Cosmic Units of Measure

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Abstract—The commonly used units of measure have changed over the centuries. The numeric value for the speed of light was measured before it was known that light was an electromagnetic wave and how electromagnetic waves were produced. The scientific community adopted a set of units of measures that were originally developed for joint commercial, scientific and common use. There is an on going effort by the various metrology organizations to update them. There is no need to change the generally accepted units of measure for commercial and common use, but scientific units of measure need major improvements.

Introduction

There is a worldwide effort to recommend major revisions to the International System of Units (SI). The National Institute of Standards and Technology (NIST) is participating in this effort.[1-2] The French government established the length of the meter in 1795. The existence of electromagnetic (EM) waves and that light was an EM wave were unknown in 1795. The official time duration unit is the second, which is approximately 1/86,400 rotations of the Earth. The Earth's rotation rate is not consistent to the accuracy required for contemporary measurements, thus the duration of the second is now defined as 9,192,631,770 cycles of the radiation associated with a specific transition of the cesium 133 atom; this change was made in 1960 and the number of cycles, or counts, were based upon the duration of the ephemeris second.

From ref.(1), “The SI is made up of 7 base units that define the 22 derived units with special names and symbols. The international prototype of the kilogram is the only remaining artifact used to define a base unit of the SI (rather than definition by a fundamental constant).” From ref.(2), “The seven SI base units from which all others are derived are the second (time), the meter (length), the kilogram (mass), the ampere (electric current), the kelvin (thermodynamic temperature), the mole (amount of substance) and the candela (luminous intensity).”

In 1983, the meter was redefined in the SI as the distance light travels in vacuum in 1/299792458 of a second. As a result, the numerical value of c in meters per second is now fixed exactly by the definition of the meter. This is a circular definition. Using this logic any measurement length can be defined by the same constant of nature, but that does not make any of these measurement lengths suitable as a scientific unit of measure. Additionally, the meter now requires the definition of a vacuum, which is not provided in the SI. Care must be taken in defining a vacuum by a locality.

James Clerk Maxwell was against having the meter designated as a scientific unit of measure.[3] Maxwell wanted to use the wavelength of the spectra from a particular molecule; in 1870 it was not known that atoms produced specific EM emissions. Ref. (3) discussed other proposed scientific units of measure.

SI Unit Changes

As noted in ref. (2), the major SI base unit issue is the use of a physical artifact to define mass, a platinum-iridium cylinder, which poses long-term problems because its mass changes slightly over time. “The new proposal defines the kilogram in terms of the Planck constant h, an important constant in quantum physics, which is expressed in units containing the kilogram.” There are problems in accurately defining the Planck constant.[4] The formula that uses the Planck constant, $E=h\nu$, defines the energy contained in specific EM frequencies. The symbol ν (nu) represents frequency, wavelengths per second. The magnitude of the source is not considered.

The numeric value of the SOL, denoted mathematically by the symbol c, is considered a fundamental constant of nature. The units of measure that describe the SOL are the meter and the second. The size of these units was established before it was known that the numeric value of *c* was to be a key value in mathematical equations dealing with physical law. If the size of the meter is considered a wavelength, *c* is defined as a frequency, a specific frequency.

Because of surveying issues unknown at the time the French established the size for the meter, their surveyed length had to be smoothed by the least squares method to establish a straight line from Dunkirk to Barcelona. The actual size of the meter could have been fudged larger or smaller. Additionally, it was not known in 1795 that the Earth was not a perfect sphere, but bulged in the center. The SOL was known to some accuracy in 1728, 301,000 km/s. The French could have established the size of the meter using a meter length that would have given a SOL value of 314,159,265 meters per second or $\pi(10^8)$. That value would have been interesting when used in equations dealing with physical law. There is a better way to establish a numeric value for *c,* but we did not have sufficient information until 1951 to recognize the significance of the emission frequency of the neutral hydrogen atom. The better way is described in the next section.

