), and then it acquired the highest nuclear (E-force) energy level (i.e., the $3p^1$ state).
2) For the ${}^{24}_{12}Mg^{**}$ nucleus, assuming that there are three layers of proton shells, the core ($3s^2 3p^1$ hybridized state, named as "n=3" state in Table-1) contains three protons, the middle layer ($2p^6$, named as "n=2" state in Table-1) contains six protons, and surface layer ($1s^1 2s^2$ hybridized state, named as "n=1" state in Table-1) contains three protons.
3) Assuming that the two (position unchanged) $3s^2$ protons have the size of a point, and are at the exactly the center of the "quasi point centered" E-force field. Assuming that the (newly mutated) $3p^1$ proton (that will be de-excited) is $r_{n=3} = 2r_{proton} = 2\times 8.4E\text{-}16 = 1.68E\text{-}15$ meters away from the center 2+ charge, the 2p orbit is $r_{n=2} = 2r_{proton} + 2r_{proton} = 4\times 8.4E\text{-}16 = 3.36E\text{-}15$

meters away from the center 2+ charge, and the $1s^1 2s^2$ hybridized orbit is $r_{n=1} = 2r_{proton} + 2r_{proton} + 2r_{proton} = 6\times8.4E\text{-}16 = 5.04E\text{-}15$ meters away from the center 2+ charge.

4) So, according to SunQM-6s6's eq-37, $n^2 = \frac{r_n}{r_1} < 1$, in Table 1, for n=3, $n^2 = r_3 / r_1 = (2r_{proton}) / (6r_{proton}) = 0.333$; for n=2, $n^2 = r_2 / r_1 = (4r_{proton}) / (6r_{proton}) = 0.667$, and for n=1, $n^2 = r_1 / r_1 = 1$.

5) For the first nuclear proton de-excitation 2p → (1s2s), I chose Z' = 8 (see Table 1a), because soon after a 2p orbital proton is moving away from 2p orbit (outward towards to the 1s2s orbit), all rest five 2p protons can be treated as the (relative) central charges (for this outgoing and de-exciting proton). Plus the three $3s^2 3p^1$ protons that can always be treated as the relative center charges for 2p orbit (and for 1s2s orbit), the total central change equals eight for this outgoing and de-exciting proton.

6) For the second nuclear proton de-excitation (3s3p) → 2p, I chose Z' = 2 (see Table 1b), because soon after a (3s3p) orbital proton is moving away from (3s3p) orbit outward to 2p orbit, the rest two (3s3p) protons can be treated as the (relative) central charges (for this outgoing and de-exciting proton).

7) The rest calculations follow SunQM-6s6's Table-3. The calculated γ_1 = 1.55 MeV (from n=2 to n=1 transition), γ_2 = 2.08 MeV (from n=3 to n=2 transition), reasonably matched to the experimental data γ_1 = 2.76 MeV, γ_2 = 1.38 MeV. Thus, this semi-quantitative estimation may also support the hypothesis (i.e., the γ decay is a pure nuclear E/RFe de-excitation process, no S/RFs involved).

According to the above descriptions, in Figure 6, I drew the (possible) 3D positions for all protons inside the nucleus in the ${}^{24}_{11}Na^* \rightarrow {}^{24}_{12}Mg$ reaction (shown in Figure 5). Based on the "quasi ^{4}He nucleus" theory, the 24 nucleons were first divided into 24 / 4 = 6 of "quasi ^{4}He nucleus" sub-structures. For a nucleus containing six "quasi ^{4}He nuclei", the most compact geometry is the octahedron with each "quasi ^{4}He nucleus" at the corner. To force the 3s3p protons to be at the core of the nucleus, the octahedron may have to be de-shaped a little bit. For example, in the ${}^{24}_{12}Mg$ nuclear structure of $(1s^2 2s^2)(2p^6)(3s^2)$, the two 3s protons have to be in the (relative) core position (in comparison with those six 2p protons), so that the octahedron has to be de-shaped to make the top and down "quasi ^{4}He nuclei" much closer to the center of the octahedron (shown in Figure 6e). The similar octahedron de-shape fits all other nuclei (in this reaction). If this depict is reasonably correct, then we see that the ${}^{24}_{11}Na^* \rightarrow {}^{24}_{12}Mg$ beta decay should start from the excited state ${}^{24}_{11}Na^*$ with $(1s^1 2s^2)(2p^6)(3s^2)$, not a ground state ${}^{24}_{11}Na$ with $(1s^2 2s^2)(2p^6)(3s^1)$. Figure 6 vividly depicted each and every nucleon's structural change for the ${}^{24}_{11}Na^* \xrightarrow{\beta,1.39\ MeV} {}^{24}_{12}Mg^{**} \xrightarrow{\gamma,2.76\ MeV} {}^{24}_{12}Mg^* \xrightarrow{\gamma,1.38\ MeV} {}^{24}_{12}Mg$ reaction. Although hard to say how correct it is, it does give us a new sight on how to understand this nuclear reaction step-by-step.

