# $E = hf = mc^2$

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*Abstract - This article shows the umpteenth ridiculousness of the expression $E=mc^2$, and simultaneously of the theories of relativity, by applying it to the energy of a photon.*

## Introduction

Another version of $E=mc^2$ is $E^2 = (m_0c^2)^2 + (pc)^2$. This expression has been analysed in the appendix.
It is generally accepted that the energy of a photon can be expressed by h·f, with h the constant of Planck and f the frequency of the photon. It is also generally accepted, at least by the supporters of Einstein's theories of relativity, that energy and mass are interchangeable by means of the expression $E=mc^2$, with m the mass of an object and c the speed of light in vacuum, leaving the reference for this speed undefined.
The consequenses of stating $hf = mc^2$ will be considered in this paper.

## Is a photon a particle or a massless electromagnetic wave?

The question mentioned is answered in modern physics with the simple explanation that we have to live with a duality: a photon can be as well the one as the other. This justifies equating hf to $mc^2$ even more.
Einstein wrote about this duality the following;
"*It seems as though we must use sometimes the one theory and sometimes the other, while at times we may use either. We are faced with a new kind of difficulty. We have two contradictory pictures of reality: separately neither of them fully explains the phenomena of light, but together they do*".

## What is a photon in genuine physics?

Nature doesn't deal with dualities, paradoxes or contradictions. Judgments like these are created by mankind, not understanding a certain phenomenon. Physical science should not accept these kinds of judgements.

In chapter VIII it is explained, in the most fundamental theoretical way, why a photon is a (very) short period (pulse) of an electromagnetic wave with a certain frequency. It has also been proven that its energy equals the difference between the kinetic energy of an orbiting electron in an atom, jumping from an inner to an outer orbit. Not the other way round! The kinetic energy of the electron in an inner orbit is higher than the one in an outer orbit. Potential energy is eliminated in such a configuration, because centripetal force balances centrifugal force. Rydberg found, *experimentally*, that this energy is hf. A difference of kinetic energy cannot directly be converted to electromagnetic energy. As has been shown this is caused by the difference of the *magnetic* energy created by the orbiting electron in the respective orbits.
The photon, created and emitted in such a way has a speed c, unavoidably with respect to the atom.
The duration of the EM pulse has been calculated as function of the radii of the two mentioned orbits.

## Consequence of the wave-particle duality of a photon

Given the well known energy of a photon, whether expressed as hf, Δkinetic energy or Δmagnetic energy, shortly as $E_{photon}$, this energy, given this duality, perfectly fits the expression $E=mc^2$, so $m_{photon}=E_{photon}/c^2$.

Mentioned chapter VIII shows in Table 1: "Frequencies and pulse lengths as function of n and Z" that an electron jumping from the most inner orbit to the next outer orbit in a Tungsten atom (Z = 74) generates X-radiation at a frequency of $1.4 \cdot 10^{19}$ Hz. So hf, given h = $6.6 \cdot 10^{-34}$ $VAs^2$, equals $9 \cdot 10^{-15}$ J.
Applying $m_{photon} = E_{photon}/c^2$ results in $m_{photon} = 10^{-31}$ kg. The mass of an electron is $9 \cdot 10^{-31}$ kg !

N.B. The theories of relativity claim that a mass at speed c, being the speed of a photon, is infinite!

In reference https://en.wikipedia.org/wiki/Elementary_particle, the mass of a photon is presented as *zero*.
But both problems can simply be solved in modern physics by presenting a "mass-mass duality":

*It seems as though we must use sometimes infinite mass and sometimes zero mass, while at times we may use either.*
Modern physics clearly lost its common sense, insofar it ever had.

## Appendix Analysis of $E^2 = (m_0c^2)^2 + (pc)^2$

$E^2 = (m_0c^2)^2 + (pc)^2$ is meant to express that this the (more) correct version of $E=mc^2$, so $E^2 = (mc^2)^2$. The p in this expression is the momentum of mass m with velocity v, with v defined as the constant velocity of an observer w.r.t. m. This momentum thus is vm.

In order to be able to compare the two expressions, $E^2 = (mc^2)^2$ will be elaborated closer.
The mass m is meant to be a function of the just mentioned velocity v: $m = m_0/\sqrt{(1-v^2/c^2)} = \gamma m_0$.
$E^2 = (mc^2)^2$ thus can be written as $E^2 = (\gamma m_0c^2)^2$, or $\gamma^{-2}E^2 = (m_0c^2)^2$ and the momentum as $p = \gamma m_0v$.

From $p = \gamma m_0v$ it follows that $v = p/\gamma m_0$ and $\gamma^{-2}$ expressed in p as $\gamma^{-2} = (1- (p/\gamma m_0)^2/c^2)$, with the result:

$\gamma^{-2}E^2 = (1- (p/\gamma m_0)^2/c^2) \cdot E^2 = (1-p^2c^2/(\gamma m_0c^2)/c^2) \cdot E^2 = (1-(pc)^2/(\gamma m_0c^2)^2) \cdot E^2$.

This expression thus equals $(m_0c^2)^2$, so:

$(1-(pc)^2/(\gamma m_0c^2)^2) \cdot E^2 = (m_0c^2)^2$ in which $(\gamma m_0c^2)^2 = E^2$, so $(1-(pc)^2/ E^2) \cdot E^2 = (m_0c^2)^2$, resulting in:

$$E^2 = (mc^2)^2 = (m_0c^2)^2 + (pc)^2$$

The two expressions thus are fully equivalent!

The extended version does split the squared energy in the static part $(m_0c^2)^2$ and the dynamic part $(pc)^2$, with $pc = \gamma m_0vc = mvc$. But mvc is by far not a realistic kind of energy. Only its dimension is correct.

**However the static part shows the most stunning example of the nonsense of modern physics:**

The intrinsic energy $m_0c^2$, of a 10-gram flint, for example as shown in the figure below, is alleged to be equal to the energy of **ten** times that of the atomic bomb, destroying Hiroshima in 1945!


ruler numbers in centimeters