The Fundamental Mass Unit

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The fall of Einstein's theory of relativity would also be the fall of the concept that light has no mass. Accepting that light and electromagnetic radiation possess mass would lead to the formulation of a natural fundamental mass unit. Present units of mass, like kilogram or pound, are arbitrary and man-made.

Max Planck discovered around 1900 a fundamental quantum of energy, with the value of h=6.626 070 15x10^{-34} J. Because the quantum of energy is a known value, we will be able to find the mass associated with this quantum and arrive at the natural and fundamental unit of mass that emerges from nature and the physical world.

Planck's search for the true *"physical interpretation"* of his energy constant *h*

Energy constant h was discovered by Max Planck around 1900 and is known as Planck's constant. Energy of a photon is expressed as the product of Planck's constant times the photon's frequency *(hf)*. Planck discovered that an increase in the frequency of electromagnetic radiation emitted by a blackbody corresponded to an equal increase in the number of energy units h. Planck wrote:

> "(Energy of electromagnetic radiation) is made up of a completely determinate number of equal parts and for this purpose I use the constant of nature h=6.55x10^{-27} (erg sec) ... this constant, once multiplied by the common frequency of the resonators, gives the energy element ..." [1]

Because energy quantum h was not predicted by any theory and was found rather accidentally, as Planck literally stumbled upon it, Planck was not happy about his own discovery. For the rest of his life, Planck tried to find the constant's true origin and meaning. Because of the accidental nature in its discovery and because no one could explain where the quantization of energy came from, energy constant h was not embraced by other physicists or by its own author. Planck expressed his reservation about the constant he discovered in his Nobel Prize acceptance speech in 1918. He said:

> "But even if the radiation formula proved to be perfectly correct, it would after all have been only an interpolation formula found by lucky guesswork and thus, would have left us rather unsatisfied. I therefore strived from the day of discovery, to give it a ***real physical interpretation*** ..." [2] Emphasis added.)

Planck never found the "real physical interpretation" of the constant he discovered, nor has anyone else.

Planck could not have gone any further. The concept of the wave nature of light, and that light has no mass, dominated physics of his time and continues to do so today. On the other hand, the concept that the energy of electromagnetic radiation is not continuous was already a revolutionary concept. Planck, being a traditionalist, was often doubtful about it and he never totally embraced the concept. Not finding the true cause of quantization, even after his discovery of the numerical value of the quantum of energy, Planck oscillated between the continuous and quantum nature of radiation. Planck dedicated the rest of his life in search for an explanation of his formula and tried in vain to circumvent his own quantization postulate.

Where does the quantization of energy come from?

As already mentioned, the energy of Planck's constant h was discovered rather accidentally without knowing where this energy came from or what caused it.

All energy equations, relativistic or classical, are the function of mass and speed. Practically every energy equation has these two components. Because the equation for the photon's energy, $E=hf$, is equated to $E=mc^2$, equation $E=hf$ also implies these two components—mass and speed.

In a more general sense, the energy of a photon is the work the photon can perform. The question is: What is it that makes it possible for the photon to perform work? Because the energy of a photon, or its ability to perform work, is determined by the number of h units it contains, we need to determine the true meaning of the energy constant h and where its energy comes from.

First of all, the quantum h is expressed in joules, that is, it indicates a certain amount of work, 6.626 070 15x10^{-34} J.

What is it that performs this work?

The same "machinery" that is behind an electronvolt is also behind the constant *h*

While it is generally assumed that an electronvolt is an arbitrary and abstract unit representing the energy an electron acquires as it passes through an electric field, this explanation does not offer an intuitive understanding of where this energy comes from.

It was shown in the previous paper [3], however, that the "machinery" behind the energy unit of an electronvolt is the amount of mass an electron captures while it passes through a potential difference of 1 volt [1]. This captured mass is capable of performing work in the amount of 1.626 176 634x10^{-19} J, which is the value of an electronvolt. Thus, the energy of an electronvolt represents the internal energy of this extra acquired mass.

Planck called his energy quantum h a *unit of action*. An electronvolt also is a *unit of action*. However, the carrier of *"action"* responsible for the energy of an electronvolt is the mass and speed an electron gains as it passes through an electric field. Action in physics is always connected to a certain mass, be it inertial or electromagnetic, as action cannot exist without its participation. So this must be the case with Planck's constant h and the amount of work it represents, 6.626 070 15x10^{-34} J.

