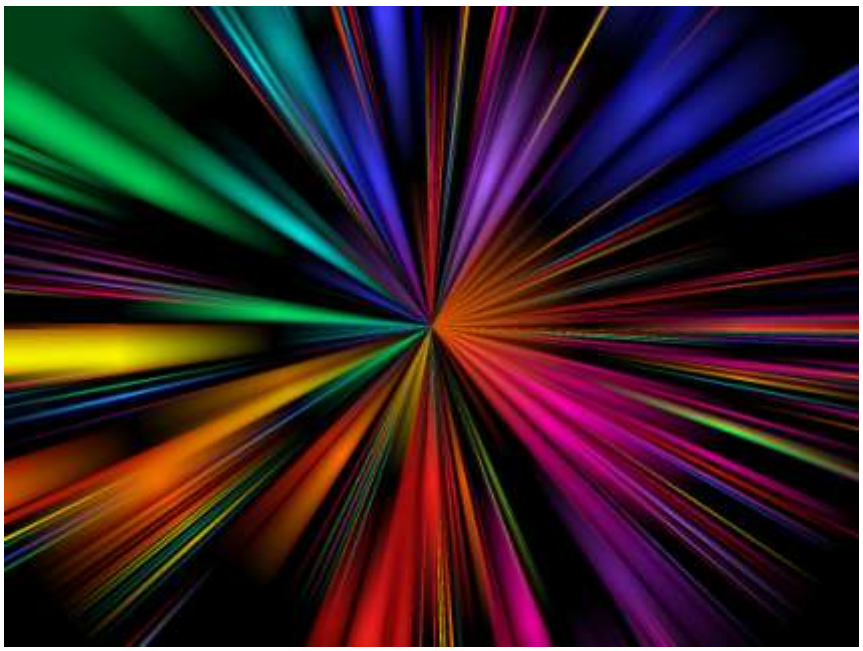
Light : wave or particle ? | By Félix Camus

What can science define ?

Light is the portion of electromagnetic radiation that is visible to the human eye: it has a wavelength in a range from about 380 nanometers to about 780 nm. Light is usually represented as a wave, as defined for the first time by Huygens during the 17th century. Newton had suggested another model at that time, which considered light as a particle; that model was abandoned until the beginning of the 20th century due to the successful experiments in favor of the wave theory, such as diffraction and interference. However, by the end of the 19th and beginning of the 20th centuries, Albert Einstein (03/14/1879 – 04/18/1955, a German-born, Swiss-American physicist) proves that light behaves as a particle, which was named 'photon' in 1926 by physicist Gilbert Lewis. From then, light presents two perfectly coherent and valid theories that are nevertheless incompatible; it was as if light changed form according to which theory one utilized.

In order to have a simplified vision of the phenomenon, we can consider the following example: when we cast a cylinder onto a 2-D plane, it can appear as a rectangle or a circle (see picture); however, it is neither of them. In the same way the cylinder isn't 'a rectangle and a circle' nor any of them, light isn't a wave, nor a particle, nor both.



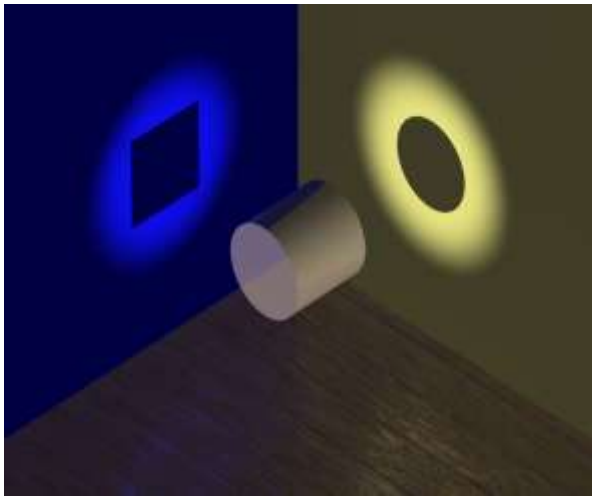
More recently, several physicists such as Jean-Marc Levy-Leblond or Françoise Balibar proposed the word "quanton" to define light, in order to avoid the former ambiguity. Light would thus be neither a wave nor a particle, but would present characteristics of both models. All this was based on Niels Bohr's complementarity, which states that objects such as photons, electrons or protons can be related to only one model at the time.

Nonetheless, defining light as 'not a particle AND a wave' although it possesses all the characteristics of both leads us to a problem: what

is, then, a photon, if it isn't a wave, nor a particle, nor both, if it behaves as such? Defining it as "quanton" doesn't give us the true nature of light, but is a word chosen almost randomly in order to, in some way, ignore our own lack of knowing. It would seem that, on a strictly scientific point of view, the question of knowing what is *really* a photon has no legitimacy. It is indeed an ontological question to which, in my opinion, physicists are not to answer. Physics are based on studying natural phenomena that can be modelized and on defining laws and theories that could explain those phenomena, but are in no way required to define the true nature of elements. The question of the nature of photons is relevant to natural sciences anymore.

This idea was developed by Kant, who, in *Critique of Pure Reason*, states the following:

> *"Supposing that we should carry our empirical intuition even to the very highest degree of clearness, we should not thereby advance one step nearer to a knowledge of the constitution of objects as things in themselves. For we could only, at best, arrive at a complete cognition of our own mode of intuition, that is of our sensibility, and this always under the conditions originally attaching to the subject, namely, the conditions of space and time; while the question: "What are objects considered as things in themselves?" remains unanswerable even after the most thorough examination of the phenomenal world."*



In other words, it is impossible to define photons out of the system of reference in which we consider it; just as the circle and the rectangle are representations in two dimensions of a cylinder present in three dimensions, wave and particle are two representations in the system of reference of classical physics of a same *ob-ject*, the 'quanton', which therefore doesn't exist as such in a referential of classical physics.

Ob-ject is a mere translation to what the Hegelian logic calls in German *Gegenstand*, as different from *Objekt*. Natural phenomena are defined as *ob-jects*, thus by definition out of ourselves; our mathematical logic can therefore consider them only through their spatial and temporal interactions: through geometry and calculations. In that way, a theory doesn't represent an element but a series of interactions. For instance, a physicist defines rigorously the difference between different interactions (gravitational, electromagnetic, weak and strong interactions) while they were referred formerly as 'forces'.

Scientifically speaking, light is therefore nothing else than a theoretic model. Therefore, in the same way the sum of the angles of a triangle are to equal the sum of two right angles on a plane, it is not the case if we take a non-plane surface such as a circle, physics *necessarily* describe different properties as we

change of mathematic model. As physics consist of mathematic modelizations of nature, they can't pretend to define the true nature of elements, but only what different mathematic approaches are able to define.

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