The revised Photon partition hypothesis. Interrogating photons

Georgina Woodward 17 March 2022

Abstract

The revised Photon partition hypothesis is set out. Providing a physical embodiment of wave-particle existence. Three experiments are described: Young's double slit experiment on light, the Elitzur-Vaidman bomb thought experiment, a variation without a bomb but a path blocking light detector. A quantum physics description of how each experiments outcome happens is given. For comparison the photon partition hypothesis is used to describe how the results come about. An experiment is described and illustrated that may provide evidence that ordinary measurable photons are not fundamental/ indivisible particles. Arrangements of *Mach-Zehnder* Interferometer apparatus are proposed for the investigation. Division at a half silvered mirror, into a part still detectable as a photon particle, the cut photon body, and a wave-like sub photon companion is hypothesized. Three possible outcomes are described. Two of them support the notion of actual physical photon divisibility. One of the outcomes is not supportive of the notion but could be indicating division of the photon from a usually accompanying environmental effect. Several models of photon divisibility are considered. Some supplementary experiments are given for further investigation according to the outcomes found. Method for 'interrogating' photons to ascertain more about their nature is set out. A clearer understanding of the physical nature of photons and its demonstration will be achieved. Concluding: This may help scientists decide on photon partition; if it fits the evidence and in which way it happens.

Why?

Physics has struggled to provide a physically real explanation for the outcome of double slit and half silvered mirror experiments. Instead there is an abstract mathematical model; Involving non local photons in superposition. Which of course are never observed as such. The quantum physics description is that any observation causes the non local superposition to be replaced by a definite localized state. That description is neither noumenal or phenomenal reality; but unreal/ abstract. That is not saying mathematically incorrect. It is an abstract model. Photon structure which physically embodies wave-particle existence is proposed, that by its composite, divisible nature can account for observation outcomes, including of apparently non local effects. Several models of photon divisibility can be considered. Ways of getting experimental outcomes in support of one of them will be explored here. Some supplementary experiments are given for further investigation according to the outcomes found.

Revised Hypothesis: Photon Partition

1. A photon is not not an indivisible fundamental particle.
2. It consists of a photon body, which is localized and measurable as a photon particle;
3. Also 'a' wave-like sub photon companion, that is not directly detectable.
4. However the effect of the sub photon companion can be known, indicating its presence.
5. The sub photon companion is divisible at double slits or beam-splitters, such as half silvered mirrors so it has non local existence.
6. This can account for non local effects such as, what has seemed to be interaction free testing and ''spooky' knowing when paths are blocked without passage of a photon particle by that route to detect the blockage.
7. *[Whether the separable companion is part of the photon, a sub photon member, or an environmental effect, a sub photon 'host' is an open question.]*
8. Photon behaviour is not the product solely of properties of the localized photon body.

Reunion of divided sub photon companion parts, can result in wave interference that influences the trajectory of the photon body.

Some experiments and their outcomes

Given to contrast the quantum physics explanation and alternative photon partition hypothesis explanation.

Young's double slit experiment with light

The double slit experiment using light, Thomas Young, 1801, is a demonstration of the wave behavior of light "Thomas Young's experiment with light was part of classical physics long before the development of quantum mechanics and the concept of wave–particle duality. He believed it demonstrated that the wave theory of light was correct" Wikipedia

This demonstration can be set up with a laser beam illuminating a barrier that has two parallel vertical slits in it. The resulting light pattern is observed on a screen beyond the slit barrier. Bright and dark bands are observed that look like a wave interference pattern – not expected if light is made of classical particles.

Further investigation using low light intensity/ 'single photon' input reveals that the light hits the screen at discrete points, as individual particles (not waves); the interference pattern is built up by the difference in density of particle hits. Having a detector at the slits always shows that each photon passes through one slit (like a particle, not a wave.) Once which slit information has been obtained no interference pattern forms. This is usually explained as wave–particle duality.

Quantum physics description

This has an undetected photon in a non local superposition as both wave and particle. With no detection of which slit the photon passes through th photon would seem to have taken both as if a wave. Detection at the slit is an observation, causing there to be a definite local particle state of the photons and no interference.

