

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 Energieinhalt 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 of the related mathematical properties at the lowest scale of reality. Therefore, it is interesting to translate the equation into the concept of quantum field theory.^[2]

"Free energy" (E)

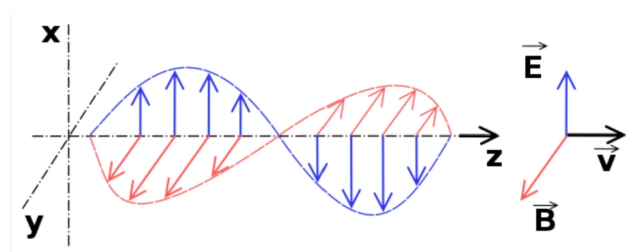
Einstein's famous equation is a simplified version of the original equation. That doesn't mean that the equation in its most compressed form doesn't represent phenomenological reality. It must be possible to understand the significance of the equation with the help of the right concepts. Actually, quantum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

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 and every quantum represents an equal amount of energy (Planck's constant).

The electromagnetic wave represents synchronous changes within the local electric and magnetic field (see image). 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 mainly known by its quality to vectorize changes so it is reasonable interpreting free energy as a property of the electric field.

Therefore, quanta represent local changes – alterations – of the electric field.

A free quantum has a velocity that is a constant (the speed of light) and the amount of energy of a quantum is Planck's constant. That's why we have to conclude that the right part of Einstein's equation must express these properties of free quanta, quanta that are transferred in space at any moment.



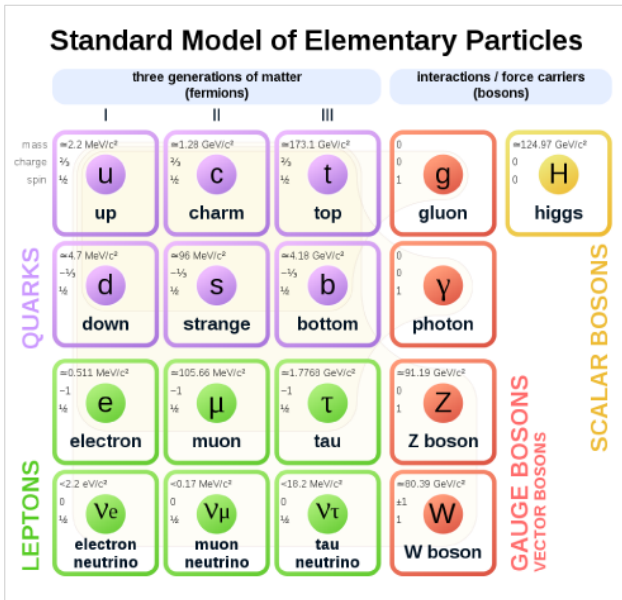
Mass (m)

If the annihilation of a particle and an anti-particle results in the creation of high energy electromagnetic waves particles must be concentrations of quanta. That's 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 describes a scale of reality that underlies the known atomic constituents like protons and neutrons. However, there is no proof that Planck's constant isn't the universal quantum of energy.

Therefore, it has no sense to argue that the mass m doesn't represent an integer or doesn't represent both mass and rest mass.

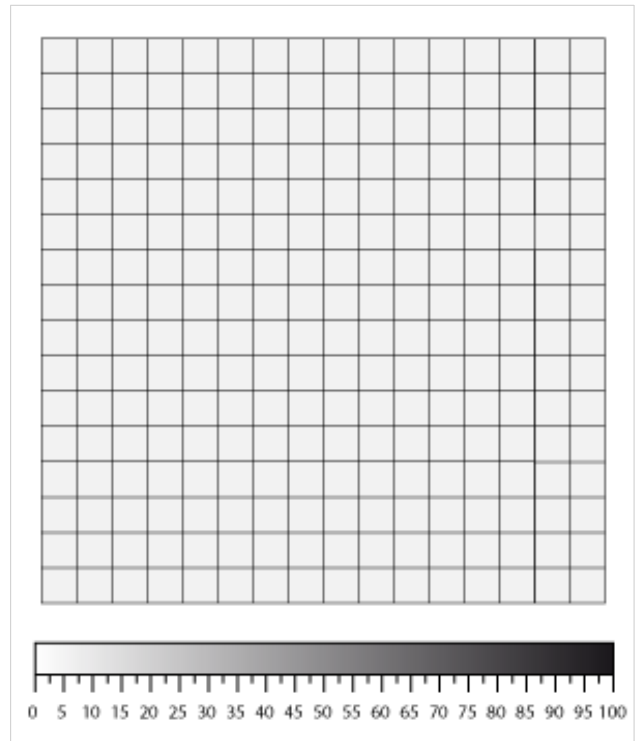
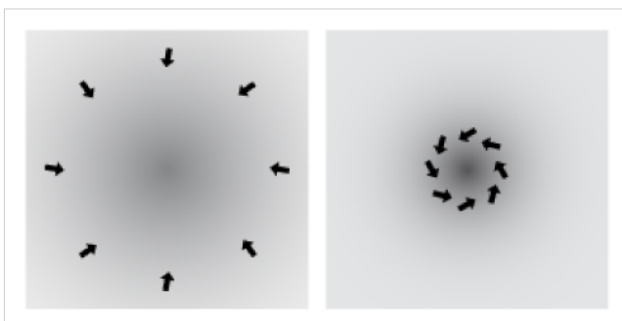
The papers describing the Standard model and the Higgs mechanism are not clear about the number of basic quantum fields and the mathematical properties of each basic field (a basic quantum field is a quantum field that exist everywhere in the universe, without any spatial exception). Actually, there are publications proposing quite alternative models that subscribe the conceptual limitations of the Standard Model.^[3]



