Experiment and Theory Removing all that Quantum Photon Wave-particle-Duality Entanglement Nonsense

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Definitions of particle and wave in the classical sense, and quantum mechanical sense, are very different. Let us define a classical particle as anything that holds itself together, and understand that a classical wave does not. They are opposite concepts. However, a quantum-particle has those two opposite classical concepts inexplicably mixed together. A quantum-wave can spread across the whole universe, then collapse to a minuscule quantum-particle. A quantum-wave is a non-physical wave of probability that goes everywhere. This kind of probability is not like throwing dice, because dice go somewhere, and that quantum-wave is everywhere. To resolve the problem requires revisiting experiments that are famous for their particle-like interpretation. Here, we show how a new Threshold Model can work for both our wave-like and particle-like experiments. Two sets of experiments have been performed to substantiate our Threshold Model: with light using gamma-rays, and with matter using alpha-rays. They are both beam-split coincidence experiments that reveal a two-for-one effect. It only looks like two-for-one if you are sold on quantum mechanics. We do not obtain something from nothing. The Threshold Model embraces a pre-loaded sub-quantum state, called for in our new experiments.

Keywords: photon, wave-particle duality, quantum mechanics, entanglement

1. Introduction

It is well known that Einstein and Schrödinger argued against quantum mechanics (QM). Schrödinger's skepticism is well documented:

"Let me say at the outset, that in this discourse, I am opposing not a few special statements of quantum mechanics held today, I am opposing as it were the whole of it, I am opposing its basic views that have been shaped 25 years ago, when Max Born put forward his probability interpretation, which was accepted by almost everybody" [1, his 1952 Dublin Seminar].

Schrödinger's works coining entanglement [2] and his cat [3] followed the so-called EPR paper [4], and followed his discussion with Einstein on that paper. Therefore papers [2, 3] can be understood to say that the world-view delivered by QM is far too incomprehensible to take seriously. Arguments have raged. Most famously, QM entanglement is said to be upheld by so-called two-"particle" experiments performed by Aspect and team [5]. In such a test, a probabilistic wave-function spreads from a central point, then detectors on opposite sides can click in either of two states as read by a coincidence circuit. When clicks happen in coincidence the wave-function is thought to collapse, and state correlations are recognized. However, a much simpler single-"particle" test will address this issue of wave-function collapse. Either test, the single or two-"particle," is most easily done with visible light, with what they call singly emitted "photons" [6]. Our examination of these fundamentals calls for careful language. There is a "tell." When you see a paper written in terms of photons, even if it is intended to question if photons exist, the result will always lead to photons. There is a way to avoid the photon model, yet embrace $h\nu$ (Planck's constant times frequency) in our equations, and that is what this essay is about. We need a new word. I use $h\nu$, pronounced h-new. An $h\nu$ is a quantity of energy, but here it is not about the energy of a light-particle. It is about a threshold-energy in matter.

Wave-particle duality, wave-function collapse, entanglement, and quantum mechanics, are all the same thing: a non-explainable model. Showing how entanglement is an illusion, is what this essay is about.

Here is the experiment: A source of electromagnetic radiation is tested to see if it emits only one $h\nu$ at a time, except by chance. Two detectors will surround our source in what is called a true-coincidence test. Then with that same source, we re-position the same detectors to do a beam-split coincidence test. This test will monitor singly emitted $h\nu$ energy encountering a wave-front-like split, to see how it interacts with our two detectors in coincidence. The coincidence circuit tests to see if one detection excludes the other detector from clicking, except by chance, as expected by QM. These "clicks" are microsecond pulses we see on an oscilloscope. The coincidence circuit will reveal: (1) if light somehow holds itself together so as to only deliver coincident clicks at a chance rate, or (2) if light can spread classically to deliver coincident click rates exceeding chance. Such beam-split-coincidence tests performed in the past [5] have upheld result (1), as predicted by QM. Literature asserts, if this one-way-or-another property of quantum particles were to be refuted, it would call for a major revision of QM [6 Brannen and Ferguson]. Previous to my work, no one performed this test with gamma-rays, perhaps because gamma-rays are thought to be the most particle-like form of light. Here we report that a gamma-ray beam-split-coincidence test can contradict the quantum mechanical chance prediction. When the chance rate is exceeded, we call it the unquantum effect.

