EUCLIDEAN ELECTROMAGNETICS

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Abstract – The association between Euclidean geometry and the electromagnetic wave phenomena was identified in 2001. A paper identifying the issue was published in a peer reviewed international publication in 2011. The title did not identify the content was directly related to Euclidean geometry, but the content did. The published title described what was accomplished, directly linking mathematical constants to a physical constant. A very serious issue involving the paper has been identified recently and it effects a vast number of other scientific publications and the theories they promote.

Introduction

The title of a 2011 IEEE article was, "A methodology to define physical constants using mathematical constants"[1] The title directly contradicts what is taught about the difference between a physical constant and a mathematical constant. I was told at the time by one of my mentors, Professor Sid Deutch, who had reviewed my paper before it was submitted to an IEEE publication, that electrical engineers are very conservative and might not read or comment on an issue that contradicts what they are taught. He had sent my paper to a mathematician friend, who returned a positive endorsement. I received no negative comments from those that peer reviewed the paper. After peer review, I was asked by the editor to provide a Benefits Section. It was published verbatim.

I have had considerable opportunity to observe how the The Scientific Authority Structure (SAS), a Thomas Kuhn term, functions as a large body that is resistance to change. The resistance to change is primarily enforced by controlling what is published in the mainstream science publications and the funding for scientific endeavors. The 1982 quasicrystal debacle is an example. A hundred years of consensus on xray crystal symmetries was based upon the poor resolution of the xray crystallographic equipment. A few years after 1982, improved xray crystallographic devices could detect quasi crystal structures. It took from 1982 to 2011 before the old consensus was officially overturned by the 2011 Nobel Prize award in chemistry.

It is understandable why where an article is published determines who reads it. In 1933, Karl G. Jansky had an article published in the Institute of Radio Engineers publication titled, "Electrical Disturbances Apparently of Extraterrestrial Origin".[2-3] No astronomers or physicists appeared to have read the Jansky article. An electrical engineer and amateur astronomer, Grote Reber, read the article and began investigating the phenomena. He made a large parabolic antenna, 31.4 feet in diameter, and several high frequency radio receivers that could detect frequencies well above what was currently being detected by contemporary receivers of that era. His work is preserved in the archives of the National Radio Observatory.[4] It took a special effort to get his paper published in an astrophysics publication.[5] It was the astrophysics publication that started radio astronomy.

The information revealed in the ref(1) paper had been submitted to several mathematical publications before it was altered and submitted to the IEEE publication.

The serious error that effects the content of ref(1) involves how the EM frequency scale was established.

EM Frequency Error

The authors amateur radio license dates to 1948. The study for the license required knowledge of the formula $c=f\lambda$ where c is the speed of light, λ is wavelength and f is frequency. It was never discussed at anytime, even in engineering college, how the longest EM wavelength was determined, which establishes the frequency of 1. Determining the longest period of a process that is cyclic requires monitoring it to identify the longest wave. In the 1800s, there were no devices that could produce or detect the longest EM wave. Apparently, in the 1800s, it was decided to use the duration of the second as the basis for the longest EM wave. Failure to properly establish the longest period an EM wave has consequences.

Magnetotelluric transmitters are producing frequencies below 1 Hz and the frequencies are being identified by using a decimal notation, 0.100, 0.0100, 0.0010 Hz etc. This means we have a non-linear EM frequency scale. It appears that all contemporary physical law equations (PLE) that contain **f** or **c** as a value are based upon the assumption that the EM frequency scale is linear. A short article describing the problem was submitted to two well known technical publication that are peer reviewed and distributed internationally. The first submission was deferred to a later possible publication date, which came and went without publication and no reason provided.. The article was then submitted to a second publication, which immediately rejected it, with the statement, “it did not fit within their editorial requirements.” These publications are well established in the SAS and I have had long term association with both of them.

Post Print

The postprint of the IEEE published article is included in the pages following the references. It is complete as submitted and includes a spelling error that was corrected in the published version.

