Exact Planck Length Unveils Quantum Gravity

by Hamid – August 2011

Abstract

Based on the newest investigations about *Quantum Geometry*, *Exact Planck Length* is not a derivative of a combination of "**G**", "**ħ**" and "**c**", but is a fundamental physical constant equal to **$(1/6)^{37}$μm** which is predictable using the new probability wave function. This numerical value is the diameter of smallest particle in physics that, quite contrary to the basic idea behind ***String Theory***, has a perfectly spherical shape. Furthermore, length, as a quantum variable, cannot be measured with an uncertainty smaller than this length, so in some sense it is really the smallest meaningful length in physics.

If we could mathematically prove that "**G"** is variable and as a result is not a fundamental constant, then we do have sufficient arguments to claim that gravity, like the other three forces, is also quantum in nature. In this article it is aimed to analyze this particular topic and, if possible, to formulate the quantum behavior of gravity.

1. Introduction

A general study of current viewpoints on quantum mechanics makes it clear that after almost a century of endeavor, the most important aspects of this branch of theoretical physics are still obscure and bizarre. Apart from other serious reasons, this situation partly originates in ambiguous and misleading views, concepts, principles and theories that are simply quoted and repeated regularly without any objective analysis and consequently, without any considerable result. Therefore, it appears that a new thought experiment (neue Gedankenexperiment) is needed to change the existing, often ineffective paradigms in this exciting branch of physics which employs mathematical models to rationalize, explain and predict natural phenomena. Perhaps it is the time for us to rinse the eyes and to introspect. In my opinion, the illiterates of the 21st Century are not the only ones who cannot read and write, but also are those who cannot throw away the false portion of their knowledge and learn again.

A couple of most-widely accepted ideas of the wonderful and sometimes bizarre world of quantum mechanics would probably be "***Wave-Particle Duality Concept"*** and "***Uncertainty Principle***", both were declared by the key 20th Century theoretical physicists. The former, which has been founded on false knowledge, is unrealistic and therefore is a misleading concept [1]. The latter is an ineffective principle, especially because of lacking the necessary qualifications for explaining the most beautiful experiment in physics, namely, *double-slit experiment* truly known as *the heart of quantum mechanics* [2]. It is worthy of mention that contrary to the opinion of most theoretical physicists, who insist on the existence of "***Measurement Problem***" in quantum mechanics, classical mechanics has not been based on certainties, but the prediction of probabilities plays a very significant and fundamental role in this branch of classical physics, particularly in the field of manufacturing technology, measurement technology and quality control.

In the course of my career as a mechanical engineer I learned that there exists a deep connection between "***Measurement***" and "***Fits & Tolerances***". These two subjects play distinctive role in solid - mechanics by which engineers can pave the way for materialization of scientific findings. Moreover, it should be insisted that

"***Geometry***" which is based on the most rational and creative type of imagination has very profound effects on the professional decisions of mechanical designers.

After we become familiar with the subject that is being discussed, It will be not so hard to accept that in various branches of human knowledge dissimilar terms may be used for the same concept or meaning. According to my experience, the word "***Tolerance***" in engineering science and the word "***Uncertainty***" in theoretical physics have the same application, in spite of the fact that apparently there isn't any conceptual relation between these two words. But of course the former has very clear definition with strong foundation of long term practice in machine design and also in manufacturing technology, on the contrary, the latter mainly based on an ambiguous and useless principle in theoretical physics. To avoid misunderstandings and to standardize scientific language, it seems reasonable to agree on a single term. How and when? Nobody knows it. I personally prefer the word "*Tolerance*" (*Rawadari*) as it is more widely understood.

In this article, I will try to follow the advice of *Albert Einstein* who said: "*Everything should be made as simple as possible, but not simpler*."