Our true-coincidence test uses the same circuit and detectors as the beam-split coincidence test, except the geometry is different. A true-coincidence test for gamma-rays will sandwich an isotope between two detectors to see if it emits two $h\nu$ in a single decay [7]. Similarly these tests can be performed upon other... phenomena. I write other "phenomena" because we are tempted to say particles. This linguistics problem is part of our 100 year-old physics problem.

Nuclear physicists have a long history of deciphering decay schemes by comparing to chance rates. But for safe keeping, this true-coincidence test has been performed inhouse on our isotopes sources: 109Cd and 57Co, well known to emit only one gamma-ray at a time. With these isotopes we detect an x-ray in coincidence with the gamma, but those x-rays are filtered out and not counted.

One might expect we are seeing two "half-photons," or a Compton effect split. We use pulse-height filters to count only full-height pulses, in a manner that delivers a two-for-one effect. The same filter and coincidence circuit we used to test for one-at-a-time emission, are then used again to test for two-at-a-time, but now our detectors are arranged like a beam-splitter. From other experiments, we know that pulse-height is proportional to electromagnetic frequency.

Many tests performed at our laboratory since 2001 show that this unquantum effect is not some artifact, it is not a special case, and it is not some experimental error. Also, the reason why it works, and not-works, is revealed in our test variants. Details of one gamma-ray unquantum test are in Appendix I [8, 9]. That test exceeded QM chance by 35.

To transcend wave-particle duality requires removing this duality from both matter and light. We have performed many beam-split coincidence tests, now here with alpha-rays, to demonstrate the unquantum effect for the matter-wave. We split the atom like a wave. The word "atom" sounds like a particle, but think of splitting a helium-nuclear-matter-wave. We are not splitting helium atoms into two deuterons. The binding-energy of helium is 7 MeV per nucleon, so it would take 14 MeV to split the alpha. We employ 241Am, known to emit alpha at only 5.5 MeV. When we direct alphas toward a gold foil, the bulk of these wave-packets will usually either go through the foil or are reflected, like a particle. Usually, but not always. When we measure detection pulses in-coincidence, we conclude the alpha matter-wave must have split. Most of these coincident pulses are half-height, and this measurement repeatedly exceeds chance by 100 times. This is not two-for-one, but it violates particle-binding theory. Now, if we measure only the full-height pulses in-coincidence we do see a two-for-one effect, and exceed chance by four. I performed many variants and control tests to remove doubt. Details of an alpha-ray unquantum test are in Appendix II [8, 10].

These tests compel us to re-interpret past experiments. Our non-dualistic model explains the relevant experiments.

Now, thinking of the gamma-ray unquantum effect, two-for-one implies energy must be pre-loaded in either the detector or the scatterer, preceding the detection event. Otherwise we violate energy conservation. We uphold energy conservation. Therefore we are forced to consider an accumulation hypothesis, also known as the loading theory. We say we are violating particle-energy conservation. This is similar to the Bohr-Kramers-Slater [11] idea, whereby energy conservation did not require particle-per-particle accounting. Arguments on this issue were poor [see 9 or 12]. Accumulation ideas are old, with many variants [13, 14, 15]. In Millikan's book of 1947 [16] he correctly considers a pre-loaded state in the photoelectric effect. However, he did not understand how it could be true. Since then, the element of time in the photoelectric effect is routinely considered as starting from empty. A way to visualize the loading theory is by figure 9.

A few definitions are overdue. First, particle and wave. A particle will hold itself together. A particle can be anything from a dimensionless point to a galaxy. A wave does not hold itself together and spreads. We just need that distinction. Particle and wave are opposite ideas. For the definition of the photon, N Bohr paraphrases Einstein:

"If a semireflecting mirror is placed in the way of a photon, leaving two possibilities for its direction of propagation, the photon would be recorded on one, and only one, of the two photographic plates situated at great distances in the two directions in question, or else we may, by replacing the plates by mirrors, observe these effects exhibiting an interference between the two reflected wave-trains [17]."