Reference

[1] Makinson, F. H. “A methodology to define physical constants using mathematical constants.” IEEE Potentials Vol: 30, Issue: 4, July-Aug. 2011 Page(s): 39 - 43 Date: 25 July 2011 ISSN: 0278-6648 INSPEC Accession Number: 12136007 DOI: 10.1109/MPOT.2011.940377
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Methodology to Define Physical Constants Using Mathematical Constants

Frank H. Makinson

Abstract

It is stated that mathematical constants are not the same as physical constants, although both utilize the same mathematical structures. Euclidean geometry is based upon a defined set of rules, established by logic, which give predictable results when followed. The mathematical process described in this paper, following the rules of Euclidean geometry, allow physical constants to be defined using mathematical constants. The process uses a pair of right triangles to define two basic units of measures, a unit of length and a unit of time. The numeric values that define the dimensions of the two right triangles are universally considered to be mathematical constants. The geometric process exploits the known physical law relationship between wavelength and frequency, this without needing to know any contemporary units of measure. A primary product of the triangle pair is a mathematically defined value for the velocity of light using mathematical constants. The geometric process readily allows a set of fundamental units, and related derivations, to be compared to contemporary SI units.

1. Introduction

Properly identifying the numeric value of physical constants is one of the keys to understanding the characteristics of the physical universe. Establishing the basic units of measure by which a physical constant is expressed must be as fundamental as the physical constants they are intended to describe.

A mathematical constant is a fundamental numeric value that is independent of any system of measurement, it is dimensionless. A physical constant is some characteristic of the physical universe that has been observed and then defined using some predefined units of measure, this within the confines of some mathematical structure.

Defining units of measure using mathematical constants will eliminate the man-made bias introduced by the manner in which units of measure are selected. The current method used to select units of measure results in unwieldy numeric values for fundamental physical constants, making them difficult to use in equations dealing with physical law; a number of efforts are being used to eliminate these unwieldy numeric values.[1] Physical constants defined using mathematical constants will result in numeric values which permit relationships to other physical constants in equations dealing with physical law to be more readily observed.

A geometric process can be used to identify the two most basic units of measure, length and time, both using mathematical constants. Sir Arthur Eddington stated, “My conclusion is that not only the laws of nature but the constants of nature can be deduced from epistemological considerations, so that we can have a priori knowledge of them.”[2] The methodology described herein affirms Eddington’s fundamental contention. The final bit of knowledge required to understand the basis of the methodology was discovered in 1951.[3]

The term “intrinsic units” is a catch-all used by experimenters to identify particular values that repetitively appear in a measurement process, but between disparate experimental processes there is no intrinsic unit commonality. The numeric value associated with the symbol π consistently appears in equations dealing with physical law, a commonality.[4] In the methodology, the term intrinsic units is used to identify two specific units of measure, both physically measurable, that are directly related to common mathematical constants.

The geometric process described in this text conforms to all the rules of Euclidean geometry, the only

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change is linking two different right triangles, defined by different mathematical constants, such that the values in one triangle are inversely related to the values in the other triangle. In this case, the inverse relationship is that which exists between wavelength and frequency.

The mathematical basis of all right triangle pairs is established by the basic pair of isosceles right triangles. The physical size of right triangle pairs can be scaled up or down by the use of a common ratio.

The mathematics of geometry, documented for over 2,000 years, has been exploited for many uses, but no fundamental "units of measure" or relationships to values that represent some physical constant have been extracted using a simple geometric form, such as a right triangle.

2. Geometric Versus Algebraic Process

The mathematical relationship between wavelength and frequency has been known for over 200 years, however, its basic algebraic forms simply define their inverse proportionality, equation (1), where λ is wavelength, f is frequency and c is the speed of light, the constant of proportionality.

$$\lambda = c/f, \qquad f = c/\lambda, \qquad c = f * \lambda \tag{1}$$

The geometric process uses a pair of right triangles, one representing an electromagnetic wavelength and the other frequency. The methodology that establishes the two right triangles represents a special case, a very restricted special case. The two triangles, presented in Figure 1, represent the general form of the "special case" at 45 degrees, and any variation of the angle from 45 degrees is a special case in itself, as one mutual leg of each triangle must be held at a fixed value. Specific numeric values for the legs of each triangle are required to create the inverse relationship geometrically, and these values become what are called "intrinsic units."