Even this model may be not perfectly correct, I still want to put forward it. Because: a) I always try to use the classical (or the traditional) way to explain the physical process if I can; b) The key duty of a citizen scientist is to provide the diversified idea to the scientific community (for the purpose to broaden the foundation of science), even these ideas are mostly wrong, it may (抛砖引玉) inspire others to think the better idea.

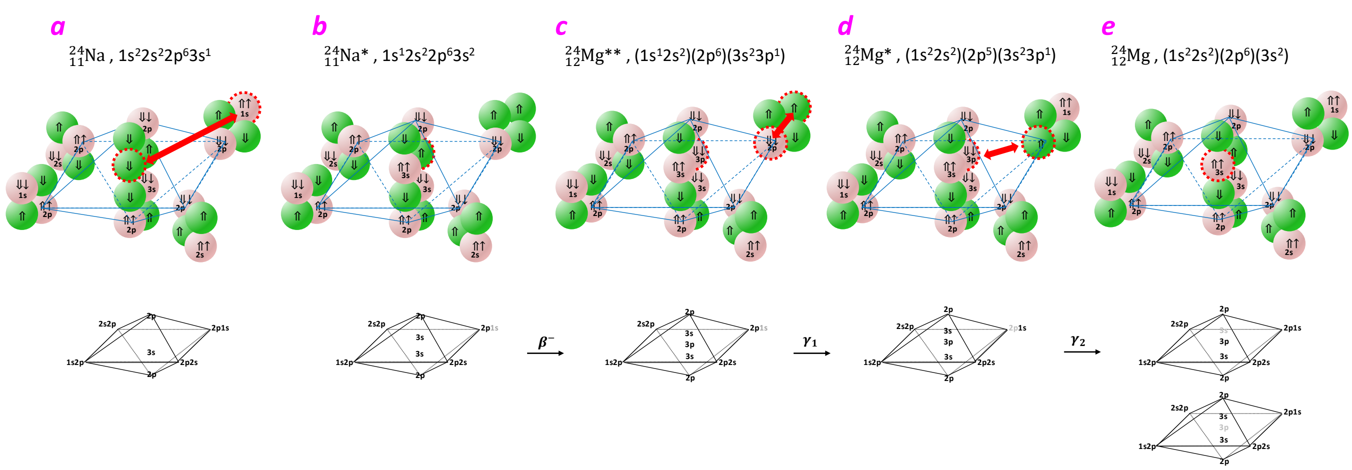

Figure 6. The possible nucleon structures and spin configurations for the ${}^{24}_{12}\mathrm{Mg}^{**} \xrightarrow{\gamma,2.76\ \mathrm{MeV}} {}^{24}_{12}\mathrm{Mg}^{*} \xrightarrow{\gamma,1.38\ \mathrm{MeV}} {}^{24}_{12}\mathrm{Mg}$ reaction process by using six "quasi ^{4}He nucleus" as the building block. (Note: Although within each one "quasi ^{4}He nucleus" it is in the ⇑⇑↑⇓⇓↓ spin configuration, how to configure spin between the neighboring "quasi ^{4}He nuclei" is not clear. So Figure 6 is only a random guess on this issue).

