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Quantum Mechanics Hypothesis of Solar System Structure: Quantum de Broglie Wavelength, LQG Similitude and Slow Bang Theory (SB)

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Abstract

This idea of quantifying the energy of bodies orbiting the Sun is not new. We have identified that quantization applies well if we use the true quantum number associated with the true energy state of rotating bodies. This quantum number is very high for the main bodies or planets ($10^{\sim 70 \text{ to } 76}$). However, since quantum energy levels E are very high and ΔE very low we observe that bodies can in practice occupy all orbits. Thus, the current observed stable positions of the bodies are the results of the quantization and the sum of the effects of other perturbative phenomena. To find a quantum state starting with $n = 1$, we expressed the true integer quantum numbers as a function of that of the planet Mercury and we find an excellent correlation. However, the search for a correlation of prediction of the average orbital radius of bodies using the simple integer number $n = 1, 2, 3, 4, 5, 6, 7, \ldots$ is not excellent for bodies beyond the planet Pluto. Indeed, several trans-Neptunian bodies have similar integer quantum numbers, which poses a problem in the sequence of integer numbers beyond 10. Moreover, it appears that the trans-Neptunian bodies seem to be grouped for many of them according to relatively well-defined bands. The study made it possible to question the de Broglie wavelength of bodies ($10^{\sim -58 \text{ to } -65}$ m). Indeed, with the hypothesis of Planck quantities that would apply to the scale of the universe, it is difficult to conceive that de Broglie wavelengths are less than the Planck length l_P. This led to an expression of the modified de Broglie wavelength λ_m that predicts an asymptotic lower limit value equal to πl_P. This modified de Broglie wavelength makes it possible to obtain a better correlation for the prediction of the average orbital radius of bodies. Finally, this modified wavelength of de Broglie made it possible to put into perspective the concept of the quantification of space with the idea of the minimum wavelength associated with photon's

energies during the generation of the energy of the universe according to a model already presented in this review. This modified de Broglie wavelength also makes it possible to imagine that the quantification of the volume of space involves the geometry of the sphere and the cube.

Keywords

Solar System, de Broglie Wavelength, Quantum Mechanics, Loop Quantum Gravity LQG

1. Introduction: Solar System and Previous Quantum Point of View

The idea behind this article comes from a concept already mentioned and used in a study about the quantum Schwardchild metric, *i.e.*, the quantification of variables at all scales and the fundamental absence of zero and infinite values in physics [1]. At the atomic scale, the demonstration of the quantum nature of particle behavior is well established. The prediction of the emission lines of the hydrogen atom and subsequently of the other atoms showed the great accuracy and ability of the quantum approach to predict the probability of position of the electrons via the wave function Ψ and the Schrödinger equation. Subsequently, by applying a certain similarity between the quantum model of the atom, several authors applied the same quantum reasoning to the scale of cosmological structures such as the Solar System [2] [3] [4] [5]. The idea is to identify the movement of the planets with that of the electrons around the nucleus or the Sun according to a model like that of the Bohr atom. The approach is quite logical and valuable because quantum theory does not exclude physical systems in any way regardless of their dimensions. The search for the mechanisms behind the formation of the Solar System is a very broad subject and several authors have proposed various theories. The Solar nebula hypothesis is generally accepted as the starting point for the formation of the Solar System (the Sun). The process of creating the star in turn produces a protoplanetary disk (dust and gas) that is at the origin of the formation of planets and other bodies. The whole process is dynamic, and it involves rearrangements of the orbits of the bodies according to the mass and position of the latter, the possible collisions between the bodies and the phenomena of resonance between the orbits of certain bodies. A numerical simulation of the evolution of the Solar System, called the Nice model [6], has made it possible to highlight the evolution of the orbits of major planets such as Jupiter, Saturn, Uranus and Neptune. In this article, we hypothesize that the current structure and current positions of the main bodies are mainly the quasi-final results of quantum mechanics because of gravitational dynamic effects and other energetic phenomena during the evolution of the Solar System. We refer the reader to Kholodenko [4], who presents a good review of previous work concerning the quantum approach applied to the Solar System.

However, the analogy with quantum mechanics causes difficulties. Indeed, we will see that the main constraint is in the individual variation of the mass of the planets which, unlike the case of electrons on orbitals, have the same mass. The proton-electron system does not have this mass diversity and the single wave function describes quantum states well (Bohr and Sommerfeld's quantisation rule model). In addition, the amounts of energy involved in the motion of the planets (~10^{35} J) and the de Broglie wavelengths λ_b associated with the planets (~10^{-63} to 10^{-58} m) bring the levels of quantization to n~$10^{70\text{ to }76}$. Nevertheless, in the past, constant efforts have been made to find quantization rules. The starting point not directly related to a quantum vision is the rather empirical observation of the law of distribution of the radius of the planets proposed by Bode, namely the Titius-Bode law (1772):

$$r = 0.4 + 0.15 \times 2^n$$

with r(AU) and $n = -\infty$, 1, 2, 3, 4, 5, 6, 7, 8 from Mercury to Neptune.

This empirical law has been the subject of much speculation for the discovery of new planets. However, the $-\infty$ value for Mercury and the r predicted values for Neptune and those beyond Nepture are becoming less and less accurate (~29% difference for Neptune). Rather, this law seems to be a clever arrangement or adjustment of the quantities involved in the Solar System. Subsequently, other laws based on different approaches were proposed, here are some of them.

Dermott's Law [7] $T(n) = T(0)C^n$;

Either $r \sim a = T(0)^{2/3}\left[\dfrac{G(M+m)}{4\pi^2}\right]^{1/3} C^{\frac{2n}{3}} = kC^{\frac{2n}{3}}$;

with a, the semi-major axis, and n a non-continuous sequence of integer.

Schmidt's law [8] $r = (a + bn)^2$;

Nesluslan's law [9] $r = 0.203(1.773)^n$;

with n (1, 2, 3, 4, …, 10) for the first 10 planets.

Scardigli's law (quantum) [5] $r = \dfrac{s^2}{GM_0}\mathrm{e}^{2\lambda m} = A\mathrm{e}^{2\lambda m}$;

with a constant A that depends on the mass of the body m and a numerical parameter λ.

More recently, Chang [10], using a quantum approach, proposes this law:

$$r = kn^2$$

with k and n variables according to the so-called terrestrial or Jovian planets.

In summary, for some studies, we see that the prediction of the average radius of the planets is based on a quantification using the integer n. The quantification of the dynamics of a system must be based mainly on the solution of the Schrodinger equation using the wave function associated with the mechanical system. That is what the next section is about.

2. The Wave Function in the Quasi-Classical Case

When the variation of the energy of one quantum state ΔE to a next is very small

compared to the energy of a state E, or the de Broglie wavelength λ_b associated with the particles is much smaller than the characteristic length l of a system, the quasi-classical approximation can be applied Landau [11] either:

$$\lambda_b \ll l \quad \text{or} \quad \Delta E = \frac{h}{T} = \frac{h}{2\pi\omega} \ll E$$

with T: the period of movement.

