A Photon is a Magnetic Dipole

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Abstract

The most important discovery in physics in the last 100 years (1920-2020) was made by Dr. Myron Wyn Evans (1950-2019) in the year 1992 [1]. The discovery of the real longitudinal magnetic field B(3) of the photon [4,5,6] was a landmark historical event, with far reaching insights, in our understanding of the physical nature of the enigmatic photon.

Circular or elliptical polarized light acts as a magnet upon interaction with matter. This is the 'inverse Faraday effect' (IFE). Thomas Young's interference experiment (1803) is simple to perform but, even after more than 200 years is difficult to understand. This article explains the basic concepts for both IFE and the double slit using a simple graphical approach [2].

The PHOTON

- *"For the rest of my life, I will reflect on what light is."*

  Albert Einstein, 1917.

- *All these fifty years of conscious brooding have brought me no closer to the answer to the question: 'What are light quanta?'*

  Albert Einstein, 1954.

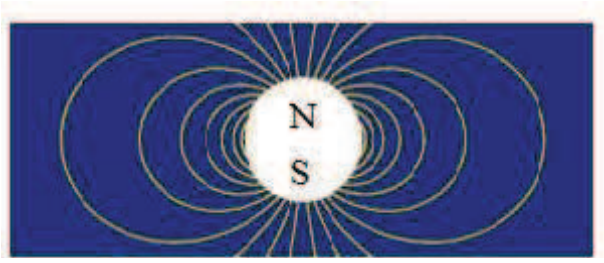
- *"I therefore take the liberty of proposing for this hypothetical new atom, which is not light but plays an essential part in every process of radiation, the name PHOTON."*

  Gilbert Newton Lewis, 1926.

Light quantum or a photon is a quantum of electromagnetic radiation and an elementary particle with a zero electric charge. A photon is an electromagnetic object. It is never at rest. A photon has energy and momentum.

A photon has a real longitudinal magnetic field B(3) whose quantum equivalent is the Evans photomagneton, which has all the known properties of magnetic flux density (Tesla = Weber per square meter). Circular or elliptical polarized light acts as a magnet upon interaction with matter. This is the 'inverse Faraday effect' (IFE).

This magnetization is proportional to the light intensity [6], and the light intensity is proportional to the photon flux density, as per Einstein's correlation of the number of photons in a light beam with its intensity. A circular polarized laser beam of intensity 10^{4} W m^{-2} (1 W cm^{-2}), the magnitude of the longitudinal magnetic field is about 10^{-5} Tesla or about 0.1 G, roughly a tenth of the earth's magnetic field [6].



- CONJECTURE: The photon, a quantum of electro-magnetic radiation, is a magnetic dipole.

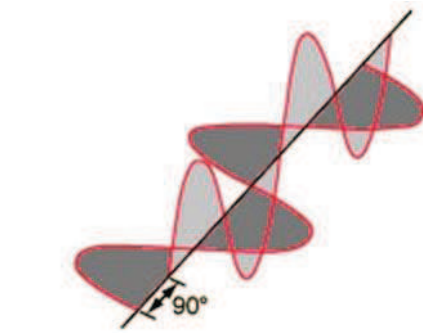
The transverse magnetic (H) and electric (E) fields of a photon are orthogonal and in phase quadrature. The magnetic field energy plus electric field energy is always a constant. This contributes to the electromagnetic inertia, simple harmonic

motion (SHM) oscillations (linear, elliptical or circular) of the photon.

In free space, photons always travel with the fundamental speed of light ($c=3x10^{8}$ m/s), a universal constant of special relativity, at all times, in all directions, in all inertial frames, independent of the relative motion of sources and detectors.

- *Photons or electromagnetic waves are self-propagating.*

- *CONJECTURE: This is possible only if the transverse magnetic and electric fields are in phase quadrature.*



- *The mathematical symmetry of the free space Maxwell's equations, imply that the magnitudes of the transverse orthogonal magnetic (H) and electric (E) fields are physically equivalent. However, their numerical values in SI units are not equal since, the permeability and permittivity of free space have unequal numerical values in SI units.*

- *In the case of an ideal simple pendulum the magnitudes of the transverse orthogonal kinetic (velocity) and potential (gravitational) fields are also physically equivalent and their numerical values in SI units are equal.*

CIRCULAR POLARIZATION, GRAPHICAL REPRESENTATION

"If I can't picture it, I can't understand it."

Albert Einstein.

Frenchman Francois Jean Arago experimentally discovered circular polarization in quartz in 1811. In circular polarization the transverse magnetic (H) and electric (E) field vectors rotate rather than oscillate as in linear polarization. In both cases the transverse magnetic (H) and electric (E) fields are orthogonal and in phase quadrature. The magnetic field energy plus electric field energy is always a constant. This contributes to the electro-magnetic inertia, SHM oscillations of the photon.

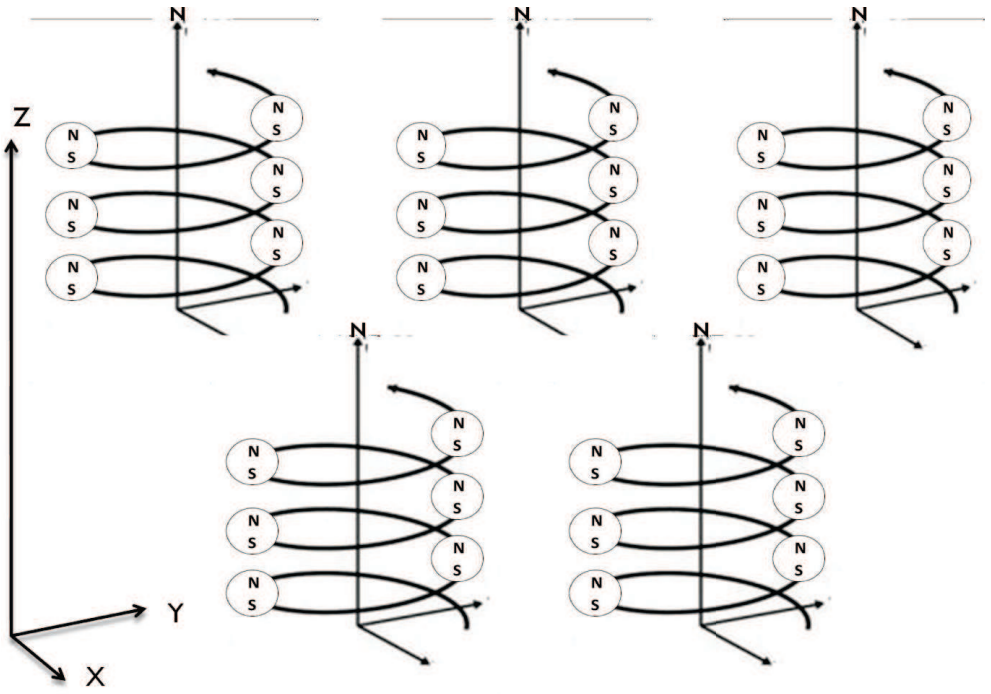


Figure above shows a beam of light consisting of 5 rays of circular polarized light. All 5 rays are travelling in the +Z- axis direction. The magnetic dipole photons in each ray with their magnetic polarity NS along the Z-axis add up so that circular (or elliptical)

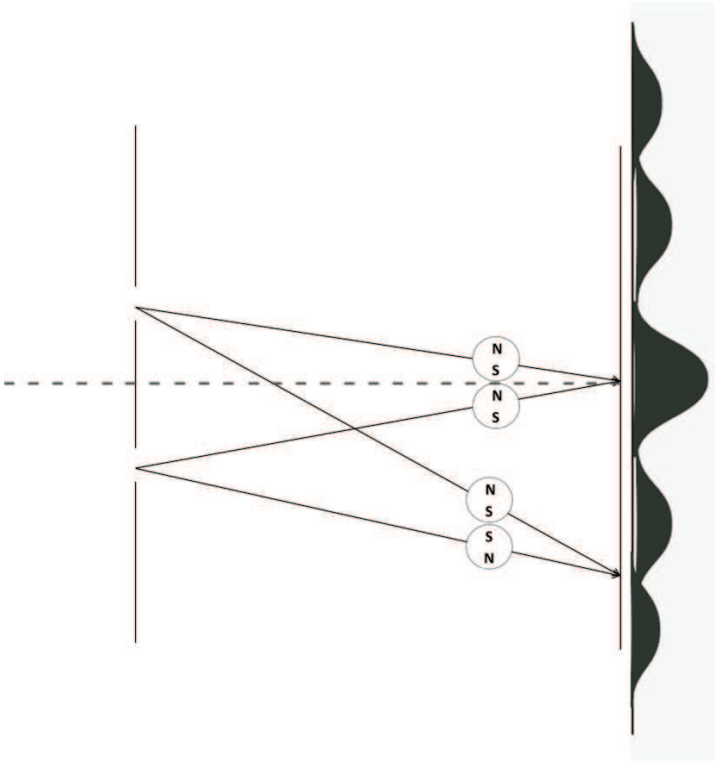
polarized light acts as a magnet upon interaction with matter. This is the ‘inverse Faraday effect’ (IFE).

In a ray of circular polarized light, photons travel along a circular (clockwise or anti-clockwise) helix or spiral path of wavelength diameter. All photons in a ray have their magnetic polarity (NS or SN) parallel to the centerline of the spiral. The magnetic dipoles of all circular polarized photons, add up to give a net resultant magnetic field along the centerline of the spiral.

TWO SLIT INTERFERENCE, GRAPHICAL REPRESENTATION

In a double slit interference experiment, coherent photons after being diffracted and traveling from the two slits towards the screen, along two convergent rays of light; if on arrival at a point on the screen, are out of phase by 180 degrees, will repel each other and get deflected to neighboring areas, thereby creating a dark band between two bright neighboring bands. This explains Thomas Young’s interference experiment (1803).

In the Figure below, along the dotted center-line of the screen, there is a high photon intensity region as the two photons are in phase and attract each other. Whereas, in the lower part of the screen the two photons are out of phase by 180 degrees and so repel each other and get deposited in neighboring areas, thereby resulting in a dark or very low photon intensity region between two neighboring bright or higher photon intensity regions.



HANBURY-BROWN & TWISS (HBT) EXPERIMENT

It is reported that two-slit interference occurs even when the intensity is reduced so much that only one photon or electron traverses the apparatus at a time.

However, Robert Hanbury-Brown and Richard Q. Twiss have observed in their experiment (1956) that photons, in a coherent beam, are not emitted one at a time at equal intervals. Photons in a coherent beam, travel in bunches or groups and not as separate individual particles at equal intervals. The HBT experiment has been well explained by Akira Tonomura [3].

Two interference patterns (formed by a low intensity beam and a high intensity beam) will be identical for an equal number of photons. The time taken to form will be different. The interference pattern is related to the number of photons striking the screen. The basic requirement for interference is a coherent

beam of photons. Coherence is the defining criterion for interference.

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04 May 2021

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