Conclusion

A ^{4}He nucleus may be formed with two of neutron-proton binaries that are doing the "face-to-face plus face-opposite-face two-level orbital motion". Within each one binary, the neutron and proton are doing the "face-to-face tidal-locked orbital binary motion" with the parallel nuclear spin ⇑⇑↑. Between the two binaries, they are doing the "face-opposite-face locked binary orbital motion" in φ-1D bi-direction with the anti-parallel spin ⇑⇑↑⇓⇓↓, that eventually transformed to be a θ-1D orbital uni-directional motion. A neutron may be formed with two sub-structures, one "u-d" binary and one "d" singlet, and they are also doing the "face-to-face plus face-opposite-face two-level orbital motion". The β decay reaction may be caused by the crash of the two sub-structures after the disruption of this θ-1D uni-directional motion and goes back to the φ-1D bi-directional motion. A proton may be also formed with two sub-structures, one "u-d" binary and one "u" singlet, and they are again doing the "face-to-face plus face-opposite-face two-level orbital motion". The "quasi ^{4}He nucleus" must be the building block of the high Z# nucleus.

Acknowledgements (of all SunQM series articles):

Many thanks to: all the (related) experimental scientists who produced the (related) experimental data, all the (related) theoretical scientists who generated all kinds of theories (that become the foundation of {N,n//q} QM theory), the (related) text book authors who wrote down all results into a systematic knowledge, the (related) popular science writers who simplified the complicated modern physics results into a easily understandable text, the (related) Wikipedia writers who presented the knowledge in a easily accessible way, the (related) online (video/animated) course writers/programmers who presented the abstract knowledge in an intuitive and visually understandable way. Also thanks to NASA and ESA for opening some basic scientific data to the public, so that citizen scientists (like me) can use it. Also thanks to the online preprinting serve vixra.org to let me to post out my original SunQM series research articles. Also thanks to the richness of the California state, and thanks to the high level of scientific research and the high level of the popular science education in USA, so that any civilized person in the world (with the good will) can use his own money (practically zero money) to do some studies on the theoretical physics (and using some free public resources).

Special thanks to: Fudan university, theoretical physics (class of 1978, and all teachers), it had made my quantum mechanics study (at the undergraduate level) become possible. Also thanks to Tsung-Dao Lee and Chen-Ning Yang, they made me to dream to be a theoretical physicist when I was eighteen. Also thanks to Shoucheng Zhang (张首晟, Physics Prof. at Stanford Univ., my classmate at Fudan Univ. in 1978) who had helped me to introduce the {N,n} QM theory to the scientific community in 2018.

Also thanks to a group of citizen scientists for the interesting, encouraging, inspiring, and useful (online) discussions: "职老" (https://bbs.creaders.net/rainbow/bbsviewer.php?trd_id=1079728), "MingChen99" (https://bbs.creaders.net/tea/bbsviewer.php?trd_id=1384562), "zhf" (https://bbs.creaders.net/tea/bbsviewer.php?trd_id=1319754), Yingtao Yang (https://bbs.creaders.net/education/bbsviewer.php?trd_id=1135143), "tda" (https://bbs.creaders.net/education/bbsviewer.php?trd_id=1157045), etc.

Also thanks to: Takahisa Okino (Correlation between Diffusion Equation and Schrödinger Equation. Journal of Modern Physics, 2013, 4, 612-615), Phil Scherrer (Prof. in Stanford University, who explained WSO data to me (in email, see SunQM-3s9)), Jing Chen (https://www.researchgate.net/publication/332351262_A_generalization_of_quantum_theory), etc. Note: if I missed anyone in the current acknowledgements, I will try to add them in the SunQM-9s1's acknowledgements.

