The new SI – another proposal on the future revision of the International System of Units

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Abstract

This article is an alternative to the proposal of the 24th meeting of the General Conference on Weights and Measures (**CGPM**) in 2011 for the future revision of the International System of units. The article starts with a survey of the existing evidence of change of the physical units in areas with different intensity of the gravitational field. For example, the physical units "meter" and "second" defined on the Earth are different from the units defined on the planet Mars by means of the same experiment - through characteristics of the electromagnetic waves (frequency, wavelength, speed …). The units defined at the sea level and units defined at the orbit of GPS stations are different too. Instead of investigation the laws of the units' change, complex relativistic models are created for different purposes for celestial mechanics, space navigation, etc., and also for the everyday needs for positioning purposes on the Earth. To match the measurement accuracy - very complex definitions, standards and conventions, time and frequency techniques, and sophisticated mathematical methods are required. That is why, in this article is suggested a completely new approach to a proper hierarchy of a new SI of proper physical units, based on proper principles that should be observed at the definition of the physical units. This proposal is based on the awareness of the physical reality of global relativity in the Universe.

Keywords: SI system, base units, measurement systems, relativity, speed of light, fundamental constants.

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Contents:

1. Introduction

„The new solutions are achieved with new thinking and actions.
The main purpose of this article is to provoke discussion
for creation a new SI-system of proper physical units"
By author

All Measurement Systems, including International System of Units (abbreviated SI) are based on our perception of full „certainty and constancy" about the physical units and physical constants in the local time-spatial domain of our existence. This perception of „certainty and permanency" is a result of the irrefutability of all perfect „mathematical and experimental evidence about this certainty", what is a real fact in any local time-spatial domain, where the physical units are defined. The perfect „mathematical and experimental evidence" of „certainty and constancy" is a consequence of the fact that the physical laws, which we obtain in our time-spatial area, remain perfectly the same, in case of change of the intensity of the gravitational field. But all the physical units and physical constants, the properties of atoms … the whole physical reality is changing in perfect synchrony at changing the intensity of the gravitational field. This fact does not allow registering by measuring of any changes in the properties of atoms, as well as any changes of both the physical constants and the physical units themselves in the local time-spatial domain, where the physical units are defined through the characteristics of the electromagnetic waves, like frequency, wavelength, speed … (Sharlanov G V 2012a). That's why we need to amend the meaning implied in the term "fundamental constant"...

On the contrary of this reality, with Resolution 1, the 24th meeting of the General Conference on Weights and Measures (2011) considers *"extending the frontiers of metrology so that SI base units can be defined in terms of the invariants of nature - the fundamental physical constants or properties of atoms"*. The Resolution 1 of this meeting also points "*that a prominent example of the success of such efforts is the current definition of the SI unit of length, the* ***metre****, which links it to an exact value of the speed of light in vacuum c, namely, 299 792 458 metre per second"* as defined (17th meeting of the CGPM 1983, *Resolution 1)*. That is why the present paper starts with a brief analysis of "the constancy" of this most notable "fundamental constant" - the „speed of light". The „speed of light" is only a local constant, and the fact that the „speed of light" actually changes with the change of the intensity of the gravitational field, is proved by the mentioned bellow experiments.

Note 1: In this paper is accepted that "the higher gravitational potential" corresponds to "the lower intensity of gravitational field", or to "the weaker gravitational field", or to "the higher level of expansion of space / contraction of time". And vice versa, "the lower gravitational potential" corresponds to "the higher intensity of gravitational field", or to "the stronger gravitational field", or to "the higher level of contraction of the space/ expansion of time" or to "the higher level of GRULW (Global Relative Universe Level of Warping)".

Note 2: Any local area of the Universe is characterized by its GRULW, or by its relative local expansion/contraction of the space-time. For example, in any time-spatial domain in the Solar system, GRULW depends on ($GL_P+GL_S+GL_G+GL_U$), where GL_P is this level depending on the gravitational potential related to the nearest planet; GL_S is this level depending on the gravitational potential related to the Sun; and GL_G is this level depending on the gravitational potential related to the current location of the Solar system in our Galaxy (the Milky way); and GL_U is the level depending on the gravitational potential related to the current location of the Milky way in the Universe - in relation to all galaxies.

2. The speed of light constancy – a brief analysis

We delude ourselves that the „speed of light" is fundamental constant in two aspects that are shown in the next two surveys.

2.1. Survey about "the constancy of the speed of light in empty space" – or in vacuum (in the reference system bound to the space itself). Explanations and proving experiments

As a matter of fact, the „speed of light" is a coefficient of the correlation between wavelength and the frequency of any electromagnetic radiation of the electromagnetic spectrum in any time-spatial domain with a certain level of intensity of the gravitational field. The electromagnetic field exists on the gravitational field. That is why the electromagnetic field changes its characteristics in case of change of the intensity of the gravitational field. That is why the „speed of light" (this coefficient of correlation) is measured exactly the same (as a constant), because the units of time and length are defined in the same time-spatial domain and again by means of the characteristics of electromagnetic radiation (obviously it is a case of circular reference…).

