

# *Journal of Theoretics*

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## **What is a photon?**

It has long been debated as to whether or not a photon is a particle or a wave. It has features of both and the debate is not yet settled. In fact, most scientists have resigned themselves to accepting that it is both. Different circumstances seem to bring out different characteristics. We still don't have a good idea of how a photon exists in reality.

Did you know that photons have mass? Though you may have been taught that all objects have mass, unless they are going the speed of light. Once a theory starts making exceptions it is the beginning of the end; a new theory needs to be developed to supplant the previous. What if photons have mass and density ( $m/\lambda$ ) but that their density was less than that of Space (yes, the aether of Space). If the photon was less dense than Space then it could achieve the speed of light and still have mass. The mass of a photon can be determined in the following manner:

$$\text{linear momentum of a photon} = \hbar \mathbf{k} = (h/2\pi)(2\pi/\lambda) = h/\lambda = mv \Rightarrow m = h/(\lambda v)$$

where  $h$  is Planck's constant and  $\lambda$  is the wavelength. For example, a 750 nm photon would have a mass of  $3E-36$  kg. Small yes, but still it has mass.

What if one were to add enough energy to a photon, could it become matter? Theoretically maybe but I don't think we can create the conditions necessary for this (i.e. an immediate post-big bang environment). Where is this threshold between photon and matter? The smallest wavelength possible (a very small gamma ray) is around 100 fm (a femtometer is  $1E-15$  m) which means that it would have a mass of  $2.2E-29$  kg. We can also calculate the density of a small gamma ray by

$$d = m/\text{volume} = 2.21E-29\text{kg}/(4/3 \times (1.00E-13\text{m})^3) = 1.7E10 \text{ kg/m}^3,$$

for an muon by

$$d = m/\text{volume} = 1.88E-28\text{kg}/(4/3 \times (1.17E-14\text{m})^3) = 8.8E13 \text{ kg/m}^3,$$

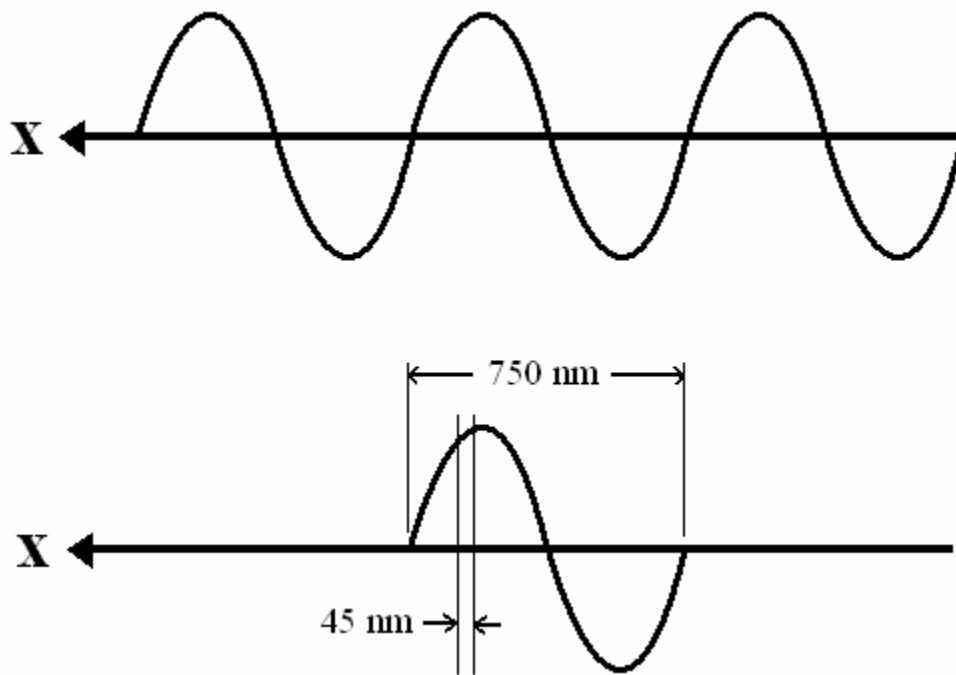
and for a proton by

$$d = m/\text{volume} = 1.67E-27\text{kg}/(4/3 \times 1.32E-15\text{m})^3 = 5.5E17 \text{ kg/m}^3.$$

Interestingly, somewhere between the density of a gamma ray and the density of a muon, is the density of Space, where those objects less dense than Space can freely and limitlessly travel Space at the speed of light and those denser can not. There must also be an "Energy of Transition" that is required for the conversion of a photon to something like an electron since the electron which has a mass of  $9.11E-31$  kg is less than the gamma ray presented above.