Reference:

[1] Yi Cao, SunQM-1: Quantum mechanics of the Solar system in a {N,n//6} QM structure. http://vixra.org/pdf/1805.0102v2.pdf （original submitted on 2018-05-03）

[2] Yi Cao, SunQM-1s1: The dynamics of the quantum collapse (and quantum expansion) of Solar QM {N,n} structure. http://vixra.org/pdf/1805.0117v1.pdf （submitted on 2018-05-04）
[3] Yi Cao, SunQM-1s2: Comparing to other star-planet systems, our Solar system has a nearly perfect {N,n//6} QM structure. http://vixra.org/pdf/1805.0118v1.pdf （submitted on 2018-05-04）
[4] Yi Cao, SunQM-1s3: Applying {N,n} QM structure analysis to planets using exterior and interior {N,n} QM. http://vixra.org/pdf/1805.0123v1.pdf （submitted on 2018-05-06）
[5] Yi Cao, SunQM-2: Expanding QM from micro-world to macro-world: general Planck constant, H-C unit, H-quasi-constant, and the meaning of QM. http://vixra.org/pdf/1805.0141v1.pdf （submitted on 2018-05-07）
[6] Yi Cao, SunQM-3: Solving Schrodinger equation for Solar quantum mechanics {N,n} structure. http://vixra.org/pdf/1805.0160v1.pdf （submitted on 2018-05-06）
[7] Yi Cao, SunQM-3s1: Using 1st order spin-perturbation to solve Schrodinger equation for nLL effect and pre-Sun ball's disk-lyzation. http://vixra.org/pdf/1805.0078v1.pdf （submitted on 2018-05-02）
[8] Yi Cao, SunQM-3s2: Using {N,n} QM model to calculate out the snapshot pictures of a gradually disk-lyzing pre-Sun ball. http://vixra.org/pdf/1804.0491v1.pdf （submitted on 2018-04-30）
[9] Yi Cao, SunQM-3s3: Using QM calculation to explain the atmosphere band pattern on Jupiter (and Earth, Saturn, Sun)'s surface. http://vixra.org/pdf/1805.0040v1.pdf （submitted on 2018-05-01）
[10] Yi Cao, SunQM-3s6: Predict mass density r-distribution for Earth and other rocky planets based on {N,n} QM probability distribution. http://vixra.org/pdf/1808.0639v1.pdf (submitted on 2018-08-29)
[11] Yi Cao, SunQM-3s7: Predict mass density r-distribution for gas/ice planets, and the superposition of {N,n//q} or |qnlm> QM states for planet/star. http://vixra.org/pdf/1812.0302v2.pdf (replaced on 2019-03-08)
[12] Yi Cao, SunQM-3s8: Using {N,n} QM to study Sun's internal structure, convective zone formation, planetary differentiation and temperature r-distribution. http://vixra.org/pdf/1808.0637v1.pdf (submitted on 2018-08-29)
[13] Yi Cao, SunQM-3s9: Using {N,n} QM to explain the sunspot drift, the continental drift, and Sun's and Earth's magnetic dynamo. http://vixra.org/pdf/1812.0318v2.pdf (replaced on 2019-01-10)
[14] Yi Cao, SunQM-3s4: Using {N,n} QM structure and multiplier n' to analyze Saturn's (and other planets') ring structure. http://vixra.org/pdf/1903.0211v1.pdf (submitted on 2019-03-11)
[15] Yi Cao, SunQM-3s10: Using {N,n} QM's Eigen n to constitute Asteroid/Kuiper belts, and Solar {N=1..4,n} region's mass density r-distribution and evolution. http://vixra.org/pdf/1909.0267v1.pdf (submitted on 2019-09-12)
[16] Yi Cao, SunQM-3s11: Using {N,n} QM's probability density 3D map to build a complete Solar system with time-dependent orbital movement. https://vixra.org/pdf/1912.0212v1.pdf (original submitted on 2019-12-11)
[17] Yi Cao, SunQM-4: Using full-QM deduction and {N,n} QM's non-Born probability density 3D map to build a complete Solar system with orbital movement. https://vixra.org/pdf/2003.0556v2.pdf (replaced on 2021-02-03)