To illustrate the hypothesis of the quasi-classical case, **Table 1** below presents some energetic parameters associated with the main planets, dwarf planets and other bodies orbiting the Sun. The data come from a few references [12] [13] [14] [15]. Of course, a very large number of bodies (millions) orbit the Sun if we think of the asteroids, comets, and other unknown objects, etc. However, we limit the scope of this study to the main ones, namely the 8 planets, 5 dwarf planets and 10 other small bodies well reported. Moreover, this classification is relatively arbitrary because bodies that have sufficiently "cleansed" their environments over time are planets [16]. In **Table 1**, we have organized the information in order of the increasing average radius of the bodies. Indeed, this order makes it possible to see the geometric arrangement of the main bodies in the Solar System. We observe that the quasi-classical quantum condition is largely satisfied for all the bodies under study ~10^{-132}.

3. Quasi-Classical Case for the Solar System 1: Normal Quantum Case

The wave function (or wave functions) associated with the mechanical system of the main bodies rotating around the Sun is not determined directly and easily as in the case of a particle of uniform mass (electron) around a nucleus (proton) as in the case of the atomic model or a particle in a conservative field or a box. The system is much more complex because it involves many energetic phenomena beyond the mechanical rotation model. Think of the effects of the energy of the Sun, the solar wind, the gases or dust present, collisions between bodies, chemical effects, etc. A hypothesis must be made, let us assume that the main condition of the movement of bodies is governed by the quantum effects of motion to which is subsequently added other phenomena whose effects are of lesser importance. In other words, let us posit as a mechanical model, the effects of a conservative central field (gravity) having a quasi-classical quantum nature by quantifying the angular momentum L. The classical energy equations of the movement of a rotating body are:

$$E_T = E_k + E_p = \frac{1}{2}mv^2 - \frac{GM_0m}{r} = \frac{GM_0m}{2r} - \frac{GM_0m}{r} = \frac{-GM_0m}{2r}$$

$$\Psi(x) = \mathrm{e}^{\frac{2\pi i}{h}\sqrt{2m(E_T - E_p)}x} = \mathrm{e}^{ikx}$$

With x: the tangent direction of the orbit s and S the length of the ellipse. The quantification is:

$$L = mvr = \frac{nh}{2\pi}$$

Table 1. Some energetic data relating to the main rotating bodies [12] [13] [14] [15].

Body	Symbol	Mass (kg)	Semi Major Axis (AU)	Eccentricity	Semi Minor Axis (AU)	Rotation period (s)	Mean radius $(a+b)/2$ (m)	Mean velocity (m/s)	$\bar{E}_k$ Kinetic classic (J)	$\bar{E}_p$ Potential classic (J)	$\bar{E}_T$ Total classic (J)	Pulsation (rad/s)	ΔE Quasi-classical condition (J)
		m	a	e	b	T	$\bar{r}$	$\bar{v}$	$\frac{1}{2}m\bar{v}^2$	$\frac{-GMm}{\bar{r}}$	E_k+E_p	$\omega=2\pi/T$	ΔE
Mercury	Me	3.3E+23	3.9E−01	2.1E−01	3.8E−01	7.6E+06	5.729E+10	3.7E+32	3.7E+32	−7.6E+32	−3.9E+32	8.3E−07	7.7E−136
Venus	V	4.9E+24	7.2E−01	6.8E−03	7.2E−01	1.9E+07	1.082E+11	3.0E+33	3.0E+33	−6.0E+33	−3.0E+33	3.2E−07	3.5E−138
Earth	E	6.0E+24	1.0E+00	1.7E−02	1.0E+00	3.2E+07	1.496E+11	2.7E+33	2.7E+33	−5.3E+33	−2.7E+33	2.0E−07	2.3E−138
Mars	Ma	6.4E+23	1.5E+00	9.3E−02	1.5E+00	5.9E+07	2.274E+11	1.9E+32	1.9E+32	−3.7E+32	−1.9E+32	1.1E−07	2.0E−136
Ceres (dwarf)	C	9.5E+20	2.8E+00	7.6E−02	2.8E+00	1.5E+08	4.135E+11	1.5E+29	1.5E+29	−3.0E+29	−1.5E+29	4.3E−08	9.4E−131
Jupiter	J	1.9E+27	5.2E+00	4.8E−02	5.2E+00	3.7E+08	7.779E+11	1.6E+35	1.6E+35	−3.2E+35	−1.6E+35	1.7E−08	2.3E−143
Saturn	S	5.7E+26	9.5E+00	5.4E−02	9.5E+00	9.3E+08	1.426E+12	2.6E+34	2.6E+34	−5.3E+34	−2.7E+34	6.8E−09	2.6E−142
Uranus	U	8.7E+25	1.9E+01	4.7E−02	1.9E+01	2.7E+09	2.869E+12	2.0E+33	2.0E+33	−4.0E+33	−2.0E+33	2.4E−09	1.1E−140
Neptune	N	1.0E+26	3.0E+01	8.6E−03	3.0E+01	5.2E+09	4.498E+12	1.5E+33	1.5E+33	−3.0E+33	−1.5E+33	1.2E−09	8.0E−141
Pluto (dwarf)	P	1.3E+22	3.9E+01	2.5E−01	3.8E+01	7.8E+09	5.807E+12	1.4E+29	1.4E+29	−3.0E+29	−1.6E+29	8.0E−10	4.9E−133
Orcus	O	8.9E+20	3.9E+01	2.3E−01	3.8E+01	7.8E+09	5.821E+12	9.8E+27	9.8E+27	−2.0E+28	−1.1E+28	8.0E−10	1.1E−130
Ixion	I	5.4E+20	4.0E+01	2.4E−01	3.9E+01	7.9E+09	5.848E+12	5.9E+27	5.9E+27	−1.2E+28	−6.4E+27	8.0E−10	2.9E−130
Haumea (dwarf)	H	4.0E+21	4.3E+01	2.0E−01	4.2E+01	8.9E+09	6.387E+12	4.0E+28	4.0E+28	−8.3E+28	−4.3E+28	7.0E−10	5.2E−132
2002TX300	X	5.4E+20	4.3E+01	1.2E−01	4.3E+01	8.9E+09	6.429E+12	5.5E+27	5.5E+27	−1.1E+28	−5.6E+27	7.0E−10	2.9E−130
2005UQ513	Q5	8.2E+20	4.3E+01	1.5E−01	4.3E+01	9.0E+09	6.445E+12	8.3E+27	8.3E+27	−1.7E+28	−8.6E+27	7.0E−10	1.2E−130
Varuna	V	5.5E+20	4.3E+01	5.1E−02	4.3E+01	8.9E+09	6.448E+12	5.7E+27	5.7E+27	−1.1E+28	−5.7E+27	7.0E−10	2.8E−130
Quaoar	Q	6.3E+20	4.4E+01	3.8E−02	4.4E+01	9.1E+09	6.520E+12	6.4E+27	6.4E+27	−1.3E+28	−6.4E+27	6.9E−10	2.1E−130
Makémaké (naine)	K	3.1E+21	4.5E+01	1.6E−01	4.5E+01	9.7E+09	6.752E+12	3.0E+28	3.0E+28	−6.1E+28	−3.1E+28	6.5E−10	8.7E−132
Gonggong	G	2.9E+21	6.7E+01	5.0E−01	5.8E+01	1.7E+10	9.398E+12	1.7E+28	1.7E+28	−4.1E+28	−2.4E+28	3.6E−10	1.0E−131
Eris (dwarf)	E	1.6E+22	6.8E+01	4.4E−01	6.1E+01	1.8E+10	9.644E+12	9.7E+28	9.7E+28	−2.3E+29	−1.3E+29	3.6E−10	3.1E−133
G!kún‖'hòm dímà	Ga	7.1E+20	7.3E+01	4.9E−01	6.4E+01	2.0E+10	1.024E+13	3.8E+27	3.8E+27	−9.2E+27	−5.4E+27	3.2E−10	1.7E−130
2005QU182	U1	1.2E+21	1.1E+02	6.8E−01	8.4E+01	3.8E+10	1.476E+13	3.6E+27	3.6E+27	−1.1E+28	−7.0E+27	1.6E−10	5.8E−131
Sedna	Se	7.0E+21	5.3E+02	8.6E−01	2.7E+02	3.8E+11	5.973E+13	3.7E+27	3.7E+27	−1.5E+28	−1.1E+28	1.7E−11	1.7E−132