Photon partition hypothesis

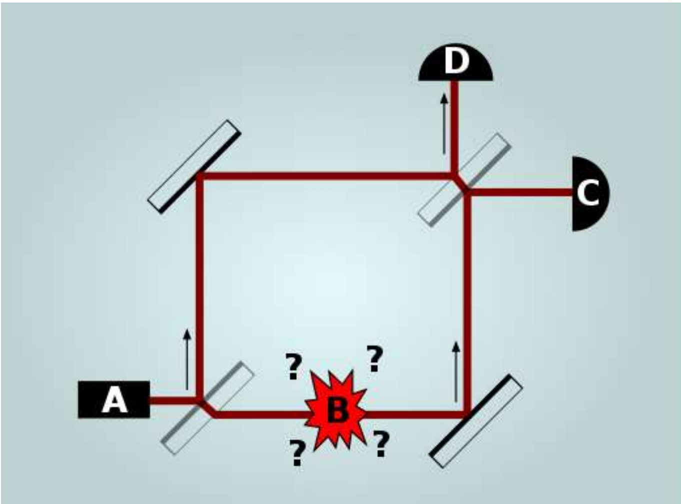
At the slits division of the photon happens. There is a measurable part, that shall be called the cut photon body, and a not directly measurable and divisible wave like companion; necessary for a wave interference pattern appearing on a screen after reunion of its divided parts.

The photon body is not readily divisible at the slits. So always passes thorough one of them. The less cohesive companion can separate and pass through both of the slits. Interfering beyond the slits. As only the photon body is measurable, the photon is always detected passing just through one slit.

Beyond the slits there is reunion of the separated companion severed parts. The photon body is guided by the traveling wave-like sub photon companion interference. Which has areas where occupation by a photon body is more likely (troughs) and areas of less likelihood (peaks). Photon bodies being guided until the ensemble reaches the screen. Where only hits by photon bodies are registered. Producing the build up of particle- like photon body hits into an interference pattern distribution.

Which way detectors disrupt or stop the sub photon companion propagation. So, they do not present an interference pattern to guide the photon body trajectory.

Questioning the validity of non local interaction free testing
The apparatus
https://en.wikipedia.org/wiki/ElitzurE2%80%93Vaidman_bomb_tester#/media/File:E-V_bomb-testing_2.svg 17th Sept 2019



Elitzur–Vaidman bomb tester This (Wikipedia) link gives background and conventional explanation.

This contraption uses a photon sensitive bomb. If live, detection of a photon causes detonation. If live but un-triggered the photon can be detected as a particle at C or D, and does not show an interference pattern. If dud the photons pass through unhindered and undetected until an interference pattern is obtained at C.

Quantum physics description:
For a dud bomb: no observation/detection is made at the bomb. So the photon stays in superposition, giving a wave interaction-like interference pattern, when separated paths are reunited. Detector C is positioned to receive the bright band of electron hits, corresponding to constructive addition of photons within the interference pattern. Detector D's position coincides with the dark band, no photon detections, corresponding with destructive addition of photons within the interference pattern. This pattern of detections at C but not at D indicates interference has happened. The pattern of C but not D detections is so even for single photon input.
[Without the interference measurable photons can reach D, as their distribution is not determined by wave interference but is particle-like.]
For a live bomb detonation: Outcome is no photon is detected by either detector as the bomb explodes first. The photon in superposition is observed by the bomb, which means there is no longer superposition of state. The photon becomes localized as a particle on the path with the bomb. That definite state photon meets the bomb; As required for detonation.
If live but un-triggered: the photon can be detected as a particle at C or D, and does not show an interference pattern. The photon in superposition is observed by the bomb, which means there is no longer superposition of state. However, the photon becomes localized as a particle on the path without the bomb. That definite state photon does not meet the bomb. As would be required for detonation. As it is in a definite particle state it doesn't show wave-like interference. D made detection can happen. This is called an *interaction free testing,* as the definite localized photon particle did not interact with the bomb.

Photon partition hypothesis description

For a dud bomb; The photon body takes one path at the beam-splitter. The sub photon takes both. When the paths are re-joined interference occurs and the photon body is *guided* to detector C. No D detection occurs. Detector C is positioned to receive the bright band of electron hits, corresponding the destructive interference lows of the interference. Detector D's position coincides with the dark band, no photon detections, corresponding with the peaks of the sub photon companion interference. This pattern of detections at C but not at D indicates interference has happened.

