The rest mass of a photon

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Abstract

The photon has several properties that distinguish it from all other subatomic particles. It is the only elementary particle wherein a high energy photon can split up into two or more low energy photons (down conversion) and vice versa (up conversion). This transformation conforms to the laws of conservation of momentum and of energy. Down conversion implies that as per the law of conservation of mass, a high frequency photon should have more rest mass or invariant mass than a low frequency photon.

Keywords: Photon down conversion, photon rest mass, particle physics.

A photon down converter is a device that splits a high energy photon into two or more low energy photons. When a photon reaches the down converter, it excites an electron into a higher energy level. But the electron returns to its ground state via an intermediate energy level, and emits a lower energy photon at each stage. The two, quantum entangled, output photons can have equal or unequal frequencies.

For equal frequencies, the twin photons will have twice the wavelength and half the frequency (or energy) of the primary or parent photon. A visible light photon (wavelength 405 nm) splits up into two infrared photons (wavelength 810 nm). Three-photon down conversion is also observed.

Photon up conversion is a process which occurs when a material is photo excited by two or more low energy photons resulting in the emission of a higher energy photon.

A crystal of beta barium borate (BBO) can split an ultraviolet photon of wavelength 390 nm into two infrared photons of wavelength 780 nm. The two down conversion photons have orthogonal polarization.

In the Sun, a gamma photon in the radiation zone, on its way to the photosphere, transforms into a hundred thousand visible light optical photons during its journey through the turbulent conduction zone.

Down conversion implies that as per the law of conservation of mass (and also of charge)*, a high frequency photon should have more rest mass or invariant mass* (and also charge) *than a low frequency photon.*

In the Particle Data Group (http://pdg.lbl.gov), July 2012 Particle Physics Booklet [1] on page8 (Summary Tables of Particle Properties) the photon mass and charge values given, make no mention of the photon frequency that these values correspond to.

The cosmic gamma photon frequency is 20 orders of magnitude more than that of the very low frequency (VLF) radio photon. So, the rest mass (or charge) of a cosmic gamma photon should be 10^{20} times more than a VLF radio photon.

Physics literature on photon rest mass assumes that all photons across the electromagnetic spectrum, from radio photons to gamma photons have the same rest mass.

Particle Data Group (PDG) should give along with the photon mass and photon charge data in [2], the corresponding photon frequency or wavelength values. This will help particle physicists to look for the nature of relationship (linear or non linear) between photon frequency or wavelength with its measured mass and charge.

L-C Tu *et al* [3] in a review article gives 11 values of photon mass for different ranges of the electromagnetic spectrum in Table 1 on p94 (18 of 54).

Down conversion is not exhibited by the electron or any other subatomic particle. If in a thought experiment an electron were to undergo down conversion and split up into two down conversion electrons then, as per the law of conservation of mass and of charge, for each down conversion electron the rest mass and charge would be one half the rest mass and charge of the primary or parent electron. The energy and momentum will also be conserved.

This communication does not prove or disprove the presence or absence of a rest mass in a photon.

REFERENCES:

[1] July 2012 Particle Physics Booklet
http://pdg.lbl.gov/2012/download/rpp-2012-booklet.pdf

p8 Summary Tables of Particle Properties

[PHOTON] Mass $m < 1 \times 10^{-18}$ eV

Charge $q < 1 \times 10^{-35}$ e

Mean life τ = Stable

[2] J. Beringer et al. (Particle Data Group), PR D86, 010001 (2012) http://pdg.lbl.gov/2011/listings/rpp2011-list-photon.pdf

[3] L-C Tu et al. The mass of the photon, Rep. Prog. Phys. 68 (2005) 77–130. See Table 1 on p94 (18 of 54).

stacks.iop.org/RoPP/68/77 OR

http://www.optica.machorro.net/Lecturas/PhotonMass_rpp5_1_RO2.pdf

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