In his work (Einstein A 1911), Albert Einstein considers the change of the frequency (one of the characteristics of the electromagnetic radiation), in places with different gravitational potential:

$$\nu = \nu_0\left(1+\frac{\Phi}{c^2}\right) \tag{1}$$

Here $\boldsymbol{\nu}$ is the frequency in a location with a gravitational potential $\boldsymbol{\Phi}$, relative to the origin of the co-ordinates; $\boldsymbol{\nu_0}$ is the frequency in the origin of the co-ordinates; and **c** is the constant "speed of light". If we have defined the unit of time "second" as the duration of 9 192 631 770 periods of certain electromagnetic radiation (using the characteristic "frequency" of a certain radiation) - this equation shows that the unit "second" changes with the change of intensity of the gravitational field. Further in this article, Einstein states:

„If we call the speed of light at the origin of co-ordinates c_0, then the speed of light ***c*** *at a place with the gravitation potential* $\boldsymbol{\Phi}$ *will be given by the relation:*

$$c = c_0\left(1+\frac{\Phi}{c^2}\right) \quad (2)$$

The principle of the constancy of the speed of light holds good according to this theory in a different form from the one that usually underlies the ordinary theory of relativity."

However, the change of the wavelength (and therefore the unit "meter") is not taken into account in this equation. If the change of the wavelength (it means change of the unit "meter") had been set into the expressions of the "**Φ**" and "**c**" **-** the result would have been uncertainty of the equation itself… All our physical equations are written on the base of the constancy of the physical units (Sharlanov G V 2012b). This is uncertainty because the change in synchrony of all units with the change of the entire physical reality does not allow us to measure/to fix the change of any particular unit in itself.

But the most important is - Einstein concludes that the characteristics of the electromagnetic radiation change when passing through areas with different gravitational potential, through areas with different intensity of the gravitational field. If we have to analyze the behavior of the electromagnetic radiation (frequency, wavelength and speed) in the global space-time in the Universe, we can give the next two explanations, followed by proving experiments:

A) One explanation is according to the general relativity:
In time-spatial area with a weaker gravitational field (larger "expansion" of space /"contraction" of time), or higher gravitational potential, or lower level of warping/distortion GRULW), we can say that:

- The time passes faster, which means that the unit "second" will be with a shorter duration. This actually is because in a weaker gravitational field, each atom absorbs and emits electromagnetic radiation at a transition of the electrons between the same levels - respectively with a higher frequency. So, if we consider the definition "*the frequency of the radiation corresponding to the transition between the two hyperfine levels of the caesium 133 atom*" (13th meeting of the CGPM, 1967/68, *Resolution 1)* … or the behaviour of the caesium 133 atom located in a time-spatial domain with a lower GRULW - this frequency will be higher. So, when fixing the duration of the same 9 192 631 770 number of periods - we will obtain that the unit "second" is shorter (contraction of time).
- The space is "expanded", which means that the unit "meter" is longer. This is actually because in a weaker gravitational field each atom absorbs and emits electromagnetic radiation with a longer wavelength at a transition of electrons between the same levels. So, if we consider the definition (11th meeting of the CGPM, 1960, Resolution 6): "*the metre is the length equal to 1650763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels $2p_{10}$ and $5d_5$ of the krypton 86 atom*", …of atom located in a time-spatial domain with a lower GRULW - this wavelength will be longer. So, when fixing the length equal to the same 1 650 763.73 wavelengths - we will obtain for the unit "meter" a longer length (expansion of space).
- The increase of the wavelength together with the increase of the frequency of any electromagnetic radiation, means that in the time-spatial domain in a weaker gravitational field (with higher gravitational potential; with a lower level of relative warping GRULW) **-** the "speed of light" increases due to the increase of the both ν and λ … (c=λν). But, if we measure the „speed of light" with the units, defined by means of the above mentioned definitions in the same domain – we will obtain again exactly the same number 299 792 458 "metre per second" (an example of circular reference). Therefore, we will be mislead, that the „speed of light" is constant.

When applying the same logic to the time-spatial domain in a stronger gravitational field (with a higher level of relative distortion GRULW, it means at a lower gravitational potential) - we will respectively conclude that the wavelength, the frequency and the speed of light decrease.

In other words the electromagnetic radiations are oppressed (overwhelmed) in a strong gravitational field. They transform themselves into vibrations with shorter wavelengths and lower frequencies, which means lower speed of spreading (c=λν). Vice versa, when the electromagnetic radiation enters into a weaker gravitational field (a higher level of "expansion of the space" / "contraction of time"), the wavelengths of electromagnetic vibrations become longer and frequencies become higher, which means a higher speed of spreading (c=λν).

Therefore, we should be aware that:

- "*At the emission, spreading and absorption of any electromagnetic radiation, its frequency and wavelength are in synchrony with the space-time distortion (curvature) of the time-spatial domains where the light emits, passes or absorbs.*" (Sharlanov G V 2012a). Actually it means that the **properties of the atoms change in synchrony and they correspond to the intensity of the gravitational field**, where the atoms are located.
- Also, "*In the frame of reference associated with the space itself, where the light is actually spreading – it is not possible to prove by measurement (getting true and valid values as a result of this measurement) carried out at a certain time – that there is a change of the value of the speed of light in the time-spatial domain where the SI based units of time and length are defined*" (Sharlanov G V 2012a).

B) Another explanation for the behaviour of the electromagnetic radiation is as a consequence of the fact that the electromagnetic field exists in the spacetime - on the gravitational field:
In other words, in a stronger gravitational field (with a higher level of GRULW), the "permittivity of the free space" (the electric constant $\boldsymbol{\varepsilon_0}$) increases, as well as "the permeability of the free space" (the magnetic constant $\boldsymbol{\mu_0}$) increases - and as a result the „speed of light" decreases:

$$c = \frac{1}{\sqrt{\mu_0 . \varepsilon_0}} \tag{3}$$

And vice versa, in a weak gravitational field, the "permittivity of the free space" (the electric constant $\boldsymbol{\varepsilon_0}$) decreases, as well as "the permeability of the free space" (the magnetic constant $\boldsymbol{\mu_0}$) decreases - and as a result the „speed of light" increases.