2. Uncertainty in Measurement

Since the matter under discussion is "*measurement*", and taking into account that "*Uncertainty*" is generally a quantification of doubt about the measurement result, I have summarized here the clearest explanations about some related technical terms that may be used frequently. They have been selected from different sources, of course with some minor changes to them for more clarification. It is important not to confuse these terms:

- ***Accuracy*** *of the measurement refers to how close the measured value is to the true or accepted value. One important distinction between accuracy and precision is that accuracy can be determined by only one measurement, while precision can only be determined with multiple measurements.*
- ***Precision*** *refers to how close together a group of measurements actually are to each other. Precision has nothing to do with the true or accepted value of a measurement, so it is quite possible to be very precise and totally inaccurate. In many cases, when precision is high and accuracy is low, the fault can lie with the instrument. In this case, the measuring instrument should be calibrated.*
- ***Error*** *is the difference between the measured value and the "true value" of the thing being measured. It is impossible to determine the exact value of an error, especially because the* "*true value*" or "*mean value*" *is a mathematical expectation only and it can never be ascertained with absolute certainty.*
- ***Tolerance*** *is the total amount that a specific dimension is permitted to vary, it is the difference between the maximum and the minimum limits for the dimension. Tolerance, as a limited value that is usually specified by designer, is always positive.*

Let us assume that a designer has specified the geometry of a cylindrical steel pin and has inserted it into the related workshop drawing. This geometrical specification is usually based on some considerations concerning the function of the pin and also the exchangeability of the pin (standards) in connection with other parts that together constitute a subassembly. All these parts, which must fit well with each other, are being designed to meet specific requirements that are necessary for the safe and correct performance of an integrated mechanical system. In Figure 1, you can find some detailed explanations about the ***geometric dimensioning and tolerancing*** of the pin diameter.

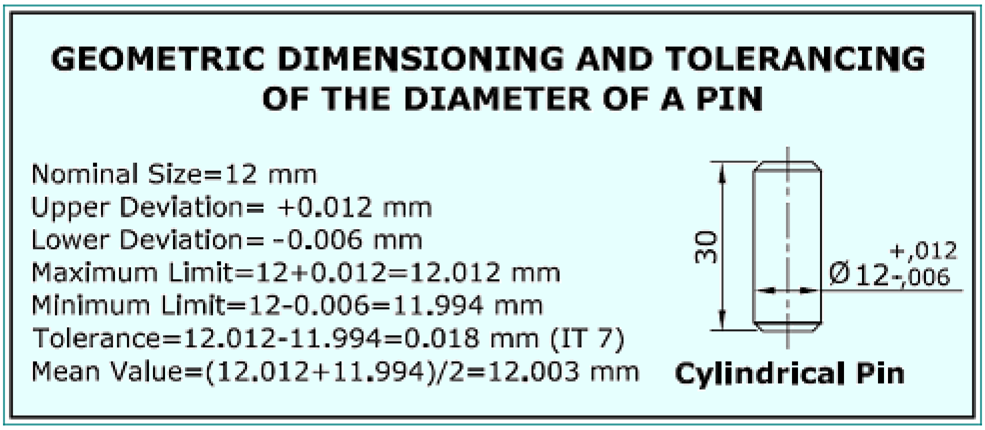

Figure 1

As a matter of fact, the designer, who has common sense about the concept of the quantum, is aware that the exact nominal size 12 mm for the pin diameter never actually can be reached. Thus, with regard to aforementioned considerations he/she specifies the range of tolerable deviations from it, that is to say upper deviation (+0.012mm or +12µm) and lower deviation (-0.006mm or -6µm). This means that, from the designer's point of view if the diameter of final product would be between maximum limit 12,012mm and minimum limit 11.994mm is acceptable, otherwise it becomes inferior or completely useless. That is to say, when the tolerance is exceeded the quantity turns into quality.

