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A possible new definition of the fundamental measure units

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Abstract: A new definition of the measure units in Physics by using the concept of cardinal number and by considering universal physical constants is proposed. Another idea is to start from the moment of the creation of the Universe (BIG BANG or better said BIG FLASH). In this way, along with the speed of light in vacuum C_V, the Planck constant h and the total energy of the Universe, E_U are introduced. As regards the measure unit for temperature, the Boltzmann constant k_B is considered. For the electrical charge, the electron charge is taken as a constant. In this way the sustenability of evaluation of technical parameters is increased. For example, the lowest sustenability is for unitts like (feet;pounds) instead of (meters; kgs).

Key words: cardinal number, universal constant, class of equivalence.

1. Introduction

Initially, the measure units for length (meter) and for time interval (second) were introduced in connection with the dimensions of Terra and pendulum oscillations, respectively. For example, one meter was equal to $0,25 \cdot 10^{-6}$ of the length of the meridian passing through Paris; the second was taken as a half of the pendulum periode of 1 meter length. Afterwards, the wave length and the frequency of emitted radiation during transition between the two hyperfine levels of Cesium 133 atom were used for definition of second [1]. At the 1983 Conference Generale des Poids et Mesures, the following SI (Système International) definition of the meter was adopted: "*The meter is the length of the path travelled by light in vacuum during a time interval of 1/299792458 of a second*". This definition follows the very precise measurement of the speed of light in vacuum: c = 299792458 m/s and the fact (not disproved till now) that this speed is constant in any inertial reference frame. As per the same Convention, the *kilogram* is the mass of the international

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prototype of the kilogram.' (definition since 1901). It is interesting to remark that the use of light in the definitions of basic units had been proposed already in 1827 by Jacques Babinet [2].

An important idea is to use however universal constants only like the speed of light in vacuum C_V; such examples are the Planck or the Boltzmann constants. We take the fact that C_V can be connected with the expansion of the Universe, being the speed of the Universe frontier.
An earlier idea of using universal constants for definition of units can be found back in 1899 when Max Planck proposed such a system of units. He used the reduced Planck constant $\hbar = 1.055 \times 10^{-34}$ kg m^2/s, the Newtonian gravitational constant $G = 6.672 \times 10^{-11}$ m^3/s^2.kg, the speed of light $c = 2.998 \times 10^8$ m/s and the Coulomb constant $1/4\pi\varepsilon_o = 8.987 \times 10^9$ m^{3}kg/s^{2}C^2. Various combination of these constants can be used to define units of length, time, mass and charge. Going further, it is possible to define other units for the rest of physical quantities, like force, energy, momentum, power, electric field etc. [3]
In the next, a new approach of definition of basic units for the physical quantities will be presented, wherein there will be chosen as universal constants only those ones which are enough precisely determined and are proved to be constant in space and time.

REMARK. Unlike Planck approach, the Newton's coefficient of gravity, *G*, will not be considered in this paper a universal constant, as it depends on the age of Universe [4].

2. The used universal constants

One selects the following quntities considered as fundamental universal constants:
a) the speed of light in vacuum C_V (meter/second);
b) the total energy of Universe E_U (joule); a particular value can be obtained by using the model of the early Universe [5];
c) the Planck constant, *h* (joule.second);
d) the Boltzmann constant k_B (joule/kelvin);
e) the electrical charge of the electron q_e; (coulomb).
In table 1, the degree of precision for the determination of universal constants is illustrated. (uncertainty represents the relative deviation of measurements for the corresponding constants).

Table 1. Some basic physical constants along with their precision of determination [2]

Quantity	**Symbol**	**Value in SI units**	**Uncertainty**
Vacuum speed of light	C_V	299792458 m/s	Connected to the vacuum definition; supposed very small
Vacuum permittivity	ε_0	$8.854\cdot 10^{-12}$ F/m	Connected to the vacuum definition supposed very small
Planck constant	h	$6.626\cdot 10^{-34}$ J.s	$7.8\cdot 10^{-8}$
Electron charge	q_e (or e)	$-1.6\cdot 10^{-19}$ C	$3.9\cdot 10^{-8}$
Neutron mass	m_{ne}	$1.675\cdot 10^{-27}$ kg	10^{-10}
Boltzmann constant	k_B	$1.38\cdot 10^{-23}$ J/K	$1.7\cdot 10^{-6}$
Gravitational constant (*)	G	$6.673\cdot 10^{-11}$ N.m²/kg²	$1.5\cdot 10^{-3}$

(*) The gravitational constant (or better said “the coefficient of universal attraction”) was included in the table only to compare the precision of determination – the weakest one!

In order to obtain a general definition of units one takes the model of Mathematics for the definition of the ***cardinal number.*** The way is the following [6]: to a set of elements X{ x_k }, k finite, one attributes a ***relation of equivalence*** ρ (i.e. a relation which is reflexive, symmetric and transitive). This relation determines a ***factor set*** X/ ρ . By definition, any element of X/ ρ is a ***cardinal number,*** therefore a class of equivalence determined by the relation ρ .

In the next, we will refer to the definitions of units within International System of Units (SI). Of course, other units can be defined following the same judgment.

For example, in case the speed (meter/second) is the relation ρ , then the factor X/ ρ contains all the elements having the dimension (meter/second) i.e having speeds. Then one has:

$$X/(m/s)=\left\{\left[x_k\right](m/s)\right\}, k=1;2;3........k_{tot}, \quad (2.1)$$

were [•] represents the numerical part (dimensionless) of the quantity in brackets. In particular [x_k](m/s) = [C_V] (m/s) for a photon in vacuum or ***better for a photon from the Universe frontier where one can consider a primordial vacuum, one writes:***

$$1(\text{m/sec}) = 1/[C_V]\ C_V; \quad (2.2)$$

where [Cv] is the numerical value of light speed in chosen unit. Of course, the value obtained for C_V could be improved in time.