Obviously, at the global motion in the Universe, the GRULW in our local time-spatial domain changes too. The characteristics of the electromagnetic field are changing, the physical units are changing, the physical constants are changing … the whole physical reality is changing in synchrony, but the laws of physics (the relationship between the different physical quantities) remain the same. That is why we cannot register by measurement the change of the physical constants. Or when we measure the „speed of light" in our local time-spatial domain with the units of length and time (defined again in our local time-spatial domain by means of characteristics of the electromagnetic waves) - we always get exactly the same result. This is one of the consequences of **the uncertainty principle of the macro-world**, defined in (Sharlanov G V 2012a).

As a proving example about the change of the „speed of light" with the change of intensity of the gravitational field, for almost 50 years, is the "Shapiro-time-delay effect". The time-delay effect is caused by the lower speed of radar signals passing near a massive object (the Sun), through a stronger gravitational field – the radar signals take slightly longer to travel to the target and back, than it would if the mass of the Sun were not present. *"The experiment was designed to verify the prediction that the speed of propagation of light ray decreases"* (Shapiro I I 1964).

The most significant experimental proof that the electromagnetic signals increase their speed in areas with a weaker gravitational field (a lower GRULW) to the border of the Solar system – is the registration of anomaly in the acceleration of the space probes "Pioneer 10", "Pioneer 11", "Galileo", "Ulysses".

"*The expected travel time of the communicational electromagnetic signals (based on the constancy of the speed of electromagnetic radiation) between the spacecraft and Earth turns out to be much more than the real travel time. As a result, we register backward attraction of the space ship/probe to the Sun.*" (Sharlanov G V 2011).

As a conclusions of that survey:

- The proposal of the 24th meeting of the General Conference on Weights and Measures, Resolution 1 (2011) about *"the redefinitions of the base units"* on the base of *"the truly invariant quantities such as the fundamental constants of physics and the properties of atoms"* should be reconsidered.
- The-so-called "**fundamental constants of physics**" are only "local constants". Similarly, and the **properties of atoms** depend on the intensity of the gravitational field of the time-spatial domain, where the atoms are located. Two tests for proving the change of the properties of atoms in areas with different intensity of the gravitational field are proposed in the last section of this article.
- That is why, it is obligatory to be exactly specified "the small time-spatial domain" (the exact place with a certain gravitational potential), where the units are defined. The most preferred "small time-spatial domain" for our local physical reality is "**at the sea level**".

2.2. Survey about the "constancy of the speed of light for all reference systems" - proving experiments and conclusions

The second delusion related to the „speed of light" is the claim that the „speed of light" is constant regardless of the reference system; that the „speed of light" is the same for all frames of reference. That is a delusion which was proved with experiments from almost 100 years ago till now, by (Sagnac 1914); (Michelson A A and Gale H E 1925); (Miller D C 1933); (Marmet P 2000); (Ashby N 2003); (Kelly A 2005); (Gift S J G 2010) and others). They prove that Galileo's transformations are valid, when the „speed of light" is measured in the reference system bound to the Earth's surface (taking into account the linear velocity of the Earth's surface at the certain latitude). The delusion that the „speed of light" is constant for all frames of reference has resulted in the wrong use by Einstein of Lorentz transformations in the Special Theory of Relativity (STR). The Lorentz transformations actually are the mathematical solution of the task "the speed of light to be the same, measured in the co-ordinates of all frames of reference". But this task does not correspond to our local physical reality and the claim "the speed of light is constant for all reference systems" is refuted by much more than the above mentioned experiments. In the paper "Awareness of Special and General Relativity and Local and General Physical Reality" (Sharlanov G V 2012b) was made analysis of the discrepancy between our local physical Reality and the mathematical model used in the Special Theory of Relativity.

All of these experiments are unambiguous clear evidence that the famous results of the Special Theory of Relativity (STR) should not be used any more for scientific purposes.

Conclusions after that survey:

- It is time to close the phenomenal page in physics – the "Special Theory of Relativity". The special relativity is a great attempt for its time to explain our local physical reality. In spite of its unconformity with our local physical Reality, the special relativity broke the scientific thinking about the "absoluteness" of the time and space, about the perception and understanding of the physical Reality. It also provides the impetus for the creation of General Theory of Relativity and as a contribution to the scientific thought - it remains an unsurpassable genius creation.
- The reference system, where the SI-units are defined, obligatory should be exactly specified. It is preferable that the reference system for units' definitions should be bound to the space itself.

For example, if the speed of light in vacuum is determined in the coordinate system bound to the Earth's surface - the result of this determination is obligatory to be taken as arithmetical average of the measured velocities in two opposite directions (to East and to West) in the time-spatial domain "at the sea level". This note is directed to the current definition of the unit "meter" (by means of the „speed of light"), as well as if the "meter" is defined by means of counting a certain number of wavelengths of certain electromagnetic radiation. In the second case, similarly, the final result of counting is obligatory to be taken as arithmetical average in the two opposite directions (to East and to West). This is a suggestion for a more accurate definition of the unit "meter".

3. The New SI-system of proper units - basic principles for creation of the new SI

"…the XXth CGPM chose to maintain the historical structure of the SI with its set of defined base units"… "The choice of which units to take as base units is to some extent arbitrary. This choice has been governed by history and tradition in the development of the SI over the last 120 years." …(Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) .