We find [3].

$$r \sim \frac{a+b}{2} = \left[\frac{h^2}{4\pi^2 m^2 G M_0}\right] n^2 = a_0^* n^2$$

with:

n (integer 1, 2, 3, 4, …, $10^{\sim 71 \text{ to } 76}$);

L (orbital angular momentum of the body);

a_0^* (equivalent to the Bohr radius of the planet of mass m).

The quantum energy levels of bodies are:

$$E_T = \left[\frac{-2\pi^2 G^2 M_0^2}{h^2}\right] \frac{m^3}{n^2} = -7.923 \times 10^{107} \frac{m^3}{n^2}$$

$$E_k = -E_T$$

$$E_P = 2E_T$$

Table 2 shows the quantum values associated with the rotating body. We see that quantum levels n are very high. This is due to the masses that are high and the de Broglie wavelength which is very small. We can draw 2 main conclusions from quantifying the mechanical energy of rotating bodies around the Sun.

1) The total energy is inversely proportional to the level of quantification n squared. This is consistent with Bohr's model.

Table 2. Quantum approach of the main rotating bodies.

body	True Level (integer) (-)	Relative to Mercury (-)	Mean radius $(a+b)/2$ (AU)	Predicted Mean radius $r \sim 0.382n^{2}$ (AU)	Diff (%)	Momentum (kg m/s)	de Broglie wavelength (m)	$\overline{E}_p$ potential quantum (J)	$\overline{E}_k$ kinetic quantum (J)	$\overline{E}_T$ Total quantum (J)	$\Delta\overline{E}_T$ (classical-quantum) (J)
	n	$n^* = \left(\frac{m_{\text{mercury}}}{n_{\text{mercury}}}\right)\frac{n}{m}$	$\overline{r}$	$\overline{r}_p$	$100(\overline{r}_p - \overline{r})/\overline{r}$	$\overline{p} = mS/T$	$\lambda_b = h/\overline{p}$	$= 2E_T$	$= -E_T$	E_T $-7.923\times10^{107}\frac{m^3}{n^2}$	%
Mercury	8.63E+72	1.00	0.38	0.38	−0.25	1.56E+28	4.24E−62	−7.65E+32	3.82E+32	−3.82E+32	3.06
Venus	1.75E+74	1.37	0.72	0.72	−0.26	1.71E+29	3.89E−63	−5.97E+33	2.99E+33	−2.99E+33	0.00
Earth	2.52E+74	1.62	1.00	1.00	−0.26	1.78E+29	3.72E−63	−5.30E+33	2.65E+33	−2.65E+33	0.02
Mars	3.34E+73	1.99	1.52	1.52	−0.26	1.55E+28	4.29E−62	−3.75E+32	1.87E+32	−1.87E+32	0.65
Ceres (dwarf)	6.65E+70	2.69	2.76	2.76	−0.26	1.69E+25	3.92E−59	−3.04E+29	1.52E+29	−1.52E+29	0.43
Jupiter	1.83E+77	3.68	5.20	5.19	−0.26	2.48E+31	2.67E−65	−3.24E+35	1.62E+35	−1.62E+35	0.08
Saturn	7.42E+76	4.99	9.53	9.51	−0.26	5.48E+30	1.21E−64	−5.29E+34	2.65E+34	−2.65E+34	0.19
Uranus	1.61E+76	7.08	19.18	19.13	−0.26	5.90E+29	1.12E−63	−4.02E+33	2.01E+33	−2.01E+33	0.16
Neptune	2.37E+76	8.86	30.07	29.99	−0.26	5.56E+29	1.19E−63	−3.02E+33	1.51E+33	−1.51E+33	0.00
Pluto (dwarf)	3.46E+72	10.07	38.82	38.72	−0.24	6.13E+25	1.08E−59	−3.00E+29	1.50E+29	−1.50E+29	4.45
Orcus	2.35E+71	10.08	38.91	38.81	−0.25	4.17E+24	1.59E−58	−2.03E+28	1.01E+28	−1.01E+28	3.65
Ixion	1.43E+71	10.10	39.09	38.99	−0.25	2.52E+24	2.63E−58	−1.23E+28	6.13E+27	−6.13E+27	4.18
Haumea (dwarf)	1.11E+72	10.56	42.70	42.59	−0.25	1.80E+25	3.68E−59	−8.33E+28	4.16E+28	−4.16E+28	2.80
2002TX300	1.50E+71	10.59	42.97	42.86	−0.26	2.44E+24	2.72E−58	−1.12E+28	5.58E+27	−5.58E+27	1.14
2005UQ513	2.27E+71	10.61	43.08	42.97	−0.26	3.69E+24	1.79E−58	−1.69E+28	8.45E+27	−8.45E+27	1.55
Varuna	1.53E+71	10.61	43.10	42.99	−0.26	2.49E+24	2.66E−58	−1.13E+28	5.66E+27	−5.66E+27	0.19
Quaoar	1.76E+71	10.67	43.58	43.47	−0.26	2.84E+24	2.33E−58	−1.28E+28	6.41E+27	−6.41E+27	0.11
Makemake (dwarf)	8.80E+71	10.86	45.13	45.02	−0.26	1.36E+25	4.87E−59	−6.10E+28	3.05E+28	−3.05E+28	1.91
Gonggong	9.73E+71	12.82	62.82	62.82	0.00	9.85E+24	6.73E−59	−4.09E+28	2.04E+28	−2.04E+28	15.36
Eris (dwarf)	5.59E+72	12.98	64.47	64.39	−0.12	5.66E+25	1.17E−59	−2.26E+29	1.13E+29	−1.13E+29	12.22
G!kúnǁ'hòmdímà	2.48E+71	13.38	68.43	68.41	−0.03	2.33E+24	2.85E−58	−9.19E+27	4.59E+27	−4.59E+27	14.61
2005QU182	5.07E+71	16.14	98.69	99.55	0.87	2.95E+24	2.25E−58	−1.07E+28	5.33E+27	−5.33E+27	24.33
Sedna	6.05E+72	33.07	399.29	417.79	4.63	7.24E+24	9.15E−59	−1.48E+28	7.41E+27	−7.41E+27	33.09

2) The quantification of energy involves the mass m of the body cubed. Thus, each body of mass m has a level of quantification of energy that depends on n and mass m. This element is different from Bohr's model.