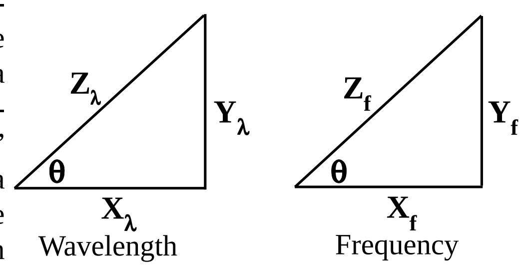

Figure 1. Special Case - 45°

3. Intrinsic Units

A wavelength is defined as the distance between successive peaks of a wave. One wavelength, or a unit wavelength, can represent a very short or a very long distance, it is a generic definition. For the wavelength triangle, this unit wavelength will be defined as an "intrinsic wavelength" or "intrinsic length", with a numeric value of one. In the geometric form, the unit wavelength represents a specific distance, which at the outset is unknown, and it has no unit descriptor, such as meters, and as a generic length it will be noted by the symbol L. A complete wavelength is represented by a numeric value of 2π radians, equivalent to a circle.

Classical physics defines angular or radian frequency by the formula $\omega = 2\pi/T$ or $2\pi f$, where T represents time, and f is frequency, 1/T. Frequency is defined as the number of wavelengths that occur in a specific period of time. If just one wavelength occurs in this time period the frequency will have a numeric value of one, but it was determined a numeric value of one would not satisfy the inverse relationship between the paired right triangles. It was found by deduction that the numeric value that defines frequency had to have a numeric value that equaled that of an angular frequency where the unit of time (T) equaled one or the frequency (f) equaled one. As a result, the "intrinsic frequency" for the frequency triangle will have a numeric value of 2π. Using the value of 2π for intrinsic frequency is not intuitive to the general scientific community, except perhaps to electrical engineers, who use 2π to represent a generic wavelength.

Figure 2 illustrates the triangle pair when the numeric value for "intrinsic length" and "intrinsic frequency" are applied to their respective triangles. The relationships between the two triangles provides a self-proof for their intrinsic values.

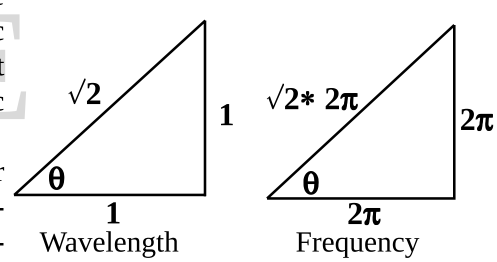

Figure 2. Intrinsic Units

The wavelength-frequency triangle pair presents a basic postulate:

When the numeric value of the leg of one triangle is multiplied by the hypotenuse of the second triangle, the resultant is the constant of proportionality between the triangles. When each of the products are equal the two triangles are inversely related.

Using the symbology of Figure 1, and applying the numeric values shown in Figure 2, the basic equations for the constant of proportionality for the paired triangles would appear as in equations (2) and (3), where L is a unit length, and τ (tau) a unit of time.

$$k = Y_\lambda * Z_f = 1 * (\sqrt{2} * 2\pi) = 8.885765\ L/\tau \tag{2}$$
$$k = Y_f * Z_\lambda = 2\pi * \sqrt{2} = 8.885765\ L/\tau \tag{3}$$

The constant of proportionality has the same meaning as that used for equation (1), it represents the velocity of the electromagnetic wave. The symbol **k** is used to represent the constant of proportionality to distinguish it from the symbol **c**, which is used to represent the constant of proportionality in SI units. It is still not obvious that the postulate is valid, even though it seems so mathematically, because the resultant numeric values are unfamiliar. When the frequency is scaled (dimentionalized) to what we call practical values, the intrinsic units can be expressed in SI units of measure, and familiar numeric values will be recognized.