However, the choice of the base physical units should not be arbitrary. The proper set of the base physical units of the new SI-system, should be determined first of all on the basis of the awareness of the physical nature of the Universe; should be determined on the basis of the awareness of certain fundamental facts, and on the basis of proper adopted principles.

3.1. The physical nature of the Universe is the basis of determination of the set of the base units

Everything in the Universe vibrates – the Universe is dynamic. The change of the frequency of the electromagnetic radiation represents the change of the space-time warping. That is why, the most fundamental quantity turns out to be the frequency and the unit of time **should be at the top of the SI-system structure!** But we should add and that the time and the space are bound each other – they are like two sides of the same coin.

For creation a proper set of base physical units for our Local Physical Reality, first of all we have to rely on a genuine definition of the Global Physical Reality of the Universe. One suitable example of definition of the global physical Reality can be:

"The Universe is warped by matter time-spatial gravitational force field, on which other fields exist, (such as the electromagnetic field), and where the energy is accumulating and transforming."

The proper set of base physical units should be established on the basis of the so-defined nature of the physical reality in the Universe. Therefore, according to this definition of physical reality of the Universe, the set of the base physical units should include the units of *time*, *space (length)*, *force*, *mass* and *energy*. These base physical units should be at the top of the hierarchy and all other physical units should be defined by means of them. The mass and the gravitational force are linked to each other, as well as the time and space are linked. The energy is a multi-layer physical quantity and exists in many forms. It accumulates and manifests at macro and micro levels, and in different force fields. Here can be mentioned the words of Richard Feynman: *"It is important to realize that in physics today, we have no knowledge what energy is."* (Feynman R P 1964).

3.2. Awareness of the fundamental facts

Here we should pay attention and realize the following fundamental facts:

- Fact 1: First of all, we should realize the fact that in the global physical reality everything is relative.

As was mentioned above, the physical constants and units, together with properties of atoms are different in areas with different intensity of the gravitational field. They change with the change of the intensity of the gravitational field, with the global motion in the Universe. Or, all the physical units and all the "fundamental" physical constants are local – they are constant only for the local time-spatial domain where the units are defined, for a local time-spatial domain with the same and unchanging intensity of the gravitational field.

- Fact 2: Secondly, we should realize the fact that in the global relativity in the Universe, only the numbers remain to be absolute in the Universe.

Therefore, it is preferable that the physical units should be defined by counting, by fixing the numerical value of certain characteristic of the physical quantity. (Comparison is another way which should be used in one independent definition, and the accuracy of comparison can be involved in the determination of the level of uncertainty at defining units).

- Fact 3: We know that every result of measurements of physical quantities is represented by numbers and measurement units. The measuring numbers are real numbers which although we accept them with a certain approximation in the process of measurement – the numbers are absolute by themselves. However, the physical units defined by means of the electromagnetic radiation are floating in synchrony with the change of the gravitational field. In other words, the physical units, as well as the physical constants change in synchrony with the change of the intensity of the gravitational field. Or thirdly, we should be aware that we cannot determine the change of any "fundamental constant" through experiments carried out in the same time-spatial domain, where the physical units are defined (Sharlanov G V 2012a). In fact we will obtain another result of the measurement (as a different number), if we use the units defined in the time-spatial domain with different intensity of the gravitational field. Such are the cases of the above mentioned experiments - using the units defined in the time-spatial domain on the Earth's surface, we get an effect of propagation delay of electromagnetic radiation (at passing through an area of stronger gravitational field) (Shapiro I I 1964), or an effect of anomaly in acceleration of the spacecrafts (at passing through an area of weaker gravitational field to the boundary of the Solar system (Sharlanov G V 2011).
- Fact 4: Fourth, we should distinguish the physical units from the geometrical units. The geometrical units are dimensionless, i.e. they are only numbers. Therefore geometrical measurement units are absolute. For example, geometric measurement units are the radian (the standard unit of plane angular measurement) and the steradian (the SI unit of solid angle measurement). The radian and the steradian were in the category of the *supplementary* units, but by 1995 this category was abandoned and the units were grouped as derived units, although they are dimensionless!

Important note: This article discusses only the physical units – the geometrical units are rather related to mathematics.

- Fact 5: Fifth, we should make a distinction between the mathematical and physical constants. The mathematical constants are dimensionless, i.e. they are only numbers (the number **π**, Euler's number **e**, etc ...). That is why, the mathematical constants are absolute just like the numbers.

The conclusion is that the perception of „certainty and constancy" (which is a result of the irrefutability of all perfect „mathematical and experimental evidence about this certainty" in any local space-time domain where the physical units are defined) - does not give us the right to accept our local physical units and our local physical constants as absolute.

Therefore, we need to discover the laws of change of the physical units with the change of the intensity of the gravitational field (with the change of the gravitational potential); we have to reconsider the law of conservation of energy in a global sense, which will give us an explanation what is the energy at all; explanation about the origin of energy; … explanations of a lot of problems (such as: "the accelerated expansion of the Universe"; "the dark matter and the dark energy in the Universe", etc.), which have been under research for a long time.

But with a new SI, we will need to standardize methods for calculating the changes of the physical units in any time-spatial domain with different gravitational potential (with different intensity of the gravitational field), despite the uncertainty of that change (see uncertainty principle of macro-world) (Sharlanov G V 2012a).