In Figure 1, we see the average radius of the bodies as a function of the true

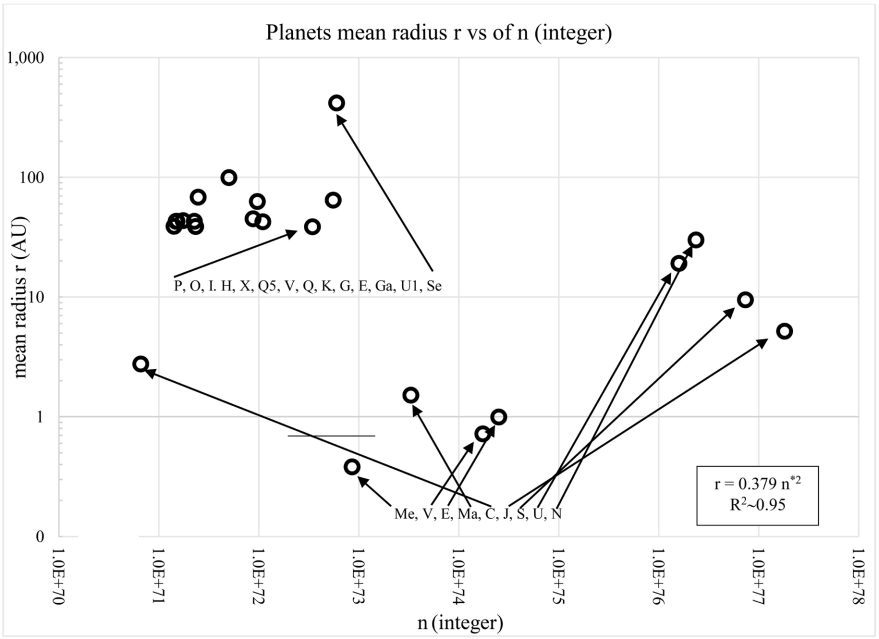

Figure 1. Radius of bodies as a function of true quantum number n (integer).

quantum number n (integer). As mentioned, the variable masses of the bodies prevent them from finding any order. Some authors have normalized quantization by expressing the angular momentum L per unit mass m. [3].

Similarly, we can express the integer number relative to the planet Mercury n^* and see the progression of the energy level of successive bodies.

$$n_{\text{mercury}} = 8.495191308550330\cdots 0\times 10^{72} \quad \text{(integer)}$$

$$n^* = \left(\frac{m_{\text{mercury}}}{n_{\text{mercury}}}\right)\frac{n}{m}$$

The quantum prediction of total energy compares well to the classical one but for distant bodies, the eccentricity of the orbit is greater which causes a greater error for the length of the orbit S and a lower estimate of the average total energy (difference of 33% for Sedna). If we plot a graph the average distance $\bar{r}$ as a function of the quantum energy level relative to the planet Mercury to obtain a variation starting with $n^* = 1$, we obtain the graph in **Figure 2**. Indeed, the correlation is like that proposed by Chang n^{*2} [10] and it is relatively excellent for the first 18 bodies in solar orbit. If we make a comparison between the correlations for the first 5 bodies (Mercury, Venus, Earth, Mars, Ceres), we obtain:

Chang [10]

$$r = kn^2 = 0.042n^2\,(\text{AU})$$

with (n = 3, 4, 5, 6, 8).

This study

$$r = k^* n^{*2} = \left[\frac{h^2 n_{\text{mercury}}^2}{1.495\times 10^{11}\,[\text{m/AU}]\,4\pi^2 m_{\text{mercury}}^2 GM_0}\right] n^{*2} \sim 0.382n^{*2} \quad \text{(AU)}$$

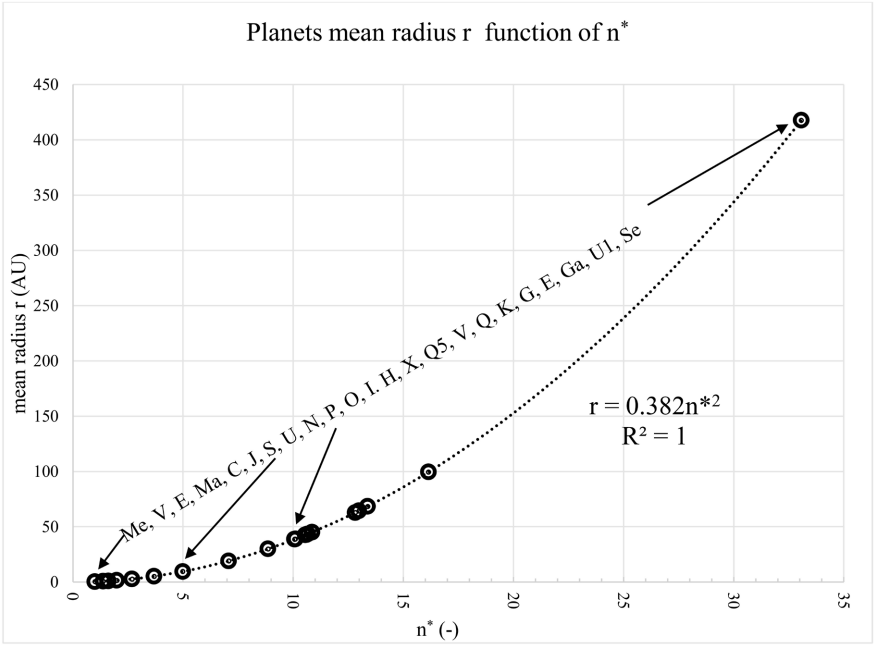

Figure 2. Prediction of the average radius of bodies as a function of the quantum number relative to the planet Mercury (n^*).

With ($n^* = 1, 1.39, 1.64, 2.01, 2.72$).