[Without the interference, measurable photon bodies can reach D, as not excluded by the peaks of the sub photon companion wave interference.]

For a live bomb detonation: Outcome is no photon is detected (50% of tests). Lower path was taken by cut photon body Explosion result!

If live but un-triggered The cut photon body takes upper path. The sub photon takes both. There is no coming together afterwards and interference. As the sub photon companion on the bomb path, needed for subsequent interference to occur, has been taken up by the bomb and removed from 'circulation'. There is the usual approx. 50:50 chance of being deflected at the 2nd half silvered mirror or not, passing through. So, for the remaining 50% of tests; The photon detected at C (25% of tests). The photon particle detected at D (25% of tests).To reiterate, there is no interference.

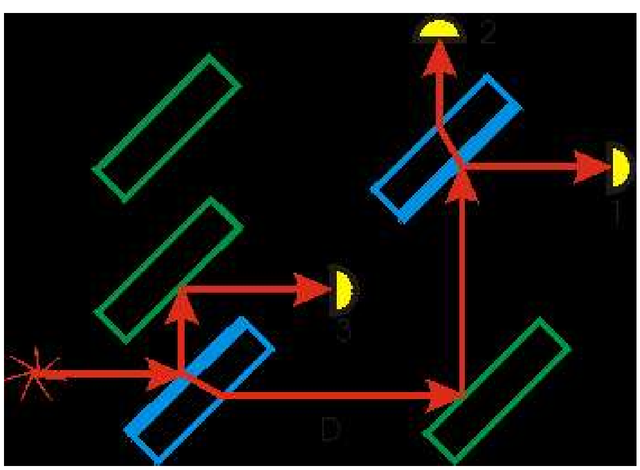
Discussion

While the photon body is localized and so, more particle-like, influence on its trajectory, especially whether or not results of wave interference play a part in controlling its location, depends upon the sub photon companion; which is divisible, able to take both paths simultaneously and be 'complicit' in some non local effects. 'Interaction free testing' is an illustration of that. 'Interaction free testing' is a misnomer, according to this hypothesis, because this outcome relies upon the *sub photon companion encountering* the bomb and being taken out of 'circulation'.

Another experiment explained using the hypothesis

Diagram copied from March 2000 by David M. Harrison, Department of Physics, University of Toronto via faraday.physics.utoronto.ca/PVB/Harrison/Locality/Locality.html

D



C

Blue=beam-splitters
Green=mirrors

This is the same apparatus as the bomb tester, with some modification. Instead of a bomb in the lower path, another ordinary mirror is placed in the upwards path; deflecting the beam to a new detector.

The quantum physics description.
Without the extra mirror and detector in place: the photon is in a non local superposition, taking both paths. When the paths join the photon interferes with itself, resulting in an interference pattern. Which is indicated by C only detections.
The extra detector, like the bomb in the previous experiment, acts as an observer. So, there is no longer superposition of the photon. The photon localized as a particle, is not affected by interference and can be detected at C or D.
As the lower beam photons do not encounter the new mirror and detector (if they are just ordinary indivisible photons, how can they know how to behave at the detectors, as particle or wave, without a non local photon explanation?)

Photon partition hypothesis description
Without the extra mirror and detector in place, the sub photon companion pieces, that have been separated at the first beam-splitter, are reunited at the second one, and interfere; resulting in an interference pattern effect. Which is indicated by C only detections. Corresponding to photon body accumulation at the destructive interference lows of the re-united sub photon companion interference pattern.
With that mirror in place one of the sub photon companion pieces is directed to the sink detector and so prevented from reuniting with the other sub photon companion piece. Consequently, there is no interference of sub photon companions. Photon bodies are not guided exclusively to C and can be detected at D. Removing the means for sub photon companions to reunite and interfere *can account for what seems to be an interaction free non local effect.*