3.3. Principles of building of the new SI-system structure.

When creating the new system of measurement, all the abovementioned facts must be observed. Furthermore, every logical structure should be built on the basis of certain principles. The principles of creating of the logical structure of a proper SI-system of proper units can be grouped into three principal groups:

Principles, group 1: "general requirements for the definition of the physical units".

- The definition of any physical unit should be defined under exact certain initial conditions with a certain experiment within a certain time-spatial domain (with a certain gravitational potential) in a definite frame of reference.
- The most appropriate "time-spatial domain" (with exact global reference location – GRL), which should be used to define the SI-units in our local Reality - is "at the sea level".
- All the units (except for the base units), should be defined by means of before established units. Constants can be used only if they are expressed by previously defined units too.
- It should not be permitted at defining the units, a presence of "circular reference". This means that we need a strict logical consistency at units' definition. For example, it is unacceptable the present definition of the unit of length "metre" by means of the constant "speed of light", which is with dimension " metre" per "second" (i.e. calculated by means of previously defined " metre").

Principles, group 2: "requirements about the definition of the base units".

The base units are at the top of the hierarchy of the structure of the measurement system.

- Base physical units should not be defined by means of other physical units or physical constants - they must be independent.
- The choice of the base physical units must be consistent with the so-defined nature of the physical reality in the Universe (see *3.1*). It means that at the top of hierarchy of the physical units by importance should stay the units of time, space (length), mass, force and energy.

Comments:

In general terms, the energy is the capacity to make change in the material world. As was mentioned above, the energy is a multi-layer physical quantity and exists in many forms. It may exist in potential, kinetic, thermal, electrical, chemical, nuclear, or other forms. The temperature is physical quantity that indicates degrees of hot and cold on a numerical scale. It is a physical quantity that corresponds to the kinetic energy contained in a thermodynamic system. Moreover, "Kelvin" can be defined as an independent unit. That's why, to the base units of time, space (length), and mass, can be added and the unit of the temperature "Kelvin" ^{O}K.

The unit of force is with basic importance too. It makes the link/connection between the units characterizing gravitational field and the units characterizing electromagnetic field. This connection can be done by comparing the forces generated by the gravitational field and electromagnetic field. However, the unit of force cannot be independent - it is not possible to be defined independent of the base units of time, length, mass or temperature. That's why, the unit of force cannot be considered as a base unit.

Another important connection between macro and micro world can be made through the definition of the unit of mass (see below).

- The base physical units must be defined by fixing the exact number of (magnitude, size or amount) of a certain characteristic of a particular physical quantity, with exact specified experiment under precise initial conditions (it is a consequence of the fact 2 /see *3.2/* that only the numbers remain to be absolute in the Universe).

For example, the physical quantity time has a characteristic duration. When defining the base unit of time, we fix the duration of certain number of periods of a particular electromagnetic radiation under precise conditions. *"The second is the time duration of 9 192 631 770 periods of the radiation in vacuum, corresponding to the transition between the two hyperfine levels of the caesium 133 atom, at the sea level".*

- The method of comparison between the same effects caused by different physical quantities can be used when we define a base unit.

For example, the base unit of mass can be defined as a mass of crystal of ^{28}Si with fixed number of atoms (by counting), witch feels the same gravitational attraction as the international Prototype in the time-spatial domain „at the sea level" (by comparing). The rationale for this way of defining the "kilogram" is given in the next section.

Principles, group 3: "requirements about the definition of the derived units"

In the new proper SI-system, all units defined by means of other units or constants are accepted to be derived units.

- All derived units should be defined only by means of previously defined units. Constants can also be used if they are expressed only by means of previously defined units too. So it will be observed a strict logical consistency and will be formed a proper hierarchy of the SI-system. At the top of this hierarchy will stay independently defined units (the base units). Physical units below in the hierarchy will be defined by the units, standing only at the higher levels in the hierarchy.
- Some derived units can be defined in different ways - by using different sets of previously defined units. Therefore, the following principle should be observed – "the less is the number of the used previously defined units, the more accurate will be the definition and higher in the hierarchy will be the unit".

Following these principles and facts, we can make an example of initial structure of the new SI-system, which will be of course discussed.

4. Starting example of hierarchy and the units' definitions in the new SI-system

The following starting example can be used as starting point which can be used as a basis for a discussion at the next session of CGPM.

According to the above principles, the base units for our local reality should be the units of time, length, mass and temperature, because they are based on the physical nature of the Universe and can be defined independently from other units. In this section the old definitions of the base units (BIPM SI brochure *8th ed.* 2006) and the proposed new definitions (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) are discussed. On their basis and according to above mentioned approach to the creation of a new SI-system of proper units - new suggestions for defining the base and some of the derived units are represented.

4.1. The base unit of time (second)

The change of the frequency represents the change of the space-time warping. The best way of definition of our local unit of time is by fixing the duration of certain number of periods of certain electromagnetic radiation with certain frequency in a time-spatial domain „at the sea level". The suggested definition in (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) is:

The second, s, is the unit of time; its magnitude is set by fixing the numerical value of the ground state hyperfine splitting frequency of the caesium 133 atom, at rest and at a temperature of 0 K, to be equal to exactly 9 192 631 770 when it is expressed in the unit s^{-1} *, which is equal to Hz.*

The current definition (BIPM SI brochure *8th ed.* 2006) is:

"The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom"

At its 1997 meeting the CIPM affirmed that: *"This definition refers to a caesium atom at rest at a temperature of 0 ^{0}K"*. That addition is because the experiment is not performed in a vacuum (i.e. in the presence of molecules), and/or of other electromagnetic radiation.