The fundamental mass unit

The mass of a photon is found from the energy of the photon equation

$$E_{ph} = hf = mc^2$$

from where

$$m = hf/c^2$$

The mass of a photon is equal to the energy of the photon (Planck's constant h times the photon's frequency f) divided by the speed of light squared.

If the frequency f is 1, then the mass associated with a single h is:

$$m_h = h/c^2$$

or

$$m_h = 6.626\,070\,15\text{x}10^{-34}\text{ J} / 299{,}792{,}458^2\text{ m/s}$$

which yields

$$m_h = 7.372\,398\,957\text{x}10^{-51}\text{ kg}$$

Hence, m_h represents the *fundamental mass unit*, or the *fundamental quantum of matter,* which has the ability to perform work in the amount represented by the constant h.

This means that the energy of a photon is quantized because its mass is quantized. Hence, the mass of a photon (m_{ph}) can be expressed as the fundamental mass unit (m_h) times photon's frequency (f_{ph}). That is,

$$m_{ph} = m_h f_{ph}$$

This has to be so because if we equate Planck's equation for the energy of a photon to energy equation mc^2, that is, if $hf=mc^2$, where the speed of light c is a constant, the only thing that can determine the quantized nature of hf, on the left-hand side of the equation $hf=mc^2$, is the mass m on the right-hand side of the same equation. Therefore, the quantization of the mass of a photon must be the source of the quantization of its energy. The mass m_h=7.372 398 957x10^{-51} kg represents the *fundamental mass unit*, or the *mass quantum*, which would be the smallest known unit of matter in our physical universe.

Therefore, the "machinery" behind Planck's quantum of energy h is the fundamental unit of mass, m_h=7.372 398 957x10^{-51} kg, which has the ability to perform work in the amount of 6.626 070 15x10^{-34} J, that is the value of the constant h.

Here is what Planck might have searched for, as there cannot be any truer *"physical interpretation"* of the quantum of energy h than by associating it to the elementary and fundamental quantum of mass m_h.

Because the energy of a photon is expressed as

$$E = hf = (m_h c^2)f$$

energy of a photon is determined by the number of fundamental mass units it contains, which is the frequency of a photon.

Because the mass of a photon is never used in contemporary physics or industry, as the prevailing theory states that photons have no mass, the mass associated with the constant h has been of no importance. Today, only the value of the energy unit h and the energy of a photon hf are used.

$E=hf$ is an abbreviated form of the equation $E=(m_h c^2)f$

Because frequency in contemporary physics is considered to be a wave property of light, the energy of a photon expressed as hf gives the impression that this energy is unrelated to any particle or mass property.

However, when hf is equated to Einstein's energy equation, that is, when

$$hf = mc^2$$

the energy unit h on the left-hand side is related to a certain mass on the right-hand side of the above equation. Because the speed of light is constant, the value of hf depends exclusively on the mass m on the right-hand side of the equation. In other words, mass is the common denominator on both sides of the equation $hf=mc^2$, even though there is no explicit mass m in the term hf. Let us see why this is so.

Because the internal energy of a photon is its kinetic energy, and because the energy of a single mass unit associated with a single h is

$$h = m_h c^2$$

and the energy of a photon is

$$E_{ph} = hf = (m_h c^2)f$$

then

$$(m_h c^2)f = m_{ph} c^2$$

Therefore, even though the energy of a photon of electromagnetic radiation is expressed by equation $E=hf$, which has no mass m in it, mass m is nevertheless present, only hidden. The constant h represents the work that certain mass m_h can perform. In other words, $E_{ph}=hf$ is an abbreviated form of equation

$$E_{ph} = (m_h c^2)f$$

Can energy and momentum exist in the absence of mass?

The prevailing view in contemporary physics is that the photons of light possess no mass but that they possess energy. Hence the inevitable conclusion: Energy can exist in the absence of mass. The fact that the energy of a photon is expressed as Planck's constant h times photon's frequency f, the wave property of light, this equation is used as proof of the above conclusion, as no explicit mass is present in the equation.

However, because $E=hf$ is an *abbreviated* form of the equation $E=(m_h c^2)f$, the energy of a photon depends on the number of the fundamental mass units the photon possesses, which is photon's frequency. Hence, *frequency now becomes also a particle property of light*. As the energy of a photon is related to the number of fundamental mass units it contains, we can conclude then that the *energy of electromagnetic radiation and, thus, energy in general, cannot exist in the absence of mass*.