If we take into consideration that the first number n of the Chang correlation is 3, we find a similarity between the constants, *i.e.*

$$k^* = 1.002k$$

We see that the quasi-quantum approach as well as the energies in question in the Solar System basically involves very high energy levels hence the generation of very large quantum numbers. In Table 2, if we try to propose a correlation based on integers starting with $n = 1$ and following with ($n = 2, 3, 4, 5, 6, 7, \ldots$), we get difficulties in obtaining an interesting correlation in n^2. We must either space the integer n or use the odd numbers and use a series of different constants for the bodies closer and farther from the Sun. We see that the quasi-classical quantization of the orbits of the main bodies is not direct because it involves a variable mass m of the bodies. In addition, we get that a certain number of bodies have about the same range of values $n^* \sim 10$ to 11. This result seems to indicate the existence of a cosmological phenomenon that favors this energy band for several bodies that have a similar mass (trans-Neptunian 10^{20} to 10^{21} kg).

4. Correction for Quantum de Broglie Wavelength

In the process of quantifying orbits and the quantum energy associated with bodies, the Broglie wavelength appears naturally because it is it that makes the link between the classical and quantum approach (quantization of the angular momentum L). However, when a question arises, can we associate wavelengths as small as $\lambda_b = 10^{-58}$ to 10^{-65} m for rotating planets? As an example, the order of

magnitude between the radius of Jupiter's orbit r and the de Broglie length λ_b is ~10^{76}! The physical significance of this quotient is difficult to conceive. Moreover, if we accept the existence of Planck quantities which are limits such as the Planck length $l_P \sim 1.62^{-35}$ m, how can we obtain wavelengths several orders of magnitude less than this limit? We can consider revisiting the expression of this de Broglie wavelength with this lower limit in mind l_P. Let be the equation of the wavelength to which we add a variation (or uncertainty) associated with the momentum:

$$\lambda = \frac{h}{p+\Delta p}$$

$$\lambda + \lambda\frac{\Delta p}{p} = \frac{h}{p}$$

$$\lambda_m \sim \frac{h}{p} + h\frac{\Delta p}{p^2} = \lambda_b + h\frac{\Delta p}{p^2}$$

We can estimate the permissible variation of Δp with the Heisenberg uncertainty:

$$\Delta p \Delta x \geq \frac{h}{4\pi}$$

$$\lambda_b = \frac{h}{p} + \frac{h^2}{p^2}\frac{1}{4\pi\Delta x}$$

In the equation above, we have added a term to the de Broglie wavelength which is a function of the uncertainty associated with the position of the particle Δx. We see that the uncertainty of the position cannot be zero ($\Delta x \to 0$) because at this time, the uncertainty associated with the de Broglie length tends towards ∞. That is, we cannot determine the wavelength of the particle or the momentum p of it. We can posit that the minimum uncertainty of the wavelength may be the Planck length l_P, *i.e.*, the minimum uncertainty of the Planck momentum $p_P/2$.

$$l_P = \sqrt{\frac{hG}{2\pi c^3}} \quad \text{and} \quad p_P = \frac{h}{2\pi l_P}$$

We find this expression of the de Broglie wavelength modified considering the uncertainty principle. The equation thus determines a lower limit to this wavelength in the case where the momentum p becomes very large (case of moving bodies in the Solar System).

$$\lambda_m = \frac{h}{p} + \frac{h^2}{p_P^2}\frac{1}{4\pi l_P} = \frac{h}{p} + \frac{h^2}{\left(\frac{h}{2\pi l_P}\right)^2}\frac{1}{4\pi l_P} = \frac{h}{p} + \pi l_P = \lambda_b + \pi l_P$$

To illustrate this modified de Broglie wavelength, the graph in **Figure 3** shows the two de Broglie wavelengths as a function of the pmomentum of the body. As an example, we see that the protons of the LHC or the electrons of CERN have a

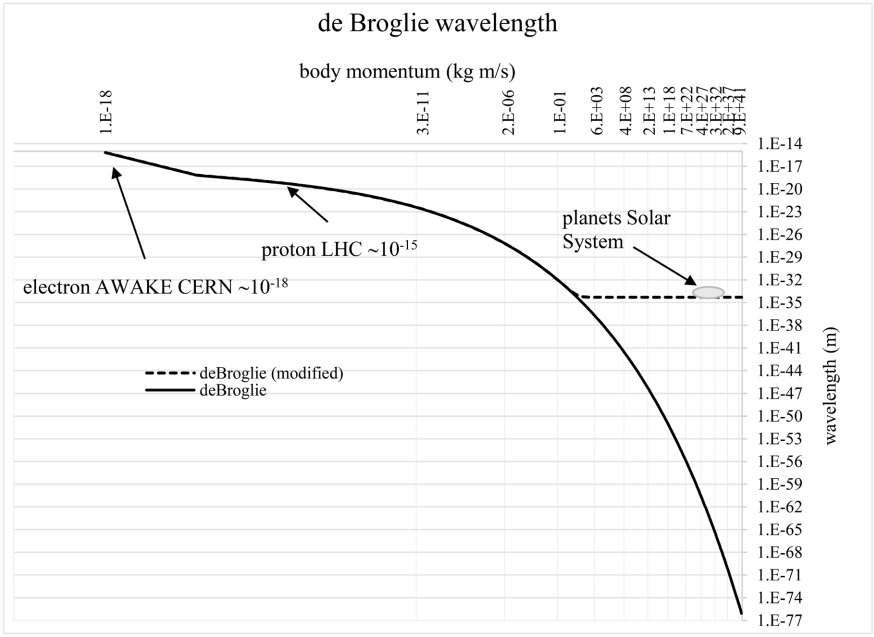

Figure 3. Wavelength of de Broglie as a function of momentum.

momentum too small to be able to detect this lower limit of the modified wavelength. In addition, the momentum of the bodies in the Solar System is in the modified wavelength zone. If we accept this lower limit of the de Broglie wavelength, we obtain the following quantum equations.

$$n_m \lambda_m = 2\pi r$$

$$n_m = \frac{2\pi r}{\lambda_b + \pi l_P} = \frac{n}{1 + \frac{\pi l_P}{\lambda_b}}$$

Finally for total energy we find:

$$E_T = \left[\frac{-2\pi^2 G^2 M_0^2}{h^2}\right]\left[\frac{\lambda_b}{\lambda_b + \pi l_P}\right]^2 \frac{m^3}{n_m^2} = -7.923\times 10^{107}\left[\frac{\lambda_b}{\lambda_b + \pi l_P}\right]^2 \frac{m^3}{n_m^2}$$

This is the same result found previously corrected for a term that considers the lower limit of the modified de Broglie wavelength πl_P. In the next section, we will apply this lower limit of the wavelength to see the impact on quantization.

5. Quasi-Classicalcase for the Solar System 2: Withde Broglie Modified Wavelength

We repeat the values in Table 2 in Table 3 with the correction for the modified de Broglie wavelength.