So, the proposed definition (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) is more precise and better represents the physical nature of the Universe – that the change of the frequency represents the change the space-time warping. But according to the statements made in this article, in the definition should be added that the local time-spatial domain where the experiment is performed is "at the sea level".

The "second" is a base unit, because its definition is independent of other units or constants. Uncertainty of definition of the unit of time "second" depends on accuracy of counting of these 9 192 631 770 periods.

4.2. The base unit of length (metre)

The proposed definition in (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) is:

"The metre, m, is the unit of length; its magnitude is set by fixing the numerical value of the speed of light in vacuum to be equal to exactly 299 792 458 when it is expressed in the unit ms^{-1}".

Further is explained: *„Thus we have the exact relation c = 299 792 458 m/s. The effect of this definition is that the metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second".*

Of course, the "meter" can be defined by using the local constant "speed of light". But "speed of light" has a dimension "meter per second" (i.e. by already previously defined "meter"). Therefore, the definition of the "meter" in (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010), as well as the current definition consist a "circular reference".

The more proper, independent way of definition of the unit of length, in accordance with above mentioned principles, is by fixing the summary length of a certain number of wavelengths in vacuum of certain electromagnetic radiation in the time-spatial domain "at the sea level". That's why, the preferable definition of the "meter" is adopted by (11th meeting of the CGPM, *Resolution 6* 1960). But according to the statements made in this article, in the definition should be added that the local time-spatial domain where the experiment is performed is "at the sea level":

"The metre is the length equal to 1650763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels 2p10 and 5d5 of the krypton 86 atom at the sea level."

If this definition of the base unit of length is determined in the reference system bound to the Earth's surface, it is obligatory the "metre" to be determined by taking the arithmetical average of the measured sum of 1650763.73 wavelengths in two opposite directions (to East-and to West) – and in the time-spatial domain "at the sea level".

Of course, it can be suggested another appropriate electromagnetic radiation…

So the "metre" is a base unit, because with this definition is independent of other units or constants and the uncertainty of definition of the unit of length "metre" depends on accuracy of counting/reading of these 1650763.73 wavelengths.

4.3. The base unit of mass (kilogram)

The proposed definition (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) is:

"The kilogram, kg, is the unit of mass; its magnitude is set by fixing the numerical value of the Planck constant to be equal to exactly 6.626 06X x 10^{-34} when it is expressed in the unit s^{-1} m^2 kg, which is equal to J s".

Planck's constant has dimension (s^{-1} m^2 *kg)* – i.e. it is defined by means of previously defined „kilogram". Therefore, the definition of the „kilogram" in (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) consists a "circular reference" too.

Before being offered another definition of the unit of mass, let's analyze the physical quantity *mass*. On one hand, material bodies with their masses create gravitational force field and warp the space-time. On other hand, we associate the physical quantity mass of a body, with the effect that this body feels by the impact of force on it. The gravitational force of attraction of a material body is a measure of the mass of this body. The material bodies with equal mass feel the same force of attraction in a place with a certain intensity of the gravitational field, and receive certain acceleration. If a force with the same magnitude (but not gravitational force), is applied to the same material body at the same place - the body will get the same acceleration. Therefore, it is naturally to conclude that the gravitational and inertial masses are not only equal – they are the same physical quantity.

In our local time-spatial domain, the gravitational field is determined by the close proximity of the huge mass of the Earth. The gravitational force, with which the Earth attracts each body, is proportional to the mass of this body. In other words, two material bodies at the same place, with the same structure, consisting of the same isotopic pure substance, feel the force of attraction proportional to the quantity of substance contained in each body (proportional to the number of atoms or molecules). That is why, the force of attraction of each body consisting of the same isotopic pure substance, in a place with certain gravitational intensity, is a measure of the mass of this body (the number of atoms or molecules). Or if we need to aware the mass as a physical quantity, it inevitably brings us to the logical conclusion that the mass of a material body is actually the amount of substance in it. Therefore, we can define the unit of mass in the small time-spatial domain "at the sea level" by fixing /determining the exact number of atoms in a sphere of pure isotopic crystal ^{28}Si, which feels the same force of gravitational attraction as the international Prototype of the kilogram. "*The results obtained for the spheres AVO28-S5 and AVO28-S8 involved in the comparison have demonstrated that by using air buoyancy artefacts and sorption artefacts it is possible to achieve a relative uncertainty of* 4.1×10^{-9}" (Picard A, Barat P, Borys M, Firlus M and Mizushima S 2011).

Therefore, in full compliances with the above principles, the following definition of the unit of mass, *the kilogram*, can be proposed:

"*The kilogram is the mass of isotopically enriched silicon crystal* ^{28}Si *with equivalent gravitational attraction to the gravitational attraction of the international Prototype of the kilogram, compared in the small time-spatial domain at the sea level. The determination of the exact integer number of atoms in this crystal will be the definition of the kilogram*".

The uncertainty of this definition of the unit of mass „kilogram" depends on the accuracy of counting atoms in the silicon artifact and on accuracy of comparing the gravitational attraction to the Earth, of *the Prototype of the mass* and the silicon artifact. In this way of definition, the unit of mass will be a base unit not only because of its significance (3.1), but also because it is defined independently of other units or constants.

4.4. The unit of thermodynamic temperature (Kelvin)

The thermodynamic temperature characterizes the kinetic energy (the motion) of the system's particles. In other words, the thermodynamic temperature is a physical quantity that characterizes the local thermal energy of matter. The change of the thermodynamic temperature represents the change of thermodynamic (internal) energy in a thermodynamic system.