It is the same with the momentum of a photon, which is expressed as Planck's constant h divided by its wavelength ($p=h/\lambda$). This equation gives the impression that the momentum of a photon is also the function of the wave property of light, with no participation of mass.

However, equation for momentum $p=h/\lambda$ is derived from equation $mc^2=hf$, or $mcc=hf$, where $p=mc=hf/c$.

Because the wavelength of a photon λ is equal to c/f, then

$$mc = p = h/\lambda$$

The *mass* of a photon times its *speed* of light c, which is its momentum p, is equal to the constant h divided by the wavelength of the photon. Equation $p=h/\lambda$ is only a different *expression* of $p=mc$, or another way of expressing the frequency and wavelength of light. It does not change the fact that the momentum of a photon is equal to its mass times its speed. Regardless of whether we express the momentum of a photon with $p=mc$, that is, with $p=(m_h f)c$ or $p=h/\lambda$, photon's mass is always present.

The momentum of a photon of the wavelength of 380 nm, for example, can be calculated using the last two equations. Either equation yields the same result, $p=1.743\ 702\ 671\times10^{-27}$ kg m/s. This means the momentum of a photon is always related to its mass m, which is expressed in kg.

Newton's mechanics can describe the subatomic world

It is commonly understood in physics today that Newton's mechanics cannot describe the atomic and subatomic interactions. However, if the momentum of a photon is described by Newton's momentum equation, $p=mv$, where speed v is the speed of light c, then, indeed, Newton's mechanics can describe atomic and subatomic world.

If mass is electromagnetic in nature, the converse also is true

Statements that the *mass of a body is electromagnetic in nature* or that *matter is entirely dependent upon energy* are often found in physics literature. But if that is the case, then the *converse* also must be true.

Electromagnetic radiation and electric and magnetic fields carry momentum; that is, they possess inertial and gravitational properties. A single event we are able to observe and measure can be the result of trillions of interactions that occur on the *subatomic* and *sub-subatomic* levels. As we observe nature on one level, we see objects and particles exhibiting ordinary mass properties. As we go a level below, we see mass as the manifestation of electromagnetic phenomena. Then, as we go a level lower, to virtual photons or carriers of forces, for example, we see that electromagnetic phenomena are the manifestation of inertia and gravity. On this level, there might not be a question of whether electromagnetism is related to mass or mass to electromagnetism. As is the case with the wave properties of light, which do not exclude particle properties, so is the case with electromagnetism and mass. Electromagnetic properties do not exclude mass properties, nor do mass properties exclude electromagnetic properties. They might be all one thing.

The concepts that Planck's constant h is connected to a mass carrier and that photons possess mass imply that *if all matter is electromagnetic in nature,* then the converse also is true: that *all electromagnetic phenomena have mass properties.*

Graininess in nature exists because *mass* is quantized, not *energy*

According to contemporary physics, the graininess in nature exists because of the quantization of energy. However, because Planck's constant h is related to a certain mass that can perform the amount of work expressed by this quantum, the graininess in nature comes not from energy but from the quantization of mass expressed through the fundamental mass unit m_h.

In contemporary physics, energy in general is considered to be quantized. However, according to the arguments presented here, only the energy of electromagnetic radiation can be quantized because its speed is always the same. The kinetic energy of all other particles and objects, which can travel at any speed v, cannot be quantized.

The internal energy of a body is a different story. Because all matter in the universe decays into radiation, thus, it could be said, is composed of radiation; and because radiation travels at a constant speed of light, leaving mass m as the only other constituent in the energy equation, and because this mass is quantized, the internal energy of all bodies also must be quantized.

Energy unit h comes only in whole discrete units, that is, it cannot come as a fraction of the quantum h, the fundamental mass unit also would come in whole discrete units.

Because the mass of any particle or object is composed of fundamental mass units, where the energy of each unit has the value of the constant h, the internal energy of any particle or body composed of a finite number of fundamental mass units must also possess a finite number of energy units. Hence the origin of the graininess in nature.

Because energy is defined as the *ability* to perform work, and because Planck's constant h also represents this *ability*, energy constant h, or the fundamental energy quantum, does not exist in a physical sense—it is only a calculated quantity; however, the fundamental quantum of mass does exist in a material and a physical sense.

References

[1] Max Planck. The seminal paper published in the late 1900 and presented to the German Physical society on 14 Dec.
[2] Max Planck Nobel Prize acceptance speech in 1918. Nobelprize.org
[3] Boris Milvich, *A New Definition of an Electronvolt*, Paper on the website ensteinsfirsterrors.com