Conceptual FrameWorks
Research papers

On the equation E = m c^2

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In physics there are different opinions about the conceptual interpretation of Einstein's famous equation that describes the equivalence between mass and energy. It is understandable that the equation has different interpretations because of the different points of view to interpret phenomenological reality. This paper is about the meaning of the equation in relation to the general concept of quantum field theory. In other words, reality is created by the underlying structure of the basic quantum fields.

Introduction

In 1905 Albert Einstein published his theory about the mass-energy equivalence in the scientific journal Annalen der Physik with the title: "*Ist die Trägheit eines Körpers von seinem Energie einhalt abhängig?*"[1]

The paper represents phenomenological physics at the macroscopic scale. That doesn't mean the theory isn't applicable at every scale of the universe. However, the concepts Albert Einstein used to construct his theory provide not an easy insight in the related mathematical properties at the lowest scale of reality. Therefore, it is interesting to translate the equation to the concept of quantum field theory.[2]

"Free energy" (E)

Einstein's famous equation is a simplified version of the original equation. That doesn't mean that the equation in its most compressed form doesn't represent observable reality. It must be possible to understand the significance of the equation with the help of the right concepts. Actually, quantum field theory.

Planck's constant represents an amount of energy that is related to the transfer of 1 quantum with the speed of light (c) during 1 second. However, a quantum is a fixed amount of local change. To determine the energy of the quantum – the minimal amount of detectable change – we have to decrease the duration of the transfer of the quantum in one direction until it equalize the minimal length scale $\underline{\lambda}$[3] of quantized space (the structure of the basic quantum fields).

The result is the constant of quantum time (notation $\underline{t}$) and the fixed amount of energy of 1 quantum (notation ($\underline{h}$). In other words, if a quantum is transferred in one direction during 1 $\underline{t}$ it represents an amount of energy of 1 $\underline{h}$. Therefore Planck's constant h = n $\underline{h}$ [n = integer (variable)]. See the schematic figure 01 below. The quantum is represented by a black square with the size of 1 unit of quantized space.

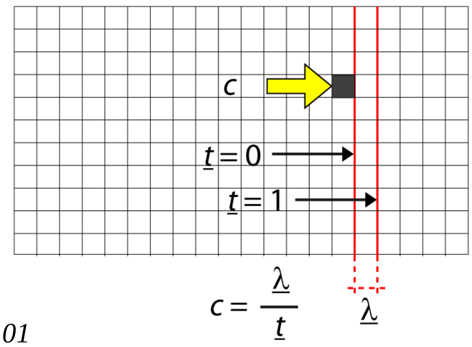

figure 01

If we annihilate a proton and an anti-proton the energy of both particles is transformed into a couple of high energy electromagnetic waves. Electromagnetic waves represent quanta so every quantum of the electromagnetic wave represents a fixed part ($\underline{h}$) of the energy of Planck's constant (h).

The electromagnetic wave represents synchronous changes within the local electric and magnetic field (see figure 02). This is a convincing indication that the electric field and the magnetic field are not transformational attributes of the same basic quantum field. The magnetic field is known by its quality to vectorize changes so it is reasonable to interpret "free energy" as a property of the electric field. Therefore, the fixed amount of energy of the quantum ($\underline{h}$) represent the minimal local change of the electric field.

Therefore we have to conclude that the left part of Einstein's equation must express an amount of free quanta. Therefore: E = n $\underline{h}$

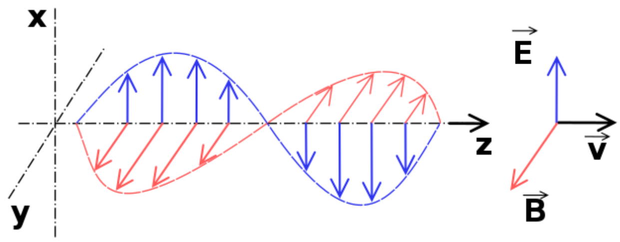

figure 02

Mass (m)

If the annihilation of a particle and an anti-particle results in the creation of high energy electromagnetic waves, particles must be local concentrations of quanta. That is why we can conclude that the mass m represents an integer; an amount (number) of concentrated quanta.