The current definition (see BIPM SI brochure 2006 *8th ed.*) of the thermodynamic temperature is:
"The Kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water".

The proposed new definition of the thermodynamic temperature in the (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) is:
"The Kelvin, K, is the unit of thermodynamic temperature; its magnitude is set by fixing the numerical value of the Boltzmann constant to be equal to exactly $1.380\,6X \times 10^{-23}$ *when it is expressed in the unit* $s^{-2}\, m^2\, kg\, K^{-1}$*, which is equal to* $J\, K^{-1}$*".*

The uncertainty of the new definition of unit of thermodynamic temperature is based on the accuracy of determination of the Boltzmann constant. But the dimension of Boltzmann constant is [$s^{-2}\, m^2\, kg\, K^{-1}$] - i.e. it is determined by means of previously defined "Kelvin". Therefore, the proposed new definition of "Kelvin" in (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) consists a "circular reference" too. That's why it is unacceptable - we cannot know the value of Boltzmann constant before the unit of thermodynamic temperature "Kelvin" to be defined.

Therefore, the preferable definition is the current definition. Furthermore, using the current definition - the unit of thermodynamic temperature is independent of other units and constants. In this way, the unit of thermodynamic temperature is the fourth independently defined of other physical units and constants unit. So in the hierarchy of the new SI-system we will have four base units.

Actually, by means of the unit of the thermodynamic temperature, we can define the unit of energy. It is more direct method instead through performed work.

Derived units are at different levels depending on the used previously defined physical units. Further down in the article, definitions of some of the more important derivative units are considered.

4.5. Derivative unit of the amount of chemical substance (mol)

The mole is a unit of measurement used in chemistry to express amounts of a chemical substance.

Following proposals of IUPAP, IUPAC, and the International Organization for Standardization (ISO), the CIPM gave in 1967 (and confirmed in 1969) a definition of the "mole" - finally adopted by (14th CGPM 1971 *Resolution 3*), which is the present definition of the *mole*:

1. The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12; its symbol is "mol".

2. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

In 1980 the CIPM approved the report of the CCU (1980) which specified that
"In this definition, it is understood that unbound atoms of carbon 12, at rest and in their ground state, are referred to".

The definition of the "mole" also determines the value of the universal constant that relates the number of entities to amount of substance for any sample. This constant is called the "Avogadro constant", which has a value of $N_A = 6{,}023 \times 10^{23}$ mol^{-1} elementary entities of the substance.

The proposed definition of the "mole" in (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) is:
"The mole, mol, is the unit of amount of substance of a specified elementary entity, which may be an atom, molecule, ion, electron, any other particle or a specified group of such particles; its magnitude is set by fixing the numerical value of the Avogadro constant to be equal to exactly 6.022 14X x 10^{23} *when it is expressed in the unit* mol^{-1}*".*

If we have to determine with greater precision the number of elementary entities in one mole, it must first be determined the unit of "mole" - or, again, this is a case of "circular reference" ... Therefore, the present definition is preferable.

Thus the unit of amount of chemical substance "mole" in the hierarchy of the new SI-system will be a "derived unit level one", because its definition uses one base unit - the unit of mass "kilogram".

The uncertainty in the definition of the unit "mole" will depend on the accuracy of determining the unit of mass "kilogram" and on the accuracy of counting the number of atoms in 0.012 kg of carbon-12. For a more accurate count of the number of atoms, more appropriate definition of "mole" can be done by counting the atoms in 0.028 kg of crystal of pure ^{28}Si. Thus the definition of mole can be the following:

"The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.028 kilogram of ^{28}Si*; its symbol is "mol".*

In this definition, it is understood that unbound atoms of ^{28}Si, at rest and in their ground state, are referred to.

4.6. Derivative unit of force (kilogram force)

In 1946, Conférence Générale des Poids et Mesures (CGPM) resolution 2 standardized the unit of force in the MKS system of units to be "*the amount needed to accelerate 1 kilogram of mass at the rate of 1 metre per second squared*". The (9th CGPM 1948 *Resolution 7*) adopted the name "newton" for this unit. This definition uses three base units ("kilogram", "metre" and "second"). Thus, this unit turns out to be a derived unit of the third level.

The most independent way to define the unit of force is the definition of the gravitational unit of force, by means of one base unit only – the unit of mass (the less used units – the higher accuracy at definition).

The suggested definition of force for our local physical reality is:

One kilogram-force is the force equal in magnitude of the gravitational force exerted on one kilogram of mass in the gravitational field of the Earth at the sea level.

Thus defined, the unit of force “kilogram force” is “derivative unit of first level”, because the definition uses only one base unit – the unit of mass “kilogram”.

The uncertainty of definition of the unit of force “kilogram force” depends on accuracy of definition of only one base unit – the unit of mass, and on accuracy of comparing. So, the suggested definition is preferable.

Here we can insert that the existence of the unit "Newton" is a consequence of the arbitrary choice of the unit of length „meter”. For example, let’s imagine that we have chosen a new unit of length - "new meter", which is 9.80665 times larger than the present “meter”. As a result, if we define the unit “new Newton” in the same way as the unit “Newton” is defined (as the force necessary to provide a mass of one “kilogram” with an acceleration of one “metre” per “second” squared), but using the "new meter" - it will not exist any difference between the units "new Newton" and “kilogram force”... and the question about the difference between the gravitational and inertial masses, would not have been arose at all ...