This way of combining classical concepts and using the same words for quantum concepts causes confusion. Many physicists assert this confusing combination is an inescapable response to experiment. There is a way out, but first please understand that a quantum particle is an incomprehensible model, not a thing. A photon has never been a thing, and it should not be spoken of that way.

To explain our wave effects and our new experiments, I propose a two-state solution. Consider that a quantum-particle, such as an atom, can hold itself together but can also "lose-it." Please examine the equations famous for "particle-wave" experiments in Table 1. These equations have ratios of e, h and m. Let us look at electron mass m. If we think of m as the mass of a particle, we will forever be stuck in wave-particle duality. Now realize that these equations have ratios like e/m. Please consider our constants in terms of thresholds; consider that our constants are maxima.

Consider an arbitrarily small cubic volume of a charge-wave. Imagine charge in this cube to be some sub-threshold value of e. Then think similarly for action and mass. The simplest relationship would be linear such that the e/m ratio in this cube will be conserved. Now realize similarly for our h/m and e/h ratios. In this scenario our experiments could not make the distinction between this

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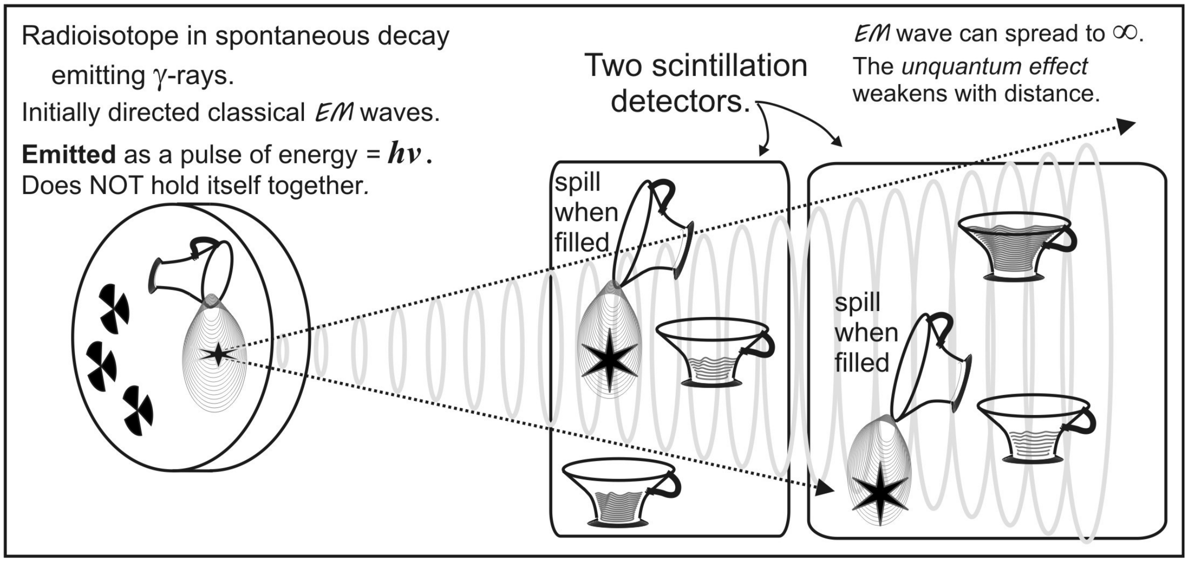


Figure 1. A way to visualize the loading theory in the gamma-ray test.

new threshold-ratio model and QM. The way to tell the difference between those models is our beam-split coincidence test.

What about experiments reporting quantized charge? Measurements of e are performed upon ensembles of many atoms, such as in the Millikan oil drop experiment (and earlier by J. J. Thompson). It is a false assumption to say that quantization seen in an ensemble will carry over to free charge. From evidence of charge-diffraction alone, it is a false assumption to think charge is always quantized at e. In our new model, if charge were to spread like a wave, maintain a fixed e/m ratio for any unit of volume, load-up upon absorption, and be detected at threshold e, it would remain consistent with observations. An electron's worth of charge need not be spatially small. Chemists performing Electron Spin Resonance (ESR) often model an electron as large as a benzine ring. A point-like electron would predict a smeared-out ESR spectrum. Carver Mead argued for an extended electron [18]. Many famous experiments become free of wave-particle duality by this threshold/ratio interpretation.