It is quite understandable that from engineering point of view design should be economically optimized in order to all products preferably to be in acceptable range, but probabilistic point of view it is unfortunately impossible. In fact, when all affecting parameters in production such as environmental conditions of workshop, accuracy and precision of both machineries and measuring devices, the physical and spiritual situation of machinists and so on would be in normal conditions, in the best case the probability of producing a pin that its diameter to be within tolerable range is 99.73%.This range, which is equal to 6σ (***Six Sigma***) and is known as "*Tolerance*" in engineering science, is that very "*Uncertainty*" which for about a century as a widely accepted "principle" has been a basis for discussion between theoretical physicists [3].

The above mentioned criterion indicates that if our target would be the mass production of this kind of pin, about 27 parts from 10,000 manufactured pins will be out of acceptable range that usually they might be considered as rejected parts. ***Gaussian Normal Distribution Law*** governs all these probabilistic predictions, Figure 2. We should not forget that the test of a prediction is whether it works in the real world.

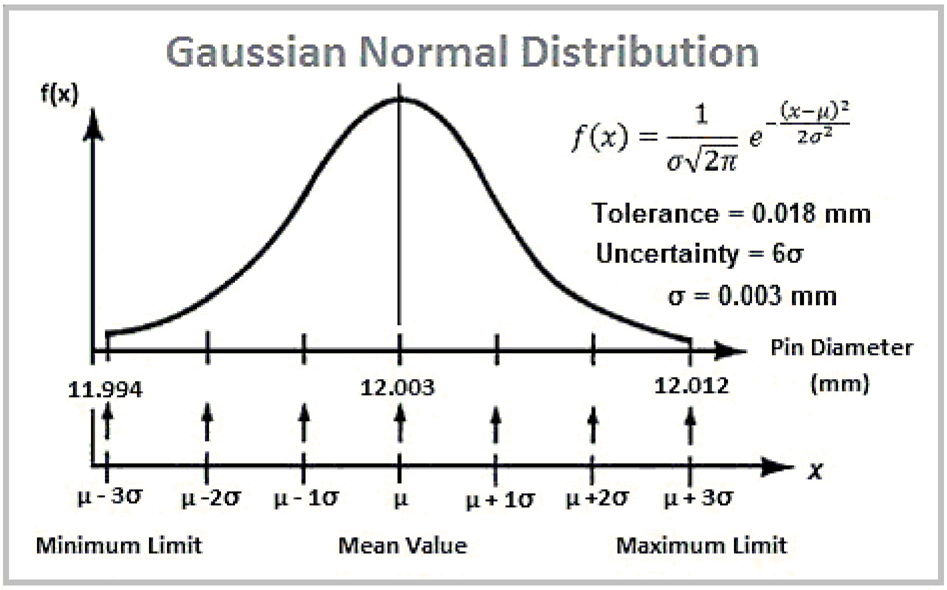

Figure 2

The normal distribution (probability density function, PDF) is symmetrical with a single central peak at the average of the data. The shape of the curve is described as bell-shaped with the graph falling off evenly on either side of the mean. It can be completely specified by two parameters: *Mean value* (µ) and *standard deviation* (σ). The probability is the area under the curve between two points on the abscissa. Here, the mean value (*Miangin* or ***Mathematical Expectation***) of pin diameter is 12.003mm and standard deviation from the mean is 0.003mm. In fact, these two parameters have been indirectly specified by designer. Ordinate f(x) indicates the relative likelihood of occurrence of each size (*probability density* or *relative probability*) that within the tolerable range is maximum at the center (12.003mm) and minimum at the ends, namely 11.994mm and 12.012mm. For example, the probability that the diameter of final product would be 12.010mm is less than that of being 12.005mm.

Area under the curve between minus infinity and plus infinity is equal to one, and between µ-3σ and µ+3σ is equal to 0.9973. The format "µ±3σ", as another type of tolerancing of a size, means that if you repeat the measurement, 99.73% of the time your new measurement will fall in this interval. The must value as a basis for determining the accuracy (*Dorosti*) of a measurement is "µ", and the must value for the precision (*Deghat*) of a size is "±3σ". Error (*Khata*) is the difference between the measured value and the mean value (µ). Consequently, this format for the subject of our discussion, the pin diameter, can be written as 12.003±0.009mm.