Electric current is defined using the ampere. The ampere is defined using the Newton, which is not a base unit. No explanation is given how a non-base unit can be used to define a base unit.

It is proposed to define the kelvin in terms of the Boltzmann constant. Since temperature is related to the energy of an object, having a definition for a base unit of energy would link all the base units that define specific types or levels of energy. The SI does not have a base unit of energy.

The candela, the base unit of luminous intensity, is defined to represent a characteristic of human vision, even though the characteristic changes with ones age. This is another unit that should be based upon an energy level. It is basically a common reference to compare intensities; it is presumptuous to call this base unit a constant of nature.

There is evidence that constants of nature within the influence of our solar system cannot be relied upon to be constant. It has been discovered that radioactive decays rates vary as a function of distance from the Sun.[5] It is odd that the kilogram artifact does not have a constant measured mass. Perhaps that measurement needs to be correlated with the same Sun-Earth distance influence that is causing radioactive decay rates to vary.

Mathematically Defined Base Units of Measure

There is a way to mathematically derive three of the current base units of measure and it is not necessary to know the size of these units. All one needs to know is a reasonably accurate value for the speed of light in a contemporary measurement system, such as SI units, and the relationship between the SOL, frequency, wavelength and a little algebra and basic Euclidean geometry. The current measured value for the SOL is 299,792,458 m/s. The mathematical relationships between the SOL (*c*), wavelength (λ) and frequency (f) are presented as equations 1a, 1b and 1c.

$$c = f\lambda \quad (1a), \qquad f = c/\lambda \quad (1b), \qquad \lambda = c/f \quad (1c)$$

In the above equation set the size of the units that describe the SOL must be known, a length and the time unit duration. For algebraic processes, we can multiply and divide numeric values that have different dimensional descriptors. There is no reason why the same process cannot be done using the dimensions of two isosceles triangles that each have a different dimensional descriptor as long as certain rules are followed to assure that the two triangles having different descriptors are properly related.

In 2011, a paper was published in an IEEE publication titled, “A methodology to define physical constants using mathematical constants.”[6] The paper described how the speed of light (SOL), its associated frequency, a unit of length and a time unit duration can be mathematically defined. The SOL and its associated frequency have the same numeric value, which is expressed as $2\pi\sqrt{2}$ times a multiplier. The IEEE paper refers to the mathematically derived units as *intrinsic units*, but they could have been called *Euclidean natural units*.

The methodology described in the IEEE paper used a pair of isosceles right triangles where one was labeled frequency and the second wavelength. One common length element of each triangle was kept as a constant, which allowed the second length and the hypotenuse to change length as the angle was changed. The angle of the triangle defines the size of the time unit duration. Basically, elementary Euclidean geometry allows one to define a time unit duration that can be used throughout the universe, as it is not tied to a division of the rotation of a particular planet or other celestial object.

The other benefit is the actual numeric values used to express the dimensions of the triangles are considered as mathematical constants, which are easily incorporated into equations dealing with physical law. For decades, mathematical physicists have attempted to find a way to *equate* the value of *c* to a numeric value that was equation friendly. The numeric value of the SOL, mathematically defined by the triangle pair, is composed of two transcendental numbers that are considered mathematical constants. The mathematically derived units of measure and SOL will make it easier to correlate relationships between various physical law characteristics.

The IEEE paper can be downloaded free by all IEEE members. The title page of the IEEE paper used an image of Euclid holding a tablet that has two right triangles on it. A post-print is available without the IEEE illustrations.

Conclusions

There is a need for a set of scientific units of measure that are not based upon provincial dimensions. The meter and the duration of the second are provincial units of measure.

The meter was created by the French because of the *politics* at that time. It was not known that the selection of a particular size for the meter as a scientific unit of measure would result in the SOL value having a cumbersome impact on the mathematics of physical law. The 1983 redefinition of the meter is an example of what not to do.

It is possible to conclude that after each intelligent species in the universe identified the units revealed by the triangle pair they would have developed a base set of scientific units of measure that were based upon those units.

References

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