[18] Yi Cao, SunQM-4s1: Is Born probability merely a special case of (the more generalized) non-Born probability (NBP)? https://vixra.org/pdf/2005.0093v1.pdf (submitted on 2020-05-07)
[19] Yi Cao, SunQM-4s2: Using {N,n} QM and non-Born probability to analyze Earth atmosphere's global pattern and the local weather. https://vixra.org/pdf/2007.0007v1.pdf (submitted on 2020-07-01)
[20] Yi Cao, SunQM-5: Using the Interior {N,n//6} QM to Describe an Atom's Nucleus-Electron System, and to Scan from Sub-quark to Universe (Drafted in April 2018). https://vixra.org/pdf/2107.0048v1.pdf （submitted on 2021-07-06)
[21] Yi Cao, SunQM-5s1: White Dwarf, Neutron Star, and Black Hole Explained by Using {N,n//6} QM (Drafted in April 2018). https://vixra.org/pdf/2107.0084v1.pdf （submitted on 2021-07-13)
[22] Yi Cao, SunQM-5s2: Using {N,n//6} QM to Explore Elementary Particles and the Possible Sub-quark Particles. https://vixra.org/pdf/2107.0104v1.pdf (submitted on 2021-07-18)
[23] Yi Cao, SunQM-6: Magnetic force is the rotation-diffusion (RF) force of the electric force, Weak force is the RF-force of the Strong force, Dark Matter may be the RF-force of the gravity force, according to a newly designed {N,n} QM field theory. https://vixra.org/pdf/2010.0167v1.pdf (replaced on 2020-12-17, submitted on 2020-10-21)
[24] Yi Cao, SunQM-6s1: Using Bohr atom, {N,n} QM field theory, and non-Born probability to describe a photon's emission and propagation. https://vixra.org/pdf/2102.0060v1.pdf (submitted on 2021-02-11)
[25] Yi Cao, SunQM-7: Using {N,n} QM, Non-Born-Probability (NBP), and Simultaneous-Multi-Eigen-Description (SMED) to describe our universe. https://vixra.org/pdf/2111.0086v1.pdf (submitted on 2021-11-17)
[26] Yi Cao, SunQM-6s2: A Unified Description Of 1D-Wave, 1D-Wave Packet, 3D-Wave, 3D-Wave Packet, and |nlm> Elliptical Orbit For A Photon's Emission and Propagation Using {N,n} QM. https://vixra.org/pdf/2208.0039v1.pdf (submitted on 2022-08-08)
[27] Yi Cao, SunQM-6s3: Using {N,n} QM and "|nL0> Elliptical/Parabolic/Hyperbolic Orbital Transition Model" to Describe All General "Decay" Processes (Including the Emission of a Photon, a G-photon, or An Alpha-particle). (submitted on 2022-08-31, but has not been able to get posted out, I asked many times, no reply)
[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] Yi Cao, 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. https://vixra.org/pdf/2308.0118v1.pdf (submitted on 2023-08-18)
[31] Yi Cao, SunQM-6s7: The Face-to-face Tidal-locked Binary Orbital Rotation May Be the Origin of the Electron Spin and the Nucleon Spin. https://vixra.org/pdf/2310.0119v1.pdf (submitted on 2023-10-25)
[32] Yi Cao, SunQM-6s8: {N,n} QM Field Theory Development on the E/RFe-force, the G/RFg-force, and the Spin-spin Interaction. https://vixra.org/pdf/2311.0147v1.pdf (submitted on 2023-11-29)
[33] Yi Cao, SunQM-6s9: Reformulating Schrodinger Equation/Solution to Show Its r-1D Reversed-Diffusion Character for Solar System's {N,n} QM Structure Formation (Drafted in January 2020). https://vixra.org/pdf/2312.0101v1.pdf (submitted on 2023-12-19)