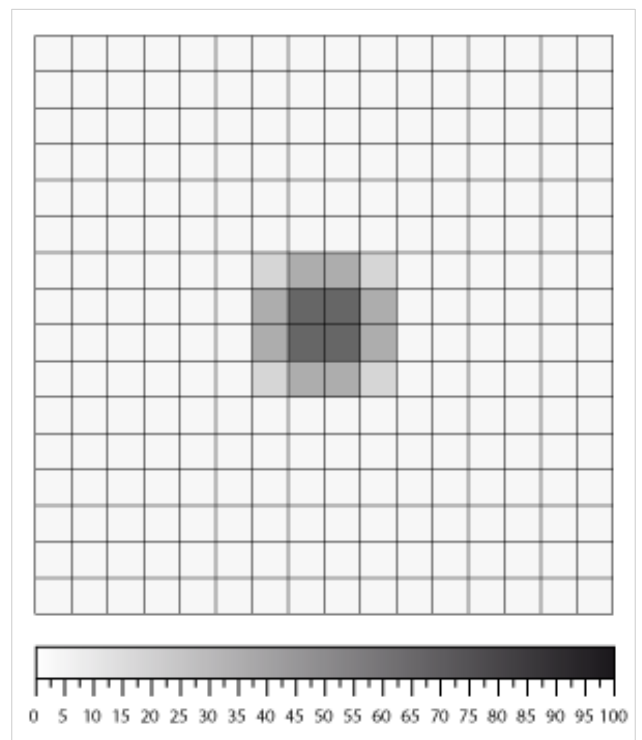
Moreover, an observable phenomenon has always properties in relation to the configuration of its surroundings. That's why there is no proof the nuclei of atoms at room temperature show the proposed configurations as described in the Standard model. These properties are only "observable" at energies that are put down in the image above.

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

The image below shows the mechanism behind the concentration of quanta that will result in the creation of a local mass/rest mass object. However, it is not necessary to know how a stable particle is created by the underlying basic quantum fields because the concentration of quanta is primary a change of the local configuration of the electric field.



We can imitate the concentration of quanta within the electric field with the help of simple drawings. The schematic image above shows a spatial field structure and every field unit has a variant property that is symbolized with the help of a percentage of black colour (4%). In other words, if quanta are concentrated within the structure of the electric field, the average topological deformation of the field structure is changed into a large volume with less deformation and a small volume that represents all the transferred quanta.



Now we can conclude that Einstein's famous equation represents the transformation of the average local deformation of the electric field (4% black colour in every unit in the image) into a spatial configuration where all the transferred quanta – because of the mechanism of concentration – is accumulated.

In other words, the square of the speed of light describes in an accurate way the difference between the 2 schematic images. Therefore, it is necessary to understand some properties of the electric field.

The main law of physics is the law of conservation of energy. Every observable change represents a local alteration of energy so it is allowed to state that all the quanta transfer in space is conserved^[4]. Because there is no conservation of energy in our universe if the conservation isn't a continuous book keeping.

Every unit of the electric field transfers 1 quantum during a period of time. Therefore accumulating quanta within a couple of units of the electric field shows to be the increase of the topological deformation of these units. But at the same time all the other units around have decreased their topological deformation.

If we want to “free” the accumulated quanta of the mass we only have to transfer the accumulated topological transformation to all the units of the electric field around.

Topological deformation of units that have an invariant volume – the units of the electric field – means the increase or decrease of the surface area of every unit. Therefore we have to increase the surface area of all the units around the mass with the *number* of quanta accumulated by the mass (m).

The amount of surface area of the distinct units of the electric field isn't important, we only have to know the amount of surface area that is involved by the increase or decrease of 1 quantum. The constant of the speed of light represents the velocity of the transfer of the topological deformation by 1 quantum from a unit to the adjacent units of the electric field. Thus c represents length. To transform it into surface area we have to square the speed of light: $E = m c^2$.

References

1. A. Einstein: “Does the Inertia of a Body Depend upon its Energy Content?” *Annalen der Physik* (ser. 4), **18**, 639–641, http://myweb.rz.uni-augsburg.de/~eckern/adp/history/einstein-papers/1905_18_639-641.pdf
 2. Art Hobson: “There are no particles, there are only fields”. <https://arxiv.org/ftp/arxiv/papers/1204/1204.4616.pdf>
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 4. S.E. Grimm: “Quanta transfer in space is conserved”. <https://zenodo.org/record/580326> (DOI: 10.5281/zenodo.580326)
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(Image 1 and 2 are Wikipedia images.)