The actual diameter of a pin is determined by measurement. It is important to understand that any measurement will always contain some degree of uncertainty which is equal to the smallest increment on the scale of the measuring device. Since the acceptable deviations of the pin diameter have three digits, this scale should not be more than 0.001mm (1µm). Therefore, the precision of measuring device in this case should be ±0.0005mm (±0.5µm). It means that even the precision of instrument has been indirectly specified by designer who follows the instructions of related existing standards. Generally speaking, higher precision of machine tools and measuring devices leads to less rejected parts.

Every mechanical designer and every machinist knows, or must know, that it is impossible to make two completely equal objects, regardless of how large or small the object is. That paves the way for a realistic understanding and interpretation of quantum mechanics which has its own rules, rules of probability.

3. New Probability Wave Function

Continuation of the matter under discussion would be much easier if another important aspect of Gaussian Distribution to be clarified here. This aspect of PDF has rarely, if any, been explained in other accessible sources, texts and articles.

I think this question should be raised first: What would be the probability of producing a pin the diameter of which lies between two arbitrary points "a" and "b" on the abscissa, for instance between 11,999 and 12.001mm (12.000±0.001mm)? The answer is this: It can be calculated by using the following formula:

$$P = \int_a^b \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \, dx < 1$$

The area under the curve between these two points will be the result of calculation, which is 0.1613, Figure 3. It means that from 10,000 manufactured pins the diameter of about 1613 parts will be between 11.999 and 12.001mm.

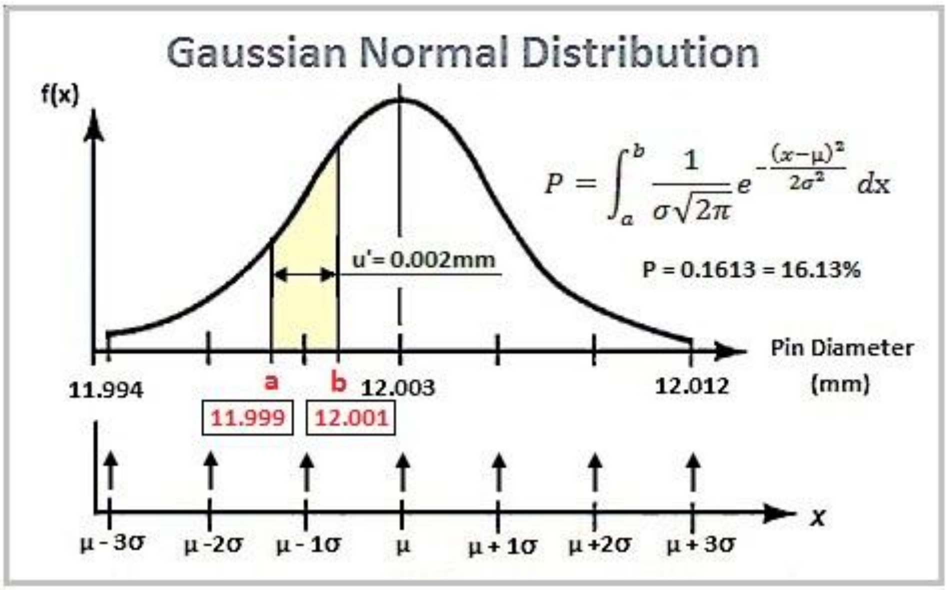

Figure 3

In this example the target value is 12.000mm and uncertainty has been reduced to 0.002mm (2μm). If we extrapolate this to the smaller uncertainty ranges step by step up to the theoretically smallest one, namely u'=zero, in order to have absolute certainty, the area under the curve, or the probability of producing a pin the diameter of which would be 12.000mmm, becomes zero. In other words, all points on the abscissa are virtual data points because they are not really achievable. It is perhaps that very phenomenon known as ***"Collapse of Wave Function***" in theoretical physics. Anyhow, this analysis very clearly indicates the difference between "probability" and "probability density".