4. Intrinsic Units In SI Units

One mutual leg of each triangle must be held as a constant as the angle is varied, the vertical leg was chosen. In the 45 degree case, it is not immediately apparent that the duration of the unit of time is a function of the angle, and this is revealed when an angle is reached that represents the duration of the SI second.

An arithmetic iteration was used to identify the triangle angle where the product of the vertical leg of one triangle and the hypotenuse of the other triangle produced a value of 299792458 m/sec. The physical size of the hypotenuse of the wavelength triangle is already known, in SI units, and is obtained by using the first formula in the equation (1) set.

$$\lambda = c/f = 299792458\ (\mathrm{m/sec}) / 6.283185307\ \mathrm{Hz} = 477134515\ \mathrm{m} \tag{4}$$

It became obvious that a scaling factor of 10^6 had to be used to express frequency. The numeric values of the resultant triangle pair in SI units are illustrated in Figure 3. The frequency of 1420.4 (10^6) Hz is familiar to all physicists. The cross products of the triangle pair, defined by the postulate, are equal, and represent the constant of proportionality between wavelength and frequency.

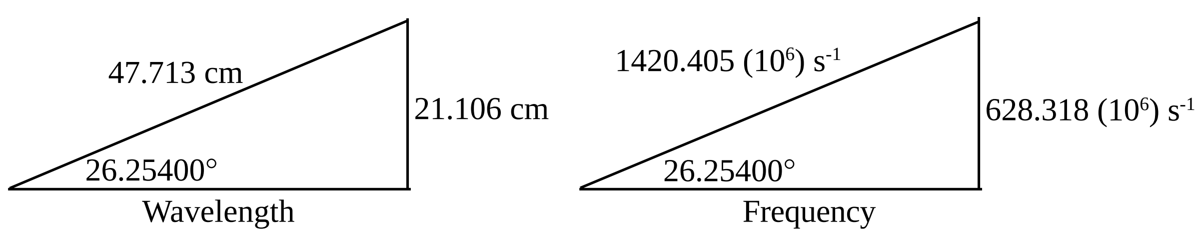

Figure 3. SI Units

If the Figure 3 wavelength triangle dimensions had been expressed in intrinsic units, the cross product of the two triangles would have returned a constant of proportionality value that had the same numeric value as that of the hypotenuse of the frequency triangle, 1420.405, adjusted for its scaling factor. This diversion from the natural value expressed by the triangle pair is an artifact of the man-made definition of the meter.

The hypotenuse of the frequency triangle when the angle is at 45 degrees versus 26.25400 degrees, represents the same electromagnetic spectrum position, even though the numeric values are different. The numeric value changed because the time duration is smaller at 45 degrees. When the time duration at 45 degrees is used as the reference, the size of the difference can be determined by the ratio of the cosecant values at 26.25400 degrees and 45 degrees, equation (5), where T_D is the time duration ratio.

$$T_D = CSC(26.25400)/CSC(45) = 2.260646 / 1.41421 = 1.5985 \tag{5}$$

The SI second is 1.5985 longer than the time duration related to the 45 degree triangle, thus there will be more wavelength cycles, a higher frequency, occurring in a SI second. The time duration defined by the triangle at 45 degrees can be referred to as *intrinsic time* with a value of one. The neutral hydrogen precession frequency is the basis for the wavelength-frequency triangle pair, which is one of the reasons why the triangle pair was identified as a special case in the Geometric Versus Algebra Process section. It should not have been too much of a surprise that the wavelength of the neutral hydrogen precession frequency can be used as a *natural* unit of length.

5. Common Ratio

The relationship between intrinsic units and SI units was determined by scaling, by factors of ten, the size of the intrinsic units, which define the base legs of an isosceles right triangle, and adjusting the angle to reflect the time duration of the second. The physical size of the intrinsic elements of triangle pairs can be scaled up or down by a common ratio, which will preserve the inverse proportional relationship between subsequent pairs of right triangles. For example, using the square root of 2 as the common ratio will double or halve the numeric value for the constant of proportionality, doubling by multiplication, halving by division. For the hypotenuse of the frequency triangle, the doubling or halving represents a harmonic relationship.