In Table 3, we see that the modified de Broglie wavelength is never less than the low limit value (πl_P), which makes it possible to obtain a progression of the modified quantum number n more regular because it depends less on the amount of motion of the body. This has an effect like a normalization of the angular

momentum L expressed per unit mass. Then, if we express the quantum number modified according to that of the planet Mercury to obtain a progession starting with 1, we find an excellent linear correlation (~R^2 0.99, see Figure 4). In Table 3, we see that the predicted quantum quasi-classical energies compare very well with the classical ones except for very distant bodies (ex Sedna) for which the eccentricity is high, and the mean radius of the ellipse is imprecise.

The correlation is expressed as follows:

$$\overline{r} = \left(\frac{l_P}{2} \frac{n_{m\ \text{mercury}}}{1.49\times10^{11}\left[\text{m/AU}\right]} \right) n_m^* \sim 0.382 n_m^* \left(\text{AU}\right)$$

Table 3. Quantum approach of the main rotating bodies (with the modified de Broglie wavelength).

body	Real Level (integer) (-)	Relative to Mercury (-)	Mean radius (a + b)/2 (AU)	Predicted Mean radius $r \sim 0.383n^*$ (AU)	Momentum (kg m/s)	de Broglie modified wavelength (m)	$\overline{E}_p$ potential quantum (J)	$\overline{E}_k$ kinetic quantum (J)	$\overline{E}_T$ Total quantum (J)	$\Delta\overline{E}_T$ (classical-quantum) (J)
	n_m				$\overline{p} = mS/T$		$= 2E_T$	$= -E_T$	E_T $-7.923\times10^{107}\left[\frac{\lambda_b}{\lambda_b + \pi l_p}\right]^2 \frac{m^3}{n_m^2}$	%
Mercury	7.09E+45	1.00E+00	0.38	0.38	1.56E+28	5.08E−35	−7.65E+32	3.82E+32	−3.82E+32	3.06
Venus	1.34E+46	1.89E+00	0.72	0.72	1.71E+29	5.08E−35	−5.97E+33	2.99E+33	−2.99E+33	0.00
Earth	1.85E+46	2.61E+00	1.00	1.00	1.78E+29	5.08E−35	−5.30E+33	2.65E+33	−2.65E+33	0.02
Mars	2.81E+46	3.97E+00	1.52	1.52	1.55E+28	5.08E−35	−3.75E+32	1.87E+32	−1.87E+32	0.65
Ceres (dwarf)	5.12E+46	7.22E+00	2.76	2.76	1.69E+25	5.08E−35	−3.04E+29	1.52E+29	−1.52E+29	0.43
Jupiter	9.63E+46	1.36E+01	5.20	5.20	2.48E+31	5.08E−35	−3.24E+35	1.62E+35	−1.62E+35	0.08
Saturn	1.76E+47	2.49E+01	9.53	9.53	5.48E+30	5.08E−35	−5.29E+34	2.65E+34	−2.65E+34	0.19
Uranus	3.55E+47	5.01E+01	19.18	19.18	5.90E+29	5.08E−35	−4.02E+33	2.01E+33	−2.01E+33	0.16
Neptune	5.57E+47	7.85E+01	30.07	30.07	5.56E+29	5.08E−35	−3.02E+33	1.51E+33	−1.51E+33	0.00
Pluto (dwarf)	7.19E+47	1.01E+02	38.82	38.82	6.13E+25	5.08E−35	−3.00E+29	1.50E+29	−1.50E+29	4.45
Orcus	7.20E+47	1.02E+02	38.91	38.91	4.17E+24	5.08E−35	−2.03E+28	1.01E+28	−1.01E+28	3.65
Ixion	7.24E+47	1.02E+02	39.09	39.09	2.52E+24	5.08E−35	−1.23E+28	6.13E+27	−6.13E+27	4.18
Haumea (dwarf)	7.90E+47	1.11E+02	42.70	42.70	1.80E+25	5.08E−35	−8.33E+28	4.16E+28	−4.16E+28	2.80
2002TX300	7.96E+47	1.12E+02	42.97	42.97	2.44E+24	5.08E−35	−1.12E+28	5.58E+27	−5.58E+27	1.14
2005UQ513	7.98E+47	1.12E+02	43.08	43.08	3.69E+24	5.08E−35	−1.69E+28	8.45E+27	−8.45E+27	1.55
Varuna	7.98E+47	1.13E+02	43.10	43.10	2.49E+24	5.08E−35	−1.13E+28	5.66E+27	−5.66E+27	0.19
Quaoar	8.07E+47	1.14E+02	43.58	43.58	2.84E+24	5.08E−35	−1.28E+28	6.41E+27	−6.41E+27	0.11
Makemake (dwarf)	8.35E+47	1.18E+02	45.13	45.13	1.36E+25	5.08E−35	−6.10E+28	3.05E+28	−3.05E+28	1.91
Gonggong	1.17E+48	1.64E+02	62.82	62.82	9.85E+24	5.08E−35	−4.09E+28	2.04E+28	−2.04E+28	15.36
Eris (dwarf)	1.20E+48	1.68E+02	64.47	64.47	5.66E+25	5.08E−35	−2.26E+29	1.13E+29	−1.13E+29	12.22
G!kún‖'hòmdímà	1.27E+48	1.79E+02	68.43	68.43	2.33E+24	5.08E−35	−9.19E+27	4.59E+27	−4.59E+27	14.61
2005QU182	1.85E+48	2.58E+02	98.69	98.69	2.95E+24	5.08E−35	−1.07E+28	5.33E+27	−5.33E+27	24.33
Sedna	7.75E+48	1.04E+03	399.29	399.29	7.24E+24	5.08E−35	−1.48E+28	7.41E+27	−7.41E+27	33.09

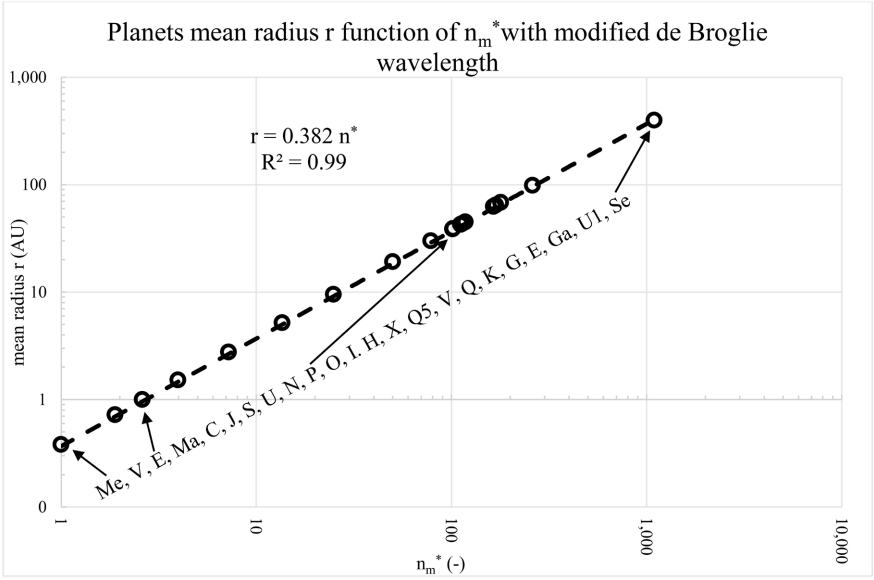

Figure 4. Prediction of the average radius as a function of the modified quantum number n^* relative to the planet Mercury.