Similarly, one obtains:

$$1(\text{joule.sec}) = 1/[h]\ h; \quad (2.3)$$

$$1(\text{joule}) = 1/\left[E_U\right]E_U \quad (2.4)$$

By combining the two relations (2.3) and (2.4) one obtains the ***unit for the time interval*****:**

$$1(\text{sec}) = \left[\frac{E_U}{h}\right]\frac{h}{E_U} \tag{2.5}$$

In particular, for h=6.62605·10^{-34} joule.sec and $E_U = 11^{77} E_{neo}$ =2.32003·10^{70} joule, E_{neo} being the energy corresponding to the mass of neutron at rest [5], one obtains

$$1(\text{sec}) = \left[\frac{E_U}{h}\right]\frac{h}{E_U} = \left[\frac{E_{ne0}}{h}\right]\frac{h}{E_{ne0}} = 2.275E23\frac{h}{E_{ne0}} \tag{2.6}$$

Thus instead of the total energy of the Universe, the equivalent energy of the neutron at rest appears in another class of equivalence.
Further by using the relations (2.2) and (2.5) one obtains the length unit:

$$1(\text{meter}) = \frac{1}{[C_V]}\left[\frac{E_U}{h}\right]C_V\frac{h}{E_U} = 1.74019\cdot 10^{95} C_V\frac{h}{E_U}. \tag{2.7}$$

Thus one has obtained particular values for "joule", "sec" and "meter" using universal constants only.

2.1. An interpretation of the "sec" time interval

By using the Heisenberg uncertainty relation combined with the Gauss principle of minimum constraint [5; 7] one obtains at BIG FLASH :

$$(\Delta t)_{BF} E_U = \frac{h}{4\pi}; 1(\text{sec}) = \left[\frac{E_U}{h}\right]\frac{h}{E_U} = 4\pi(\Delta t)_{BF}\left[\frac{E_U}{h}\right] = 4.39997\cdot 10^{104}(\Delta t)_{BF};.$$
$$E_U = 11^{77} E_{ne0}; E_{ne0} = 1.5075\cdot 10^{-10}\text{ J} \tag{2.8}$$

Therefore, in particular, the 1(sec) time interval is 4.39997·10^{104} times the time interval required for the creation of the Universe! Then the 1(meter) length interval is the length traveled by the light in vacuum in this time interval.

Remark. According to the model of Universe given in [5], the total energy of Universe is expressed as a function of E_{ne0}, the energy corresponding to the mass of the neutron at rest. However using the total energy E_U has its advantage: E_U can be determined in other possible ways as well, the most safe being finally retained.

2.2. The mass unit (kg) and the temperature unit (kelvin)

According to the relativistic relation between mass and energy, for ***the equivalent mass of the Universe***, M_U , one has:

$$E_U = M_U C_V^2 ; M_U = E_U / C_V^2 (\text{kg}) = 2.57781\cdot 10^{53}\text{ kg} \tag{2.9}$$

Therefore for the mass unit one can take the following definition:

$$1(\text{kg}) = \left[\frac{C_V^2}{E_U}\right]\frac{E_U}{C_V^2} = \left[\frac{1}{M_U}\right]M_U \tag{2.10}$$

For the ***thermodynamic temperature*** one uses the Boltzmann constant, $k_B = 1.38462 \cdot 10^{-23}$ J/K, as fundamental unit. Then one obtains the ***particle temperature of the Universe,*** T_U **,** and an expression for *kelvin* unit:

$$E_U = k_B T_U;\ \ T_U = \frac{E_U}{k_B};\ \ 1(\text{kelvin}) = \left[\frac{1}{T_U}\right]T_U = \left[\frac{k_B}{E_U}\right]\frac{E_U}{k_B} \tag{2.11}$$

Of course, the same particle temperature can be found at BIG FLASH:

$$T_U = T_{BF} \tag{2.12}$$

2.3 Two electric units

In the following we give two electric units: one for the ***electric charge*** (*coulomb*) and other for
the ***electric current (ampere)***.

To this aim one uses the charge of electron, $q_e = -1.602 \cdot 10^{-19}$ C. Then one writes:

$$1(\text{coulomb}) = \left[\frac{1}{q_e}\right]q_e. \tag{2.13}$$

Then the "ampere" being "coulomb/sec", by using the relations (2.5) and (2.13), one obtains"

$$1(\text{ampere}) = \left[\frac{1}{q_e}\right]\left[\frac{h}{E_U}\right]q_e\frac{E_U}{h} \tag{2.14}$$

Remark. Other units (ex. for force, momentum, magnetic units, etc) derived from those given above are simply obtained.

3. Conclusions

In order to obtain a new definition for the fundamental measure units in Physics, the mathematical concept of ***cardinal number*** is combined with the idea of using universal constants only. Thus ***attributing a unit measure is a relation of equivalence*** introducing classes of equivalence in sets of physical quantities. ***A measure unit is any class of equivalence introduced by it***. Among all one is expressed as a function of universal constants only in the way considered safest. This has obvious advantages, being connected with essential properties of the Universe [8;9;10]. ***It seems that no fundamental measure unit can be exactly calculated: only classes of equivalence are accessible. Using quantities even from***

the BIG FLASH has the advantage of avoiding new assumptions and sources of errors.

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