The common ratio could be another way to scale physical constants, versus factors of ten. The selection of a common ratio should not be arbitrary, there must be some physical law rationale.

6. Conclusion

Fundamental physical constants are directly related to mathematical constants through a geometric structure defined by mathematical constants.

Using the wavelength-frequency triangle pair, the numeric value for the speed of light is derived without knowing the physical size of the units by which it is defined, length and a duration of time. The physical values for the units are mutually derived with an associated frequency value of $888.5765...(10^6)\ L/\tau$. The numeric value, when expressed in intrinsic units, provides a reference value for the velocity of electromagnetic waves, an energy level represented by the frequency of the neutral hydrogen precession emission, and the number of electromagnetic cycles which define the duration of the time unit. The mathematical precision of the size of the units will be nearly unlimited, and the precision, as applied in practice, will be limited only by the technology available at a given time. A unique characteristic of the neutral hydrogen atom provides the common link between time, length and energy.

The values derived by this process will allow the creation of a set of scientific units that are universal, permanent and invariant in time, with the base units referenced to the same numeric value, $\sqrt{2}*2\pi(10^8)$, Figure 4. The mathematical correlation between time, energy and length represents a “paradigm shift” in how scientific units of measure should be defined.

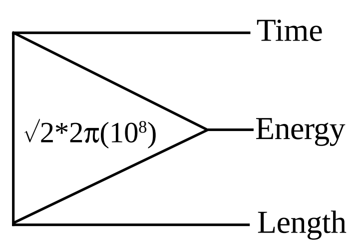

Figure 4 - Time, Energy, Length

7. Summary

The characteristics of the methodology presented herein require readers to reexamine some of the ingrained assumptions which are taught at all levels of mathematics and physics. It is not known who first made the statement, “fundamental constants in mathematics are not the same thing as fundamental constants in physical law,” and there are a variety of ways this is stated in various publications. Essentially, everyone is taught that the two types of constants cannot be the same. Perhaps the relationships revealed in this paper will allow physicists and mathematicians to resolve just what purpose π, and its multiples, are serving in physical law equations.

Wave motion has been described using radian or angular measure for well over a century. The use of 2π to define the segments of a circle is attributed to Roger Cotes, in 1714, but he did not coin the word radian to describe the segments, that term appearing sometime in the late 1800s. Although a complete wave is represented by a numeric value of 2π radians, no particular attention was paid to the wavelength that is obtained with an angular frequency with a numeric value of 2π, when time or frequency equals one, or a regular frequency with a numeric value that equals 2π. That value, 47713451.59 meters, is their point of coincidence. The significance of this point of coincidence in relationship to physical law is not known, except it is the value associated with the hypotenuse of the wavelength triangle.

The mathematical characteristics of waves were developed in the past few centuries by observation and measurement. Whether the waves were produced by some physically observable motion or those produced by electromagnetic emissions, they exhibited the same relationship between wavelength and frequency, their constant of proportionality was the wave velocity. Electromagnetic waves propagate throughout the universe and there are a host of very unique frequencies that are persistent, one is that generated by the neutral hydrogen atom, this being physically detected in 1951.[3] The wavelength of this hydrogen emission is one of the best known values in physics, approximately 21 cm, its actual length having been measured to the precision limits of SI units. The value is not identified as a “physical constant” by the SI.

All electromagnetic waves have a consistent underlying “energy conditional”, their velocity, regardless of their wavelength, which defines the spectral position of a particular emission. This energy conditional is the coincidence point, or reference, for all electromagnetic emissions. When the two fundamental units of measure, length and time, are defined in terms of this electromagnetic point of coincidence, the point can be used to express a unit of energy. The spectral energy of any particular electromagnetic emission then will be either higher or lower than that at the reference level.

It was recognized at the time of discovery that using two right triangles, one representing wavelength (length) and the other frequency (cycles per unit time), was a very special case, it worked at all angles between the range of 0 to 90 degrees when one mutual leg of each triangle was held at a constant value. When the concept was distilled to its angular center point, two 45 degree right triangles, the value of the constant leg of the wavelength triangle became one and that of the frequency triangle 2π. Identifying just what these two values meant led to the decision to define them as “intrinsic units.”.