4.7. Derivative unit of electric current (ampere)

The unit of force is very important, because it gives connection between the physical units of the electromagnetic field and the physical units of the gravitational field. Those fields are force fields. So, if we choose the “ampere” to be the most important quantity of the electromagnetic field, we should define this unit by means of comparing forces. Defining the unit “ampere” through an experiment comparing the gravitational and electromagnetic forces is not only a strategic approach, but in this way minimum previously defined units are used - (the less used units – the higher accuracy at definition).

The current definition of the unit *ampere* is:

The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} *newton per metre of length.*

The suggested definition in the (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) is:

“The ampere, A, is the unit of electric current; its magnitude is set by fixing the numerical value of the elementary charge to be equal to exactly $1.602\ 17X \times 10^{-19}$ *when it is expressed in the unit s A, which is equal to* ***C****.”*

In the new definition, the uncertainty of the definition of the unit “ampere” is based on the accuracy of definition the elementary charge, which has to be equal to $1.602\ 17X \times 10^{-19} C$. But the unit *coulomb* has a dimension [*s A*] - i.e. it is determined by means of previously defined “ampere”. Therefore, the definition of the “ampere”in the (Draft Chapter 2 for 9th SI brochure, following redefinitions of the base units 2010) consists a “circular reference” again. Therefore, this definition is unacceptable, because we cannot determine the value of the elementary charge before the unit of electric current “ampere” to be defined.

So, the current definition of the unit “ampere”is preferable. Only we should add to that definition and the words “at the sea level”.

Or, it would be better, if the following proposed definition will be discussed (Или би трябвало да бъде дискутирана и следната дефиниция):

“The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to $(2 \times 10^{-7}) / 9{,}80665$ *kilogram force per metre of length at “the sea level”.*

In this way the unit of electric current “ampere” is a derived unit of second level, because at its definition, the minimum of used base units are two – the unit of length “metre” and the unit of mass “kilogram” (used for definition of the unit of force “kilogram force”).

The uncertainty of definition of the unit of electric current “ampere” depends on accuracy of definition of the used units “kilogram force” and “metre”.

In this way we can go on to define all the physical units and place them in appropriate level in the new SI-hierarchy. In this way all the physical units will be proper units and will floating, depending on the intensity of the gravitational field in the certain time-spatial domain. In the future, we have to know how the units will differ … at surface of other planets …

5. Examples of tests to prove the change of the properties of the atoms in locations with different intensity of the gravitational field

The development of technologies and the accuracy of the measurement can made possible the following two tests concerning the change of the properties of atoms in case of change of their location to another time-spatial domain with different intensity of the gravitational field.

5.1. Proposal for a test proving the change of the frequency of optical atomic clock located to an orbit around Earth.

Optical atomic clocks today are with highest accuracy. The test can be carried out using two perfectly identical optical atomic clocks, tested in a laboratory on Earth at sea level. To increase the accuracy and reliability, the clocks may have to be more than two. They may be set up so that by using the identical apparatus, to emit pulses of a certain number of periods - for example, at an interval of one hour. After their adjustment and synchronization (possibly fixing a displacement, if any), one of the optical atomic clocks should be launched with a satellite into stationary orbit (preferably a higher orbit). In order to increase the accuracy of the experiment, the orbit should be stationary orbit. In this way, will be avoided the application of complex mathematical techniques associated with the relative motion of the satellite to the point on the Earth, where is the location of the other atomic clock. The expected result is that the period of the pulses coming from the clock of the satellite will be shorter. In other words, a longer time interval between the pulses generated by the optical atomic clock located on the surface of the Earth will be reported. This means that the frequency of the optical atomic clock located at sea level on Earth's surface will be lower than the frequency of the identical atomic clock located on the stationary orbit (in weaker gravitational field). With this will be demonstrated that the property of atoms „the frequency of electromagnetic radiation" (any frequency corresponding to the transition between the two hyperfine levels of the ground state of any atom) varies with the change of intensity of the gravitational field in the time-spatial domain, where the atom is located.

5.2. Proposal for a test proving the change the wavelength of electromagnetic radiation emitted by of accurate source, launched with a satellite into orbit around the Earth.

This test might be more difficult to be realized. It is based on the fact that the space/distances between the particles of a material body (molecules or atoms) feels much weakly influence by the intensity of the gravitational field outside the body. In other words, the distance / space between the molecules of a material body (or between atoms in a metal lattice) will be affected by the gravitational field outside the body much less than the wavelength of electromagnetic radiation spreading outside in close proximity to the body.

The experiment consists of measuring the number of wavelengths of suitable source of electromagnetic radiation along the length of the material rod (with possibly longer length for greater accuracy) at sea level of the ground surface, and at the space station, located in orbit around the Earth where the gravitational field is weaker. The material of the rod should be with small thermal expansion coefficient, although the two experiments (on the ground surface and on the space station) must be made at the same temperature. The positive result of the experiment would be a smaller number of wavelengths of the electromagnetic radiation along a fixed rod in a space station (due to the increase in wavelength) in comparison to the number of wavelengths of the electromagnetic radiation from the same source along the same rod on the sea level of the ground surface. Thereby will be demonstrated that the property of the atoms "wavelengths of electromagnetic radiation" corresponding to the transition between two hyperfine levels of the ground state of any atom changes depending on the intensity of the gravitational field in the time-spatial domain, where the atom is located.

With these two experiments will be demonstrated again that the „speed of light" increases in a time-spatial domains with lower intensity of the gravitational field ($c=\lambda\nu$). Or in other words will be demonstrated that the constant „speed of light" is not a "fundamental constant", but only "local physical constant" (like the other physical constants…).

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