Our Threshold Model, supported by the unquantum effect easily resolves the enigma of the double-slit experiment. For light, its kinetic energy would load up in the charge-wave. For matter, we say matter actually loads up. Much detail can be encoded in a spreading matter-wave to equal an identifiable element (atom). However, it is beyond reason to expect a complicated molecule to load up. We stand with convincing experiments on the wave nature of atoms, charge, and neutron matter-waves (neutrons) [19, 20].

Consistent with the threshold model is a recent helium diffraction experiment that revealed both particle and wave signatures in a helium diffraction pattern [21]. The matter-wave behaves like a solution; it can either hold itself together in a particle state, or spread in a wave state. This is subtly different from complementary, whereby the distinction between a wave or particle state depends on how one looks at it.

2. Flaws in Recent Experiments of Others

To challenge QM is to show how its key experiments are flawed. Here I handle two key tests, one using light and one using matter.

Recall the popular work by Aspect and team [5] that convinced mainstream publishers the world is made of spooks. They used an atomic beam, stimulated by a laser, to emit pairs of "photons." Correlated clicks behind polarizers are reported to defy classical interpretation. Take notice: they failed to tell you their laser delivers polarized light. The atoms in the beam are known to emit in a two-$h\nu$ cascade. Therefore we can expect the atomic beam to emit polarization-correlated $h\nu$ pairs. By $h\nu$, I mean that this energy was emitted in an initially-quantized and initially-directed burst. Thereafter this energy can spread classically. Their data is in figure 2. This graph is just what is expected from Malus's law and classical polarized light as a function of angle. Indeed, I am not the only one saying this; see figures 3 and 4.

An article in Nature received much attention for claiming that giant molecules emitted one-at-a-time, could somehow project an interference pattern [24]. It is a far stretch to imagine how such a thing can be true, by either QM or the loading theory. They argue that their diffraction fits the de Broglie equation 1:

TABLE 1. Table 1. Equations of wave-like experiments expressed by quantum mechanics, and those equations re-written by our new Threshold Model.

	Quantum Mechanics	Loading Theory
Matter wavelength	$\lambda_{\text{phase}} = \dfrac{h}{m\varpi}$	$\lambda_{\text{group}} = \dfrac{Q_{h/m}}{\varpi_{\text{group}}}$
Photoelectric	$h\nu_{\text{L}} - h\nu_0 = \dfrac{m\varpi^2}{2} = e\text{V}_0$	$Q_{h/m}(\nu - \nu_0) = \dfrac{\varpi^2_{\text{group}}}{2} = Q_{e/m}\text{V}_0$
Compton	$\Delta\lambda = \dfrac{h\,(1-\cos\theta)}{mc}$	$\Delta\lambda_{\text{group}} = Q_{h/m}\,\dfrac{1-\cos\theta}{c}$
Lorentz force	$F = ma = e\,(\varpi \times \boldsymbol{B})$	$a = Q_{e/m}(\varpi_{\text{group}} \times \boldsymbol{B})$
Aharonov-Bohm	$\Delta x = \dfrac{e\,L\lambda Bw}{h}$	$\Delta x = Q_{e/h}\,L\lambda_{\text{group}}Bw$

$$\lambda = d\sin\theta = \frac{h}{mv} \tag{1}$$

It is more reasonable to expect these molecules are casting mere shadow patterns, and that the pattern is magnified by an electric field. Electric field effects are the most obvious source of artifact and were not addressed. I have identified and posted four striking anomalies (see appendix) that require explanation: (1) there is insufficient velocity resolution in their model to prevent their fringe widths from being blurred-out to twice as wide, (2) fringe orders have the wrong relative intensities, (3) there is a large mismatch upon applying $d = (gt^2)/2$ = (dist of particle fall) = one half (acceleration of gravity)$(distance particle travels/velocity)^2$ to their data, and (4) their movie-data shows a sharp-edge fringe intensity profile that is characteristic of a shadow pattern. Crucial control tests addressing electric fields are required before taking their message seriously. A graphic from this Nature article, detailed calculations in a letter to its author, and his response are in Appendix III.