A logical conclusion: ***If absolute certainty (u'= Zero mm) is not really achievable, then there must exist a length which is the smallest length in physics and is also a fundamental minimum limit to the uncertainty of a measurement. This means that length is quantum in nature and "Quantum Geometry" is true, not a vague supposition.***

Now, suppose that these 1613 parts have been separated from 10,000 manufactured pins. A logical mind immediately concludes that the distribution of separated parts must also be generally in accordance with Gaussian Distribution, with some differences of course, as follows:

- Mean value is 12.000mm,
- Uncertainty is $u' = 6\sigma' = 0.002$mm (2µm),
- Standard deviation is $\sigma' = u'/6 = 2/6 = 0.333$µm,
- Area under the curve between maximum and minimum limits is 0.1613, instead of 0.9973.

This kind of distribution may be called "*Abnormal Distribution*", because the area under the curve from minus infinity to plus infinity is noticeably less than one. In our example, this area is computable: $0.1613/0.9973 \approx 0.1617$.

All these mathematical explanations lead us to generate a new "*Probability Wave Function*" which is based on Gaussian Distribution (Bell Curve) and is able to lay the foundations for a reasonable interpretation of Quantum Mechanics [4]. General pattern of this function has been shown in Figure 4.

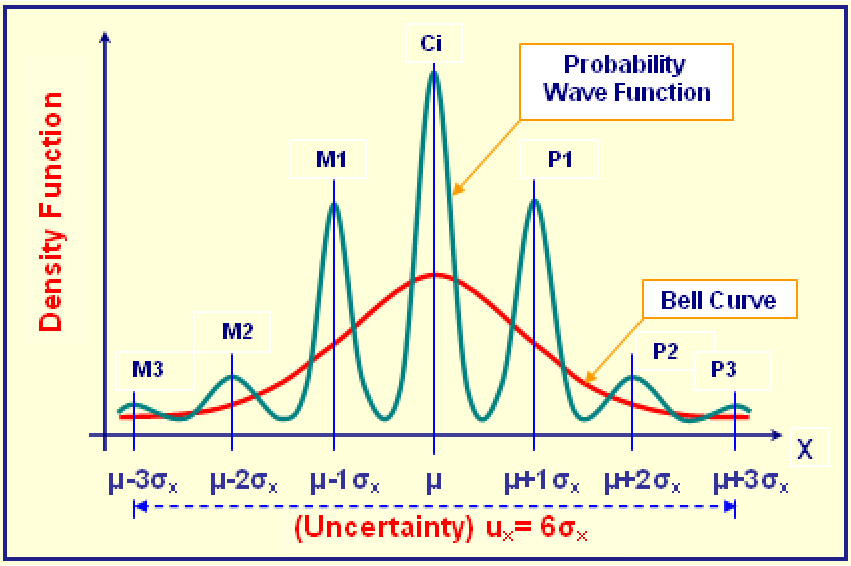

Figure 4

A curious reader may ask, why seven components of this function are formed around quantum variables μ-3σ, μ-2σ …, and μ+3σ and not around other data points on the abscissa? In this case, the reader should be patient enough and should attempt to comprehend and dominate the capabilities of this function. It doesn't mean that there aren't any reasons behind generation of this pattern. A few of them are listed below:

1. The extract of over 30 years of my experience as an engineer, which is summarized in this proposition: **"Scientific findings will ultimately manifest themselves in solid – mechanics through transformation to shapes and volumes"** [5].
2. A true probability wave function should be universal, without dimension, in order to be applicable to the measurement results related to all natural phenomena at all scales, from the smallest subatomic particles to the entire universe.
3. Facts, observations and experimentations, such as; light spectrum, seven musical notes, diffraction phenomenon [6], black body radiation curves, electron orbital in atomic structure, … and especially different types of double-

slit experiment with photons, electrons or atoms. I do insist that the ultimate authority in science is nature, not what it says here, there or in the book.