Interrogating photons

Outline:
An experiment is described and illustrated that may show that ordinary measurable photons are not fundamental/ indivisible particles and rule out the non locality (and interaction free measurement) due to superposition of photons.
Arrangements of *Mach-Zehnder* Interferometer apparatus are proposed for the investigation. Other kinds of beam-splitter than those used in the apparatus exist and could be used for a similar experiment. I will not be discussing their pros and cons. Division at a half silvered mirror, into a part still detectable as a photon particle, the cut photon body, and a wave-like sub photon companion is hypothesized. Three possible outcomes are described. Two of them support the notion of actual physical photon divisibility. One of the outcomes is not supportive of the notion but could be indicating division of the photon from a usually accompanying environmental effect.
Some supplementary experiments are given for further investigation according to the outcomes found. Hope is expressed that this investigation is widely conducted, so there is widespread consensus on the nature of photons. It is also hoped that this becomes a standard demonstration of that nature.

Question:
Is a treated photon that has encountered a half silvered mirror and not been reunited by path joining,
1. divisible into all non detectable members
2. divisible into a detectable and an undetectable part like an untreated entire photon or
3. fundamentally different from an entire photon in its *indivisibility.*

Hypothesis:
Photon divisibility is proposed. Half silvered mirrors are able to divide photons into a detectable portion, detected as a particle. That particle is still called a photon despite having undergone ‘amputation’. Both an entire photon particle and a cut photon body particle are detected as if the same; a photon. For clarity it shall be called a cut photon body
 Also a sub detectable portion is formed having wave like character. Which will be called a sub-photon companion. It is not cohesive and can split apart, taking separate paths. Identified by causing wave-like interference when severed light paths are recombined. The sub-photon companion is an existing element of noumenal Object reality. Source of the phenomenon observed indicating wave interference has happened. This can explain observed outcomes, rather than needing to use superposition for explanation.

Possible outcomes and what they imply

Outcome 1: **no detection.** Addresses the question Can the cut photon body be divided? May indicate that even a cut photon body is not an indivisible fundamental particle. As will occur if *divisible* into all non detectable members. Supports the photon partition hypothesis for explanation of so called quantum effects. (Check the apparatus is working and set up correctly by testing with opaque blocks removed and getting usual photon detection results.)

Outcome 2: **Usual photon behaviour.** Detectable as particle or showing interference pattern if paths are reunited.
Supplementary question: If this is found How many times can an un-reunited photon be ‘re-cut’? If the answer is many or indefinitely many it may be indicating that the sub photon companion is being regenerated from the environment. Further investigation is needed to differentiate non split-table photon (photon partition hypothesis is wrong) from one that can split (so can have non local effect) and also spontaneously regenerates.. Lets call it ‘partition plus hypothesis’

Supplementary experiment: If outcome 2 is found, use a series of interferometers as a modification of the apparatus to investigate; after how many half silvered mirror encounters, the interference pattern ceases to be formed after necessary pathway joining. Given a laser of sufficient intensity for use with a series of interferometers.

Outcome 3: Photons can be detected but **no evidence of an interference** pattern can be obtained, suggests that the photon minus part of its sub photon companion can not be re-divided into normally interfering sub photon companion, and a cut photon body complement. Showing that a cut photon body is different from an entire photon. Supports the photon partition hypothesis for explanation of so called quantum effects.

Method
Starting out [Full instructions on how to set up a Mach Zehndler interferometer is available at MODULE 10-7 MACH-ZEHNDER INTERFEROMETERS, experiment 1, via https://pe2bz.philpem.me.uk/Lights/-%20Laser/Info-999-LaserCourse/C10-M07-Mach-Zehnder-Interferometers/Module10-7.htm

or LD Physics Leaflets P5.3.5.1 Setting up a Mach-Zehnder interferometer on the laser optics base plate https://www.ld-didactic.de/literatur/hb/e/p5/p5351_e.pdf]
and elsewhere on the internet.