[34] Douglas C. Giancoli, Physics for Scientists & Engineers with Modern Physics, 4th ed. 2009, p1183, Fig-43-15.

[35] Douglas C. Giancoli, Physics for Scientists & Engineers with Modern Physics, 4th ed. 2009, p1183.

[36] Stephen T. Thornton & Andrew Rex, Modern Physics for Scientists and Engineers, 4th ed. 2013. p525, Table 14.1.

[37] David J. Griffiths, Introduction to Quantum Mechanics, 2nd ed., 2017, p362, eq-9.78.

[38] 周世勋, 量子力学教程, (Shi-Xun Zhou, Quantum Mechanics Tutorial) 1979 edition, p171, Fig-5.9-8.

Note: A series of SunQM papers that I am working on:
SunQM-4s4: More explanations on non-Born probability (NBP)'s positive precession in {N,n}QM. (in drafting since 2020)
SunQM-7s1: Relativity and non-linear {N,n} QM … (part-1, drafted in May 2024).
SunQM-7s2: Relativity and non-linear {N,n} QM … (part-2, drafted in June 2024).
SunQM-8: {N,n} QM and the condensed matter physics … (drafted in Jan. 2024).
SunQM-9s1: Addendums, Updates and Q/A for SunQM series papers. (in drafting since 2019).

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. (Figure 9.11, Figure 10.5)
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!
So far, my identity (for the {N,n} QM development) is: a former lecturer of Fudan University, and a (10 years closed-door, 2014 ~ 2024) citizen scientist of California.

Note: With my 34 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 suitable not only for the mass field, but also for the force field (or the energy field, etc.). Thus, my (10 years of closed-door) research phase on the {N,n} QM will end (most likely in the summer of 2024). After that, I will re-write the SunQM papers (~ 36 of them) in form of a text book. The initial plan is, 1) Try to formally publish all ~36 of SunQM papers as the original version (version-1, or version 2018) if possible; 2) Using ~ 2 years, to brief (by re-writing) all ~36 of SunQM papers (as version-2, or version 2025), the main purpose is to unify the nomenclature and the description, compress the total words from over 400,000 to less than 200,000, (and publish it if possible), make it ready for the text book writing; 3) Using 2 ~ 4 years, to write a Bohr-orbit-QM based {N,n} QM text book with ~ 100,000 words (as version-3, for high-school and college students), formally publish it if possible, and may make a few online video lectures; 4) Using 2 ~ 4 years, to add Schrodinger-equation-QM based {N,n} QM into the version-3 text book with final ~ 200,000 words (as version-4), formally publish it if possible, and may make a few online video lectures. It may take me total 6 ~10 years (2024 ~ 2035) to finish all the work.

Appendix A. All inversed RF-forces, including the inversed RFe-force (i.e., one kind of magnetic force), the inversed RFg-force (i.e., one kind of dark-matter force), and the inversed RFs-force (i.e., one kind of Weak force), are in the quasi-r-1D space and in the "quasi" nL0 mode (that does not produce the bound states nor the binding energy)

According to wiki "Weak interaction": "*The weak interaction does not produce bound states nor does it involve binding energy – something that gravity does on an astronomical scale, that the electromagnetic force does at the atomic level, and that the strong nuclear force does inside nuclei*". In SunQM-6, I showed that in the steady state, the RFe-force is in 100% RF (besides in nLL mode), so it does not show any magnetic force (or the magnetic $\vec{\mathbf{B}}$ field strength equals to zero, or $\vec{\mathbf{B}}$ vector =0). Only when a positive charge is in translation or spinning, then its primary E-force gains translational velocity $\vec{\mathbf{v}}$ or spin speed $\vec{\mathbf{s}}$, and then its primary E-force's orthogonal companion RFe-force decreases it RF from 100% to less than 100%, and become either the φ-1D "circular RFe-force" (under the translation motion, in nLL mode), or the "inversed RFe-force" (under the spin motion, in the "quasi nL0 mode", and in a "quasi-r-1D space"). Obviously, the φ-1D circular RFe-force (as one kind of magnetic force) will produce neither the bound states nor the binding energy (because it is sealed inside a circle). This result can be extended to the φ-1D circular RFg-force (i.e., one kind of dark-matter force), and to the φ-1D circular RFs-force (i.e., one kind of weak force), and they will produce neither the bound states nor the binding energy.

For the "inversed RFe-force" (as the second kind of magnetic force), it is in the "quasi nL0 mode", it does not produce the bound states neither the binding energy. In contrast, all the true nL0 mode force (the E-force, G-force, and S-force) do produce the bound states and the binding energy. So, this "inversed RFe-force" is not in a "true" nL0 mode. This result can also be expanded as: all inversed RF-forces (including RFe-force (i.e., a second kind of magnetic force), RFg-force (i.e., a second kind of dark-matter force), and RFs-force (i.e., a second kind of Weak force)) are in the "quasi nL0 mode" and in a "quasi-r-1D space" (that produce neither the bound states nor the binding energy).