3. Conclusion

Entanglement is an illusion of the threshold and ratio properties of charge, action, and mass. Much elaboration upon experiment and theory outlined here has been developed; please see http://www.thresholdmodel.com. We welcome visitors to Unquantum Laboratory in Pacifica CA to witness or adjust our experiments.

4. APPENDIX I, The Gamma-ray Unquantum Experiment [8, 9]

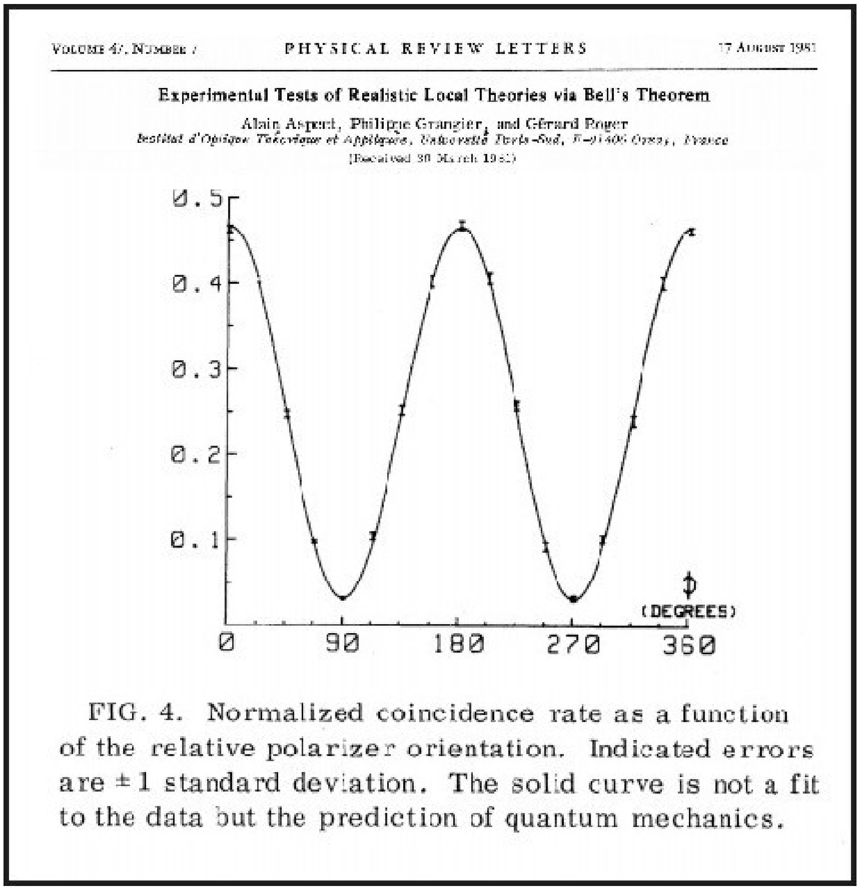
After spontaneous decay by electron capture, 109Cd becomes stable 109Ag. 109Cd also emits an x-ray, far below the lower level of our discriminator (LL). Chance is immediately recognized by a flat band of noise on a time-difference histogram Δt, and can be measured by 2:

$$R_c = R_1 R_2 \tau \tag{2}$$

where R_1 and R_2 are the singles rates from each detector, and τ is the chosen time window within which coincident events are counted from the Δt histogram. Later we will compare this to the experimental chance rate Re to see how they differ.

Recent tests were performed with two detectors, each consisting of a NaI(Tl) scintillator crystal coupled to a PMT. Detector 1 was a custom-made thin detector, at 4 mm thick, and is shown in figure 5. Behind the thin detector was thick detector 2, a 1.5" Bicron. We call this thin-thick detector arrangement tandem geometry. The thin detector serves to randomly absorb a fraction of an emitted gamma-ray. Two 10 μCi check-sources of 109Cd were inside a Pb box of 1/4" walls with a 1/4" diameter hole and a 1/8" square tungsten aperture. The aperture was designed to optimize how the cone of emitted gamma fits the larger detector 2. Poor collimator design can just deliver chance. The test was performed inside a lead shield lined with tin and copper; this lowered singles background rate 1/31. Coincidence background rates are manageable fractions to be subtracted. To assure that the unquantum effect was not generated by background, several all-night and all-day tests, with and without the source, were examined.