The basic tenets of electromagnetic waves were applied to the mathematical structure of algebra about 200 years ago, wherein the methodology herein substitutes the mathematical structure of geometry. If one fundamental physical constant can be identified by a pair of simple right triangles based upon mathematical constants, it raises the issue that other fundamental physical constants might be identified using the same or other geometric structures.

It is fitting to include a quote by James Clerk Maxwell, ‘In the Address to the Mathematical and Physical Section of the British Association for Advancement of Science on Sept. 15, 1870 in Liverpool, J.C.Maxwell (1831-1879) noted: “If we wish to obtain standards of length, time and mass which shall be absolutely permanent, we must seek them not in the dimensions or the motion, or the mass of our planet, but in the wavelength, the period of vibration, and the absolute mass of this imperishable and unalterable and perfectly similar molecules.”[1] Maxwell stated the same thing at other times with slightly different wording. Maxwell was voicing his objection to the meter being considered as a scientific unit of measure. Maxwell was considering the wavelength of a spectral line produced by a particular element, sodium, but the “light” of the neutral hydrogen atom, which illuminates the universe, would have been an acceptable wavelength if Maxwell had known of it.

8. Benefits

Those in the sciences will be the first to recognize the benefit of having units of measure that are mutually linked mathematically to fundamental physical constants. Eventually, versions of the material in this paper will filter out to the general public, and later, into teaching students about units of measure. Anything that provides the public with knowledge about the characteristics of the universe will be beneficial.

The Consultative Committee on Units stated in a 2005 report,[5] “the consensus that now exists on the desirability of finding ways of defining all of the base units of the SI in terms of fundamental physical constants so that they are universal, permanent and invariant in time.” Now, a basic set of scientific units of measure can be created that will be truly universal. Additionally, a fundamental unit of energy, based upon electromagnetic principles, can be established that will be directly correlated with the mathematically calculated value for the velocity of electromagnetic waves. Having mathematically defined basic units of measure will make it desirable to have a separation between those units that are suitable for commerce and those best suited for scientific applications and discovery.

The numeric value for the speed of light will be mathematically calculated rather than *defined*. The mathematically calculated value will be limited in significant figures only by our ability to compute the value. Timing devices can be produced, referenced to the mathematically calculated numeric value, that will have more significant figures than possible with the current definition for the SI second. The cycle counts of hydrogen masers, using the intrinsic time duration, can be matched to the numeric value of $\sqrt{2}*2\pi$ to the limits of the particular hardware’s capability. Actual values for the speed of light, in mediums that permit electromagnetic wave propagation, can be compared to the mathematically calculated value.

The duration of the *time unit* of many planetary bodies, one of their signatures, can be described as a ratio relative to the duration of the unit of time identified at 45 degrees. The resultant ratio value, for any planet, can be readily translated into conventional terms understood by the general populous.

The choice of a word used in another Eddington quote, long before computers came on the scene, now implies a negative taint. “If, instead of length being defined observationally, its definition were left to the pure mathematician, all the other physical quantities would be infected with the virus of pure mathematics.”[2] The intrinsic length defined herein is a consequence of mathematics, which coincides with observation.[3] It should be viewed as a beneficial virus.

Who does and does not benefit from a paradigm shift is discussed in the book by Thomas Kuhn, “The Structure of Scientific Revolutions.”[6] The process used by the author that led to identifying the relationships in this article was not originally directed at the issue of constants. It is doubtful I would have recognized the meaning of the dimensions presented by the geometric relationships except for my electrical engineering background; the process started with one triangle and I added the second when it became obvious it was needed. Kuhn described the typical scientific process that occurs before a paradigm shift is universally adopted, but the simplicity of the concept presented in this paper will make its acceptance atypical. I expect there will be other old conclusions challenged and a few more paradigm shifts shortly after intrinsic units are applied to equations dealing with physical law.

The ultimate benefit is the use of 2,000 year old mathematics and 200 year old electromagnetic principles in the methodology; there is no need to defend them.

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