One can argue that mass and rest mass are 2 different types of concentrated quanta. Moreover, the Standard Model of Particle Physics – see figure 03 – describes a scale of reality that underlies the known sub-atomic constituents like protons and neutrons. However, despite of this proposed sub-level there is no evidence that the quantum isn't the minimal fixed amount of change in our universe.

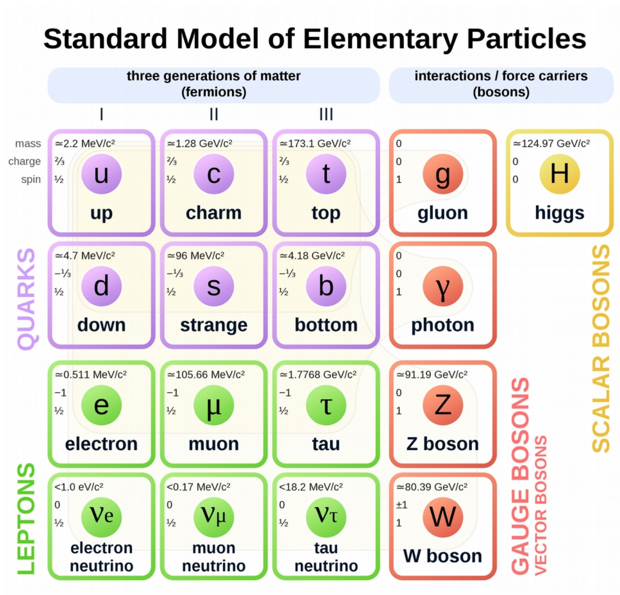

figure 03

An observable phenomenon has always properties in relation to the configuration of its surroundings. That's why there is no theoretical evidence that the nuclei of atoms *at room temperature* will show the proposed quark structure as described in the Standard model. These properties are only "observable" at energies that are put down in figure 03 above.

In other words, the energy of mass m can be interpreted as a local amount of concentrated quanta.

The square of the speed of light (c^2)

The attribution of c^2 to the right part of Einstein's equation $E = mc^2$ must be the exponent to change the concentrated quanta of the mass into free quanta" (E).

The square of the speed of light (c^2) must be related to the properties of the electric field. Because to create a particle with mass m the electric field has to concentrate free quanta.

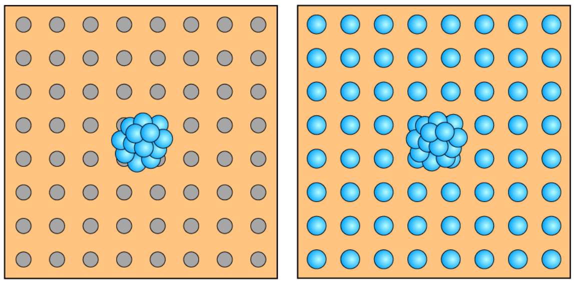

figure 04

I can simulate the distribution of concentrated quanta to vacuum space around with the help of a marble board (figure 04). The left image shows the concentration of quanta – the mass m – and to distribute all the concentrated quanta I have to transfer every quantum to the empty holes around (the spatial units of quantized space)

Unfortunately, the main law in physics is the law of conservation of energy. Every observable change represents a local change of energy so it is allowed to state that all the quanta transfer in space is conserved[3]. Because there is no conservation of energy in our universe if the conservation isn't a continuous book keeping of all the quantum transfer within quantized space.

That is why the right image must represent reality because every spatial unit of quantized space shows a quantum that will be transferred at the next moment (*t*).

The local changes within quantized space have to be topological changes because the volume of quantized space is invariant. In other words, local changes are mutual topological deformations between the spatial units of quantized space. So every unit is a topological object that represents a homeomorphism. Every unit of quantized space has an invariant volume thus a quantum is a fixed amount of surface area.

The concentration of quanta in the right image of figure 04 represents a couple of spatial units with a very high deformed surface area (mass m).

To release the involved spatial units of the mass I have to distribute this local surplus of surface area to the spatial units of quantized space around. The square of the speed of light (c^2) represents surface area and the amount of mass (n $\underline{h}$) determines the total amount of surface area that must be distributed in vacuum space to transform the mass into "free" quanta.

References

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(Figures 2 and 3 are Wikipedia images.)