4. Einstein held fast to his belief that something was missing from quantum physics. He said there must be hidden quantum variables, and that the quantum theories would not be complete until those hidden variables were found. He was right.

It appears that the role and importance of probability in engineering science and its relation with theoretical physics has been sufficiently explained, especially that relates to “*Tolerance*” or “*Uncertainty*”. However, a short hint about the possible effects of this wave function in the reduction of industrial production costs could be useful. Of course it has another story and therefore needs to be investigated very precisely somewhere else.

At the present time, international standard implements 20 IT Grades (IT= International Tolerance) and also a series of fundamental deviations for different nominal size ranges to establish what is known as “*making parts interchangeable*” (*Taviz.pazir.sazi*) [5]. In our example, the nominal size of the pin diameter is 12mm, tolerance Grade is IT 7 (0.018mm or 18µm) and fundamental deviation is -0.006mm (-6µm). Tolerance Grades and also recommended fundamental deviations are calculated by using some empirical formulas. From this we can wisely conclude that the related DIN ISO or DIN EN ISO standards need to be revised in order to be consistent with scientific regulations. Most likely the new probability wave function could be used instead of the aforementioned empirical formulas.

4. Speeds of Light

Let us summarize the current predominant view about the speed of light:

“*The speed of light in vacuum, usually denoted by “**c**”, is a fundamental physical constant. Its value is 299,792,458 m/sec. This figure is exact and is the maximum speed at which all energy, matter and information in the universe can travel. It is the speed of all massless particles and waves, including electromagnetic radiation such as light in vacuum, and it is predicted to be the speed of gravity.*”

There are several convincing evidences that seriously support *the only particle physics* and consequently are against wave-particle duality concept. Among them are double-slit experiments especially those which have been carried out with single photons, electrons or atoms. In fact, the patterns produced by double-slit experiments demonstrate very clearly the classification of particles according to the *New Probability Wave Function*. They have nothing to do with interference (addition or superposition) of two or more combining waves. Interpretation of *the electron double-slit experiment* on the basis of this function sheds light on the mysteries behind the heart of quantum mechanics [1].

Photons, as the visible or invisible particles of electromagnetic radiation (light), are energy quanta. Quantizing the energy of photons is equivalent to quantizing their speeds. Therefore, it can be concluded that in nature no two photons are alike, namely they cannot have the same energy or the same speed. The measured value for the speed of light in vacuum, 299,792,458 m/sec (uncertainty = 1 m/sec), is actually a value extremely near to the average speed of visible photons that constitute a very narrow band along a very much wider speed spectrum of electromagnetic radiation. Furthermore, the diffraction pattern of double-slit experiment with single photons very clearly represents the differences between these particles and proves that each photon has its own path and the probability of light traveling in straight lines is zero [6].

A logical conclusion: ***Speed of light in vacuum is a quantum variable and hence, "c" cannot be considered as a fundamental physical constant.***

5. Quantum Geometry and Exact Planck Length

In theoretical physics, the development of a quantitative understanding of quantum geometry is necessary to describe the physical phenomena at very short distance scales (comparable to Planck Length). At these distances, quantum mechanics has a profound effect on physics. At the present time, Planck Length "l_p" is defined by the following equation, where "**c**" is the speed of light in vacuum (as a fundamental constant), "**G**" is the gravitational constant, and "**ħ**" is the reduced Planck constant:

$$l_p = \sqrt{\frac{\hbar G}{c^3}} \approx 1.616252 \times 10^{-35} m$$

Now it is the time to take a short imaginary trip to the world of very, very small particles. In this trip the guidance will be done by means of mathematics, the poetry of logic. However, paying attention to the applicable standards should be the starting point of our trip; we must lean on the existing facts in the field.