Referring to figure 6, components for each of the two detector channels are an Ortec 471 amplifier, an Ortec 551 SCA, and an HP 5334 counter for singles rates (not shown). A four channel LeCroy LT264 digital storage oscilloscope (DSO) with histogram software, monitored the analog pulses from each amplifier on DSO channels (1)


VOLUME 47, NUMBER 7 PHYSICAL REVIEW LETTERS 17 AUGUST 1981

Experimental Tests of Realistic Local Theories via Bell's Theorem

Alain Aspect, Philippe Grangier, and Gérard Roger
Institut d'Optique Théorique et Appliquée, Université Paris-Sud, F-91406 Orsay, France
(Received 30 March 1981)

FIG. 4. Normalized coincidence rate as a function of the relative polarizer orientation. Indicated errors are ±1 standard deviation. The solid curve is not a fit to the data but the prediction of quantum mechanics.

Figure 2. Data from [5] PRL 47, pg 460 (1981), Aspect, "Experimental Tests of Realistic Local Theories via Bell's Theorem."

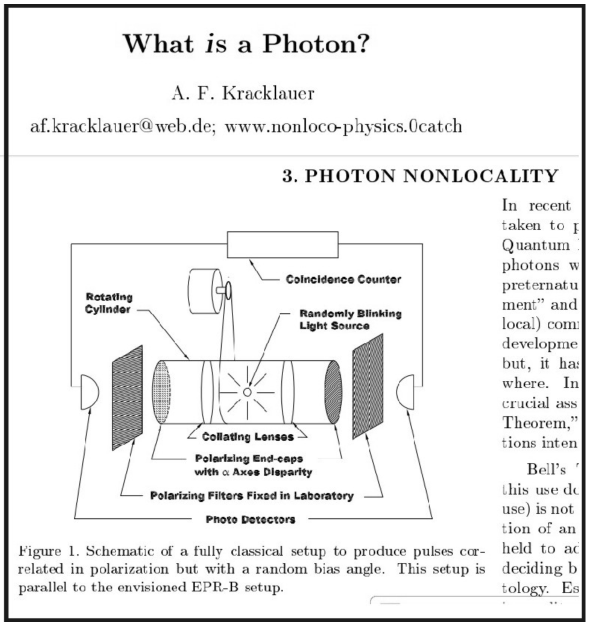
and (2). DSO also monitored SCA timing pulses at channels (3) and (4). The stored image of each triggered pulse show well behaved pulses to assure that noise and pulse-overlap were not a factor. This DSO can update pulse-heights, (A)(B), and time difference Δt (C) histograms after each "qualified"-triggered sweep. To assure exceeding particle-energy conservation, LL on each SCA window was set to at least 2/3 of the 109Cd 88 keV gamma characteristic pulse-height.

A coincidence background test with no source present had 304 counts/49.4 ks = 0.00615/s, a rate to be subtracted. Within the same time window τ taken as 200 ns, the chance rate from Eq. 1 was R_c = (8.21/s)(269/s)(200 ns) = 0.000442/s. The experimental coincidence rate within tau was R_e = (101/4.59ks) - (0.00615/s) = 0.0158/s. The unquantum effect was R_e/R_c = 0.0158/0.000442 = 35.7 times greater than chance.

5. APPENDIX II. The alpha-ray unquantum experiment [8, 10]

Americium-241 in spontaneous decay emits a single 5.5 MeV alpha-ray and a 59.6 keV gamma. An alpha is known as a helium nucleus. Two silicon Ortec surface barrier detectors with adequate pulse-height resolution were employed in a circuit nearly identical to that used in figure 6. Figure 7 shows the detectors and pre-amplifiers in a vacuum chamber. These tests were performed under computer (CPU) control by a program written in QUICKBASIC to interact with the DSO through a GPIB interface. Here, both SCA LL settings were set to only 1/3 the characteristic a pulse-height because it was found that an alpha-split usually, but not always, maintains particle-energy conservation. By this we mean the "energy" read from the two detectors in coincidence usually adds to the emitted 5.5 MeV. The coincidence time-window was τ = 