6. Search for a Simplified Quantification (n = 1, 2, 3, 4, 5, 6, 7, ...)

Can we find a more simplified quantization, *i.e.*, function of progressive integers n rather than on the modified quasi-classical quantum number n_m^*? **Figure 5** shows the graph of the average radius as a function of the integer n (=1, 2, 3, 4, 5, 6, 7, …). We see a first mode for the first 10 planets (Mercury to Pluto). Subsequently, the second mode, which begins in the trans-Neptunian zone, no longer seems to correspond to an exponential progression. For major bodies 11 to 19, simplified quantification does not work. Finally for the last planets, the third mode seems to be similar to the first, but the exponential correlation uses the cubic power of n (**Figure 4**).

Of course, in this article we do not have the ability to analyze the evolution of the Solar System. Indeed, this is beyond the scope of this article. However, as shown in **Figure 6** [17], we see that beyond Neptune, several small bodies orbit according to similar ellipses as grouped by band of a certain width.

Is there a simple explanation? One thing is certain, the authors classified objects beyond Neptune as trans-Neptunian and identified resonances according to the number of orbits they make in full relation to that of Neptune (2:1, 3:1, etc.). One question remains, why do small bodies in large numbers, such as plutinos (2:3) end up there as grouped according to "bands" (well beyond the number mentioned in this article)? This question cannot be answered directly, but we can mention that, according to this study, the main bodies in this area (11 to 18) have similar modified quantum numbers n_m^* (~100 to 115). This is an observable feature of some quantification of the orbits of bodies around the Sun. In addition, it should be mentioned that the orbital velocities of the objects in this area as well as the spatial volumes traveled by them are much lower than those

closer to the Sun and this reduces the possibilities of rapprochement, collisions, ejections or formation under the aspect of a larger planet by gravity. If we consider that the volume increases as r^3 well as the orbital velocity as decreases as $r^{1/2}$, we see that the probabilities of collision of bodies decrease greatly with the semi-major axis a. Another band, less concentrated around 45 AU, called the Kuiper belt contains many bodies called cubewanos. Several larger bodies such as Haumea, Makemake, are present in this wider band. Beyond the Kuiper belt, the bodies appear to be more dispersed although it is possible to distinguish a faint appearance of smaller bands (see around 54, 63 and 68 AU). In summary, we observe some form of arrangement of bodies beyond the planet Neptune that could be like a form of energetic quantification in part according to the mass of bodies, distances and resonances between bodies.

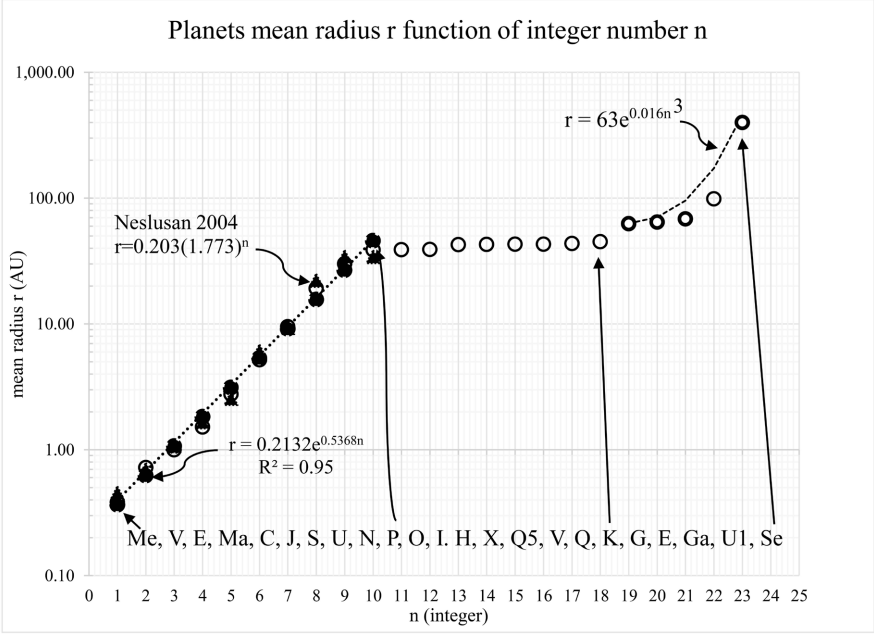

Figure 5. Prediction of the average radius as a function of an integer sequence (n = 1, 2, 3, 4, 5, 6, 7, …).

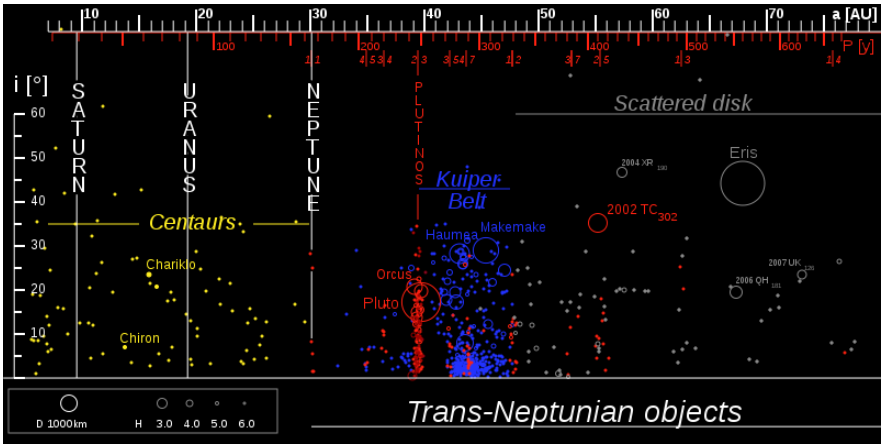

Figure 6. Relative position of bodies in orbit (trans-Neptunian) [17].