A short glance at the table of **IT Grades** should suffice to understand that today, considering the existing level of manufacturing and measurement technology, the smallest achievable uncertainty of length measurement is practically about 0.001mm (1µm). Therefore, at present time the standard deviation of length measurement is 1/6µm. Let us now imagine that we want to measure the distance of a very small particle from a reference point, for example zero point on the abscissa. We are almost sure that the particle lies between 0 and 1µm, because this amount of uncertainty can be achieved with suitable measuring devices which are available today. Figure 5 demonstrates the related probability distribution f(x).

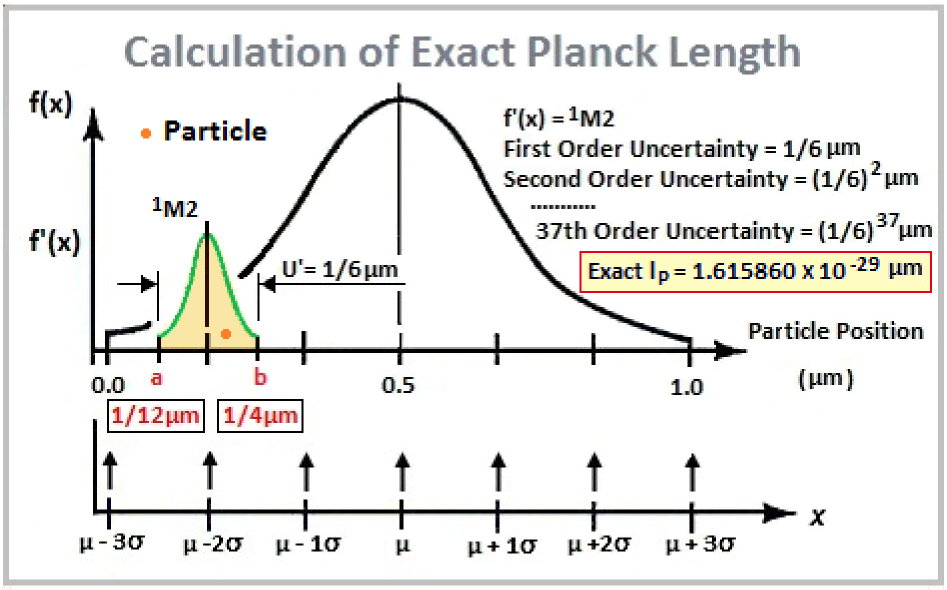

Figure 5

If quantum geometry and the new probability wave-function Ψ are true, then they must be applicable here. This function, which represents the sub-quantum structure(s) of all natural phenomena, states that the next higher level of measurement technology will enable us to measure the lengths with an uncertainty equal to 1/6μm, a ***quantum jump*** in length from 1μm to 1/6μm (mutation). It is completely in agreement with the concept of quantum geometry.

Now suppose the first order measurement indicates that the particle is, for example, a part of ^{1}M2 which itself is a component of Ψ, that is to say, the distance of particle from reference point would not be more than 1/4μm and not less than 1/12μm. If we human beings would be lucky enough and act wisely don't commit suicide and don't destroy our beautiful Mother Earth, then we may have the chance to continue our trip and to improve one step more the measuring instruments. At that time the second order uncertainty of length measurement will be attainable, **$(1/6)^2$μm**. It is predictable that the particle will belong to one of the components ^{2}M3, ^{2}M2, ^{2}M1, ^{2}Ci…..or ^{2}P3 from ^{1}M2, f'(x) on Figure 5. If we would be tolerant enough and be able to protect our species, in the far future we may reach to **$(1/6)^{37}$μm** which is the Exact Planck Length [7]:

$$\text{Exact } l_p = l'_p = (1/6)^{37}\mu\text{m}=1.6158600\times10^{-29}\ \mu\text{m}=1.6158600\times10^{-35}\text{ m}$$

The numbers 6 and 37 remind us of "Backgammon" and "Roulette" in which probability plays the central role. Why there exist such mathematical relation between these two numbers and Exact Planck Length? And what does it mean?