But there is even more confusing research coming to light (sorry for the pun). Recently, scientists have been able to create 150 attosecond pulses<sup>1</sup> of the wavelength 750 nanometers (nm). One attosecond (as) is  $1E-18$  of a second. With the wavelengths of infrared light being  $>750\text{nm}$ , visible light being  $400-750\text{nm}$ , ultraviolet light being  $<400\text{nm}$ , and X-rays being about  $1\text{nm}$  for comparison, what is the length (distance as measured in meters) of an attosecond pulse? Assuming that it is measured in a vacuum or air (whose refractive index is roughly equal to one), we can use the formula  $d=t \times c$  where  $d$  is distance,  $t$  is time, and  $c$  is the speed of light. The result is that a one attosecond is about  $0.3 \text{ nm}$  long.

Such an attosecond pulse was recently described in Nature (2004 427:817) and was  $150\text{as}$  which means that it was  $45\text{nm}$  in length. But how can this be? How can a photon be shorter than its wavelength? Basically, it can not. In Figure 1 below, the EMF of a photon is shown on spatial axis X. The top diagram shows the propagation of the EMF and the bottom shows  $45 \text{ nm}$  of the  $750 \text{ nm}$  wavelength (1 cycle).



**Figure 1.** Top diagram shows the propagation of light EMF. Bottom diagram shows the length of a 150 as pulse (45nm) compared to the 750nm wavelength of the light.

One might be able to say that we are seeing just a clump of photons which overlap to produce the smaller  $45 \text{ nm}$  pulse as shown in Figure 2a. But if we were to create a  $750 \text{ nm}$  ( $2500 \text{ as}$ ) pulse as shown in Figure 2b, then get a  $45 \text{ nm}$  ( $150 \text{ as}$ ) pulse out of it as

<sup>1</sup> Technically, it should probably be called a “transient” rather than a pulse but more people can understand the concept of a pulse. Besides the nuance reasons for calling it a transient could be the subject of an entire paper.

shown in Figure 2c, then we will have proved that we have demonstrated a fraction of a photon. According to current theory such is not possible and therefore, new theory will be needed. Something where photons are no longer discrete entities but rather energy that can be taken full or in part.

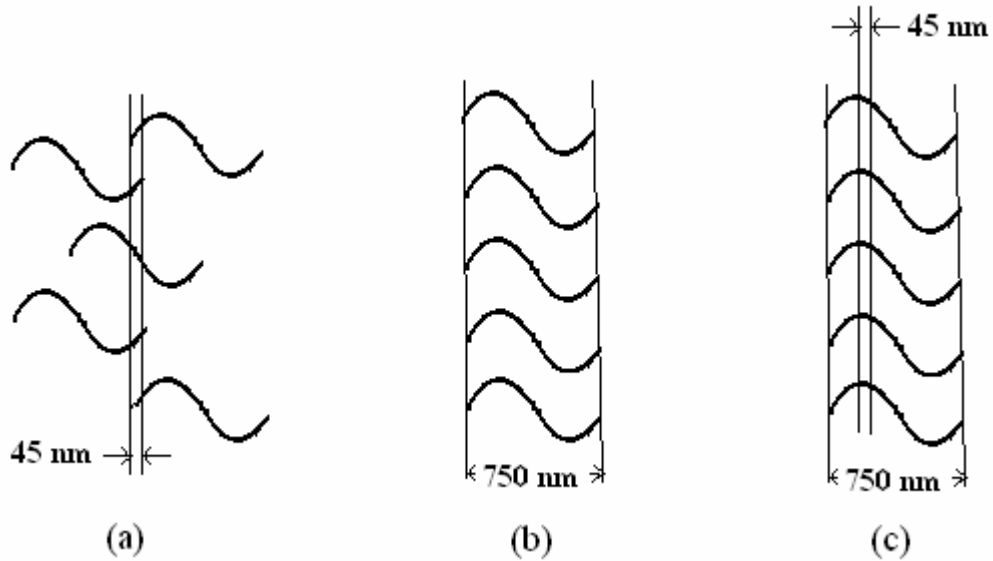


Figure 2.

Because of the complicated nature of achieving attosecond light pulses, this latter experiment has not yet been done to my knowledge. But the way things are going, we are going to have to rethink what photons *really* are.

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