Basic Apparatus
Specification recommendations can be found together with full instructions on how to set up a Mach Zehndler- see above.
Here is the basic apparatus and a few ideas.
The light source.
A monochromatic (as easiest to use) laser, long wavelength (easier to adjust) is recommended. As a low dispersion light source is needed.
Coherence of the light source is important."...the interferometer …. shows pronounced interference fringes only if the coherence length of the laser light is at least as long as the path-length difference of the two arms."https://www.rp-photonics.co... path-length difference is difference due to difference in glass thickness (of the half silvered mirrors) traversed.
Check that the laser light has sufficient intensity. It needs to, at least, theoretically reach the detector of a second interferometer, despite halving and halving again because of the path blocking that is part of the apparatus set up.
The beam-splitters.
Half silvered mirrors, *clean.* A half silvered mirror is just a standard means of beam splitting. The photons either bounce off the incomplete coating (maybe aluminum) or pass through.
Ordinary mirrors.
Clean, fully silvered. For controlling direction of beam.
Opaque barriers.
To absorb the photons of the beam and prevent further transmission. Non reflective material. Must be able to tolerate the beam intensify; not smolder or catch fire.
Light meter.
Screen
4 photo-detectors-photocells. [Alternatively a screen to display interference pattern, or for low light intensity output photo-multipliers. As best suits individual set up/ preference.]
Vibration dampening surface to build on

Preparation of the apparatus

1/ Set up a Mach Zehndler interferometer (see above or other detailed instructions) with the first reflected light path blocked with an opaque barrier.

2/Test and adjust the placement of the components, especially the detector so that there is clearly interference, without opaque barrier in place.

3/Then place the barrier and remove the detector so that the beam is available for analysis.
WHY: This initial interferometer apparatus is to prepare the input beam, for analysis.
[The photons in it may(outcomes 1,3) or may not (outcome 2) appear to behave differently as a result of this treatment.

For analysis of prepared beam
1/ Two more Mach Zehndler interferometers can be set up with opaque, removable barriers in the reflected beam paths, from the first beam-splitter of the analyzer interferometers (2nd tier interferometers).
One using the reflected beam from the second beam-splitter of the first interferometer. The other using the transmitted beam from the second beam-splitter of the first interferometer.

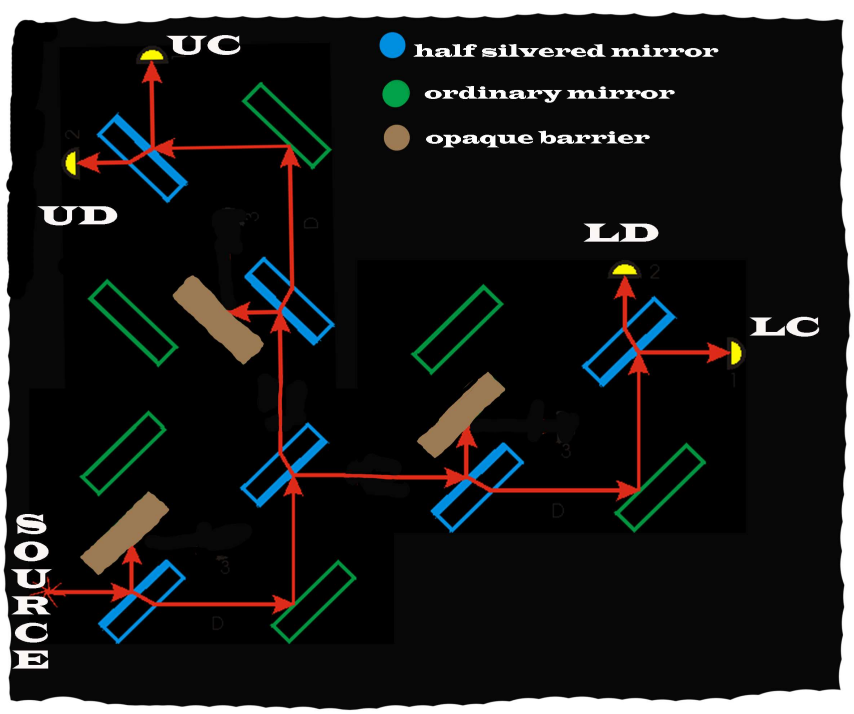
[Aside: Just one input beam could be used to save time and money at the expense of less results and assuming both halves of the re-divided beam, divided and not reunited in the first interferometer with opaque barrier, are equivalent (rather than demonstrating it with two analysing interferometers used together. Using two second tier (analyzer) interferomters: Naming the second tier intrerferometers U (upper) and L (lower), and their detectors C and D. UC and LC result and UD and LD should be the same, if set up correctly.]