According to the existing knowledge it is believed that the smallest possible unit of length is Planck Length. On the other hand, we reached to this conclusion that this length is also a theoretically achievable uncertainty in length measurement. Since this uncertainty is not zero, that is to say, probability > 0 even if it is very, very small, so there must exist in nature particles that have a perfectly spherical shape the diameter of which is Planck Length. We should not forget that since this length is the smallest in physics, the smallest particles must have the same size, equal to this length, in all directions and therefore they cannot be like a *STRING* or other non-spherical objects.

It should be reminded that different orders of the new probability wave function, representing the sub-quantum structures, are simultaneously valid for all related components of this function at each order. It doesn't matter where the particle is; we always reach to the same uncertainty of length at each order, even at 37th order. It means that the smallest particles are closely spread all over the universe, fill every part of it and pervade everything.

Exact Planck Length is really the smallest meaningful length in physics. It is not a derivative of a combination of "**G**", "**ħ**" and "**c**", but is a fundamental physical constant equal to **$(1/6)^{37}$μm** which is predictable using the new probability wave function.

6. Quantum Gravity

Quantum gravity is an overall term for theories that attempt to unify gravity with the other three fundamental forces of physics which are already unified together. It generally postulates a theoretical entity, a graviton, which is a virtual messenger particle that carries the gravitational force.

In an effort to summarize the subjects that have been discussed till now in this article we can rewrite the famous equation which defines Planck Length:

$$l'_p = \sqrt{\frac{\hbar G}{c^3}} \rightarrow G = \frac{{l'_p}^2}{\hbar} c^3 \rightarrow \xi = \frac{{l'_p}^2}{\hbar} \rightarrow G = \xi c^3$$

Since "l'_p" and "ħ" are fundamental constants, then "ξ" is also a fundamental physical constant. The related values and descriptions are as follows:

- $l'_p = 1.6158600 \times 10^{-35}$ m — Exact Planck Length constant
- $\hbar = 1.054571726 \times 10^{-34}$ J·s — Reduced Planck constant
- $\xi = 2.475890015 \times 10^{-36}$ $m^2/(J.s)$ — Love constant
- **c** = Speed of light in vacuum m/s — quantum variable
- **G** = Ground gravitation factor $m^3/(kg.s^2)$ — quantum value

Now, when we do accept that "l'_p" and "ħ" and consequently "ξ" are fundamental constants, since "**c**" is a quantum variable, as a result "**G**" is also quantum in nature. Curious readers may search and find out many facts showing that "**G**" is not constant; its average value depends on the average speed of light which itself depends on where in the universe the observer is. Anyhow, taking into consideration that the force of gravity pervades everything, thus it can be concluded the messenger particles of this force are that very same the smallest particles in physics.

It is worthy of mention that at the present time the obtained value for "**G**", as a fundamental constant, is equal to $6.673\,84 \times 10^{-11}$ $m^3/(kg.s^2)$. But when we use Exact Plank Length instead of "l_p", the average quantum value of "**G**", in a very small part of the universe in which we live, will be $6.671038654 \times 10^{-11}$ $m^3/(kg.s^2)$. Which one is more precise and accurate?

The name for the smallest particle in physics could be one of these alternatives: *Spation, Graviton, Aethion, Ethion….* and perhaps *Attarion.*

7. Conclusion

Even though the concept of the quantum was extended by theoretical physicists in the early 20th Century, it doesn't make the end of classical physics or the birth of quantum physics because it has already existed in mathematics and has been being used practically for many years in engineering science. In other words, quantum mechanics doesn't differ considerably from classical physics in its predictions when the scale of observations becomes comparable to the atomic and sub-atomic scale, provided that we employ a real mathematical model to explain natural phenomena.

The general and abstract law of nature, which enables us to prove that quantum gravity is true, can be discovered rationally by a realistic interpretation of quantum mechanics. Therefore, it could be considered as the ***Theory of Everything (TOE)***, especially when we become absolutely sure that it is also applicable to the human mind, the history.

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The German version of this article can be found at:
Genaue Planck-Länge Enthüllt die Quantengravitation