Appendix B. For the e1{0,1//6}o, after moving r_1 inward by ΔN = 1, only the expression of e1{-1,n'=6..11//6}o is correct.

In {N,n} QM, the position of r_1 can be re-chosen (quantumly) at your will (see SunQM-5s2's section I-i). For example, after moving r_1 inward by ΔN = 1, a e1{0,1//6}o orbital shell can be re-expressed as e1{-1,n'=6..11//6}o orbital shells. (Note: n is the base quantum number and the n' is the high-frequency quantum number). Notice that e1{0,n=1//6}o cover n=1 to n=2 in size, or e1{0,n=1//6} to e1{0,n=2//6} in size, or e1{-1,n'=6//6} to e1{-1,n=12//6} in size, or e1{-1,n'=6..11//6}o orbital shells. Therefore, for H-atom, both e1{0,1//6}o orbital shell and e1{-1,n'=6..11//6}o orbital shells cover the exact same r-1D range from r_1 = 1× (5.29E-11) meters up to r_2 = 4× (5.29E-11) meters). In contrast, e1{-1,n'=1..5//6}o orbital shells cover r-1D range from $r_{n'=1}$ = (1/36)× (5.29E-11) meters up to $r_{n'=6}$ = 1× (5.29E-11) meters. This correct expression also fits to {N,n//6} with other prefixes and/or other q(s). Note: In my earlier SunQM papers, for the purpose of moving r_1 inward by ΔN = 1, I might have (occasionally) used some wrong expressions for e1{0,n=1//6}o, and if so, now I need to correct it.

Also see SunQM-5s2's section IV for **{N=-15..-14,n=1..5//6}o = {-15,n=1..35//6}o = {-14,n=1..35//6^2}o**.

Appendix C. How to explain some other stars have "hot Jupiter" in the {1,n=1..5//6}o orbital shell region while our solar system has only terrestrial planets?

(This should go to SunQM-1s1). This may mean that in our solar system, the H/He/NH_3/CH_4/H_2O atoms/molecules were evaporated before they accreted to be the primitive atmosphere of the {1,n//6} planets. This may further because that our Sun may have a relative large mass and thus may have started H-fusion at relative early stage of the quantum collapse of the pre-Sun ball evolution (most likely in {2,1//6} state), while those other suns that has relative small mass would start the H-fusion at relative later stage of the quantum collapse of the pre-Sun ball (most likely in {1,1//6} sized stage?), so that it had enough time to let all H/He/NH_3/CH_4/H_2O atoms/molecules in {1,n//6} n shells to be accreted as the primitive atmosphere of the {1,n//6} primitive planets (so they become "hot Jupiter"). Once the primitive atmosphere of the {1,n//6} primitive planets are formed, it is much more difficult to be evaporated away from a "hot Jupiter", because the "hot Jupiter" has enough G-force to hold it (even the ice-evap-line has passed {2,1//6} later on). This can be seen that even the current ice-evap-line is expected at {1,9//6}, and it has passed Earth's orbit {1,5//6}, the H_2O molecules in the ocean of Earth is still not evaporated away from Earth, because Earth has enough G-force to hold it.

Appendix D. Re-explain the "newborn" 0.02 Hz low-f photon that fly away in the general z direction

(This should go to SunQM-6s5's Appendix H). SunQM-6s5's Fig-12a can be re-explained as: the "newborn" 0.02 Hz low-f photon, once spun-off (initially in x direction) from the "mother" 656.1 nm photon, is still attracted by the "daughter" the red-shifted 656.1 nm photon (through the "entanglement force"), so it fly away in the general z direction, (just like a "newborn" α particle is spun-off initially in x direction but then is changed into the general z direction because it is attracted by the "daughter"). SunQM-6s5's Fig-12b should be discarded.