7. Modified de Broglie Wavelength, Some Similudes with LQG

In the previous section, we presented the modified de Broglie wavelength according to the Planck length l_P hypothesis which is, maybe, the permissible minimal length for all measurable quantities expressed as a length. We found this minimal modified de Broglie wavelength λ_m to be πl_P. Now, how can we interpret this result with the idea of the quantification of space as suggested by LQG theory [18]? First, the π value refers to the geometry of the circle since this length is at the origin and does not come from an evolutionary process of the universe since space is present hypothetically from the foundation of the universe. Always keeping in mind, a simple explanation, we can imagine that the minimum de Broglie length must be contained in this minimum length. It is in a way a maximum possible vibration (electromagnetic) of a maximum amount of energy in a minimum space. This amount of energy corresponds to the Planck energy E_P of a photon of wavelength πl_P contained in a Planck volume l_P^3, the maximum energy density that can be reached in our universe is.

$$\rho_{EP}^{\max} = \frac{E_P}{l_P^3} = \frac{h\nu}{l_P^3}\frac{hc}{(\pi l_P)l_P^3} = \frac{4\pi c^7}{hG^2} = 9.26\times 10^{113}\ \mathrm{J/m^3}$$

An image of the quantification of space could be that of a volume quantum having a nature like the sphere and the cube. Indeed, only the repeated cube or the combination of regular octahedra and regular tetrahedra can fill the space (there are 5 regular polyhedra). We must admit that to fill the space using the same repeated structure, we must choose the cube (or a modified cube). The lengths of the stops of the cubes can be distorted according to a certain rule in accordance with the space-time (length dilation) but the invariant could be the volume. This image of the quantification of space could be the following in a flat space (**Figure 7**).

A particle (or group of particles) occupies a number n (nodes) of quantum of space bound by a number l of links (6 links for the cube) ($n \sim 9\times 10^{38}$ for a simple e^-). The propagation of momentum follows a wave form of wavelength associated with that of de Broglie (mass) or electromagnetic (photon), the changing direction of the trajectory of the particle, involves a zig-zag arrangement or step of *n* quantum of space that is added one by one according to a process *p*, *q*, *r*. The curve followed by the particle could involve the "memory" of a certain number n of quantum of space called "graph" via the l links. Thus, the evolution of the quantity of motion (or energy) must follow a quantum profile at the base (succession of *p*, *q*, *r*). The volume of space occupied by energy is no longer an independent continuum that is contained in an independent volume but rather a bi-univocal relationship of the evolution of energy in quantum space (series of *p*, *q*, *r* evolution) via a function that would possibly be the wave function. This idealized vision resembles in part that proposed by Ashtekar [18] and Rovelli [19] who propose an approach rather based on the non-regular tetrahedron.

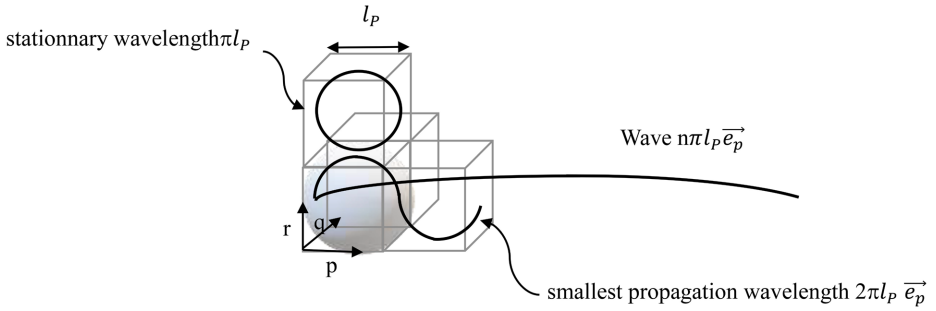

Figure 7. "Cubic-spherical space atom" (quantum of space) and smallest wavelength (3 directions *p*, *q*, *r*).

8. Beginning of the Universe and the Generation of Energy According to Quantification and Slow Bang Theory (SB)

In an earlier study on the origin of the universe, Perron [20], this energy density associated with the first alpha photon is ~11% at the first Planck step t_P at the beginning of the generation of the energy of the universe (first Planck time and first Planck volume). Here is a possibility of a mechanism for generating the energy of the universe considering the quantum nature of the process. According to the model, Perron [20] and the quantization of energy and space, alpha photons are generated, at each Planck time, for ~10^{-9} s according to a progression close to $(n+1)^3$, n being the Planck time number. The energy source causing alpha photon generation is contained at the outer edge of the universe. The number reached is about 6.4×10^{89} γ. During this period of energy generation, new alpha photons of wavelength close to πl_P are created and those already present can move from one quantum space to another that is like spherical geometry whose radius r corresponds to $l_P/2$. Photons oscillate in this quantum space from one quantum volume to another. Each photon is generated at the same energy but due to the expansion of the universe the frequency of each decrease as it goes. At the end of the generation process, all photons represent about 3.5×10^{98} J and the radius of the universe currently is ~0.4 m. Subsequently, the expansion of the universe continues and the energy of the photons decreases in proportion to the increase in the expansion since the number of alpha photons is fixed. The expansion of the universe causes the generation of new quantum of space around the perimeter, but the expansion could also involve some expansion (volume) of the already present quantum of space. Photons subsequently propagate and the generation of particles of all kinds occurs at different energy scales as the universe cools. We refer the reader to the model in question. One could call the model in question Slow Bang (SB). Of course, the process of generating the energy of the universe is much more complex in its fundamental nature but the principle of quantum jump generation at the rate of $(n+1)^3$ seems possible. One fact is to be noticed with this model. There is no longer a singularity properly speaking at the beginning of the universe (Big Bang) because the energy is generated according to a progressive process (Slow Bang)

and in phase with the volume. Inflation theory is no longer necessary because photons have time to exchange information faster than expansion. However, the source of energy, external to this universe, is unknown…

9. Conclusion

We have identified that quantization applies well if we use the true quantum number associated with the true energy state of rotating bodies. This quantum number is very high for the main bodies or planets ($10^{\sim 70 \text{ to } 76}$). However, since quantum energy levels E are very high and ΔE, very low we observe that bodies can in practice occupy all orbits. Thus, the current observed stable positions of the bodies are the results of the quantization and the sum of the effects of other perturbative phenomena. To find a quantum state starting with $n = 1$, we expressed the true integer quantum numbers as a function of that of the planet Mercury and we find an excellent correlation. However, the search for a correlation of prediction of the average orbital radius of bodies using the simple integer number $n = 1, 2, 3, 4, 5, 6, 7, \ldots$ is not excellent for bodies beyond the planet Pluto. Indeed, several trans-Neptunian bodies have similar integer quantum numbers, which poses a problem in the sequence of integer numbers beyond 10. Moreover, it appears that the trans-Neptunian bodies seem to be grouped for many of them according to relatively well-defined bands. The study made it possible to question the de Broglie wavelength of bodies ($10^{\sim 58 \text{ to } -65}$ m). Indeed, with the hypothesis of Planck quantities that would apply to the scale of the universe, it is difficult to conceive that de Broglie wavelengths are less than the Planck length l_P. This led to an expression of the modified de Broglie wavelength λ_m that predicts an asymptotic lower limit value equal to πl_P. This modified de Broglie wavelength makes it possible to obtain a better correlation for the prediction of the average orbital radius of bodies. Finally, this modified wavelength of de Broglie made it possible to put into perspective the concept of the quantification of space with the idea of the minimum wavelength associated with photon's energies during the generation of the energy of the universe according to a model already presented in this review [20]. This modified wavelength of de Broglie also makes it possible to imagine that the quantification of the volume of space involves the geometry of the sphere and the cube.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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