

# Is the energy of a photon also equals $mc^2$

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Abstract

This paper whether the energy of a photon also equals  $mc^2$ .

## Introduction

It is generally accepted that the energy of a photon can be expressed by  $h \cdot f$ , with  $h$  the constant of Planck and  $f$  the frequency of the photon. It is also generally, at least for the supporters of Einstein's theories of relativity, accepted 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, disregarding the reference for this speed. The consequences of stating  $hf = mc^2$  will be considered in this paper.

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

The mentioned question is in modern physics answered with the simple explanation that we have to live with this 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.

Chapter VIII in <https://vixra.org/abs/2107.0027> explains in the most fundamental theoretical way why a photon is a (very) short period (pulse) of an electromagnetic wave with one frequency. It also proves 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 of the electron in the respective orbits.

The photon, created and emitted in this way has a speed  $c$ , necessarily 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  $hf$ ,  $\Delta$  kinetic energy or  $\Delta$  magnetic energy, shortly by  $E_{\text{photon}}$ , this energy, given this duality, perfectly fits the expression  $E = mc^2$ , so  $m_{\text{photon}} = E_{\text{photon}}/c^2$ .

Table 1: "Frequencies and pulse lengths as function of  $n$  and  $Z$ " presented in mentioned chapter VIII shows that for X-radiation produced by Tungsten ( $Z = 74$ ) a frequency of  $1.8 \cdot 10^{19}$  Hz is generated by an electron jumping from the most inner orbit to the next outer orbit. So  $hf$ , given  $h = 6.6 \cdot 10^{-34}$  VAs<sup>2</sup>, equals  $1.2 \cdot 10^{-14}$  J. Applying  $m_{\text{photon}} = E_{\text{photon}}/c^2$  results in  $m_{\text{photon}} = 1.3 \cdot 10^{-31}$  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 [https://en.wikipedia.org/wiki/Elementary\\_particle](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 the one mass and sometimes the other mass, while at times we may use either.*