Appendix E. Two ways to explain the quantum (or major) rip off vs. the continues (or minor) rip off the surface matter of the planet Mercury

(Note: This example should go to SunQM-7's Appendix-D Example-4). (Note: All these examples will become questions/excises in a text book about the {N,n} QM that I am going to write during years of 2025 ~ 2035). For the planet Mercury, the passing rock-evap-line causes Mercury's surface matter to be burning-off at the rate of one millimeter/year (assumed). So far, in {N,n} QM, there are two major ways to describe this process. The first way was shown in SunQM-7's Appendix-D Example-4, using {N,n//q^j} QM and by moving r_1 inward, we can describe this process as either a quantum process (with a large r_1, or with a small j), or a continues process (with a small r_1, or with a large j). The second way is to use the method shown in SunQM-6s5's Appendix-i Fig-13, "*Using the "|nL0> Elliptical/Parabolic/Hyperbolic Orbital Transition Model" to describe that how an atom/molecule of H, H_2, He, H_2O, NH_3, CH_4, etc., in {1,n=1..5//6}o super shell was excited to the {2,n=1..5//6}o super shell, after the expanding of Sun's ice-evap-line*". The second way uses the concept of spin-off the outmost shell of the 3D wave packet.

Appendix F. Using {N,n} QM to determine the extra-stable orbits for an artificial Earth satellite

A more detailed explanation on SunQM-6s4's Fig-6c. Using n=3 as the example, when ~100% mass-occupancy, the mass fills in all |3,0,m> , |3,1,m> , |3,2,m> QM states, so that it forms a solid mass ball with r up to $r_{n+1=4}$; when < 1% mass-occupancy, the little mass only concentrated only at |3,2,2> QM states, so that it only forms a ring at $r = r_{n=3}$ (because the radial Born probability density function r^2*|R(3,2)|^2 has the maximum at $r = r_{n=3}$). This {N,n} QM nLL effect formed the Sun-planet system and the planet-moon system (e.g., Saturn-moon system, see SunQM-3s4's Table-2). For the same reason, the nLL force of {N,n} QM of the spinning Earth provides some extra-stable orbits for the artificial Earth satellites. First, because it is caused by spinning Earth's nLL force, all extra-stable orbits are in the equatorial plane of the spinning Earth. Besides it,

1) If using Earth's surface radius $r_{Earth} \approx 6400$ km as the $r_1 = r_{n=1}$, then either at $r_{n=2} = 4\times r_1 = 4\times6400$ km, or at $r_{n=3} = 9\times r_1 = 9\times6400$ km, or at $r_{n=4} = 16\times r_1 = 16\times6400$ km, etc., they become the extra-stable orbits for the artificial Earth satellites;

2) If using Earth inner core's radius $r_{Earth} \approx 6400/4$ km as the $r'_1 = r'_{n=1}$, then at $r'_{n=3} = 9\times r'_1 = 9\times6400/4$ km, $r'_{n=4} = 16\times r'_1 = 16\times6400/4$ km, etc., they become the extra-stable orbits for the artificial Earth satellites;

3) If using Earth inner-inner core's radius $r_{Earth} \approx 6400/4/4$ km as the $r''_1 = r''_{n=1}$, then $r''_{n=5} = 25\times r''_1 = 25\times6400/4/4$ km, $r''_{n=6} = 36\times r''_1 = 36\times6400/4/4$ km, etc., they become the extra-stable orbits for the artificial Earth satellites;

4) Then, for any specific orbit, the more times it showed up in the above three r_1, r'_1, r''_1 systems, the more extra stable it will be. For example, r = 4×6400 km = $r_{n=2}$ = $r'_{n=4}$ = $r''_{n=8}$ showed up in all three r_n, r'_n, r''_n systems, so it is the most stable orbits for the artificial Earth satellites; Also, r = 9×6400/4 km = $r'_{n=3}$ = $r''_{n=6}$ showed up in two of the three r_n, r'_n, r''_n systems, so it is the second most stable orbits for the artificial Earth satellites (meaning less stable than the r = 4×6400 km orbit, but still more stable than a random r orbit at nearby); $r''_{n=5}$ = 25×r''_1 = 25×6400/4/4 km is among the least extra-stable orbits for an artificial Earth satellite (because it only showed up in one of the three r_n, r'_n, r''_n systems, although this orbit is still more stable than a random r orbit at nearby).