2/ Check the analyzer interferometers are correctly set up.
a. Make and position 3 barriers with a hole just big enough for the laser beam to pass through without touching, along the path of the incoming prepared beam.
b. Now turn off laser of first interferomer. Using a laser the same as used in the first interferomer, substitute its beam for the prepared beam beyond the second beam-splitter of the first interferometer; so that it passes thorough the three holes.
WHY: Perforated barriers ensuring beam alignment, so function of second tier (analyzer) interferometers can be checked.

c. Remove the opaque barrier stopping reflected beam. Adjust components until clear interference is observed for the test beam.
WHY: Checking the interferometer is able to show interference pattern.

Apparatus for primary investigation
Used with and without opaque blocks placed.

Find detailed instructions for setting up a Mach Zehndler interferometer.
Then follow the experiment method, under the headings:
Preparation of the apparatus and **Running the experiment for ascertaining photon nature**
Modify as required for further analysis of outcome, as per instructions.



<u>Running the experiment for ascertaining photon nature</u>

Remove test beam laser. Switch on first interferometer's laser.
Replace opaque barrier in first interferometer.
Turn out and or exclude other 'light' sources.
Look for which outcome occurs
1 no detection,

2 interference pattern (interference pattern can be displayed on a screen used for detection. Or C but no D detections obtained.
Due to the interference pattern affecting photon body particle distribution.

3 detection but no interference pattern. (No interference pattern can be displayed on a screen used for detection. Or C and D detections are obtained.
Indicates there has been no interference effect on photon body distribution
If 1 or 3, adjust the distance of the detector from the last beam-splitter slightly and carefully to see if any detection can be found or an interference pattern can be obtained, as applicable. Check setup.

<u>Further investigation of outcome 1 if found.</u>
1 outcome may indicate that even a cut photon body is not an indivisible fundamental particle. As will occur if *divisible* into all non detectable members.
Remove the opaque barrier from the first interferometer so the output is complete/ united photons. Now a detection should be made; Evidence that a 1 (no detection) is a result not an error.

<u>Further investigation of outcome 3 if found</u>
3 outcome: [suggesting cut photon body and sub photon companion once divided, can not be redivided and subsequently reunited into a photon body and complete sub photon capable of detection via production of interference pattern.]
If a 3 result, [Showing that cut photon bodies are different from a divisible entire photons.] Check this. Use the light meter to check the intensity of the light. Is it as expected given the starting intensity, and losses due to beam-splitting, mirror reflections and transmission path length. Some calculation needed inputting specific apparatus and lay out parameters.
WHY: If there is extra loss that is not accounted for it might be indicating the result is a 1, 3 mix. i.e. Some, not all, of the cut photon bodies are divided beyond detection and mixed with still detectable cut photon bodies.

<u>Further investigation of outcome 2 if found.</u>
A. Is there normal interference as if the missing part has regenerated (from the environment) or is it less distinct because there is only half as much sub photon interaction (something responsible for interference, not reunited)? Compare, using input to a second tier (analyzer) interferometer, from first interferometer *with and then without* opaque barrier in place. Is there noticeable difference. Pattern should not be less distinct if regeneration of sub photon companion ('host') happens. A difference noticeable if there isn't regeneration and a partial beam, so partial sub photon companion content is being redivided and reunited.
B.The first interferometer alone with opaque barrier in place will give photon detection but not show interference. Can what's missing be supplied by a different identical as possible, laser and beam-spitter. Introduce this donor beam using mirrors to the second beam-splitter. So that it takes the place of the stopped beam. Is interference restore-able in this way? This would indicate that interference is not due to the photon in superposition interfering with itself. This could be interpreted as two distinct sources of sub photon companion meeting and interfering.

Conclusion A clearer understanding of the physical nature of photons and its demonstration will be achieved. This may help scientists decide on photon partition; if it fits the evidence and in which way it happens.

Acknowledgments

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LD Physics Leaflets P5.3.5.1 Setting up a Mach-Zehnder interferometer on the laser optics base plate https://www.ld-didactic.de/literatur/hb/e/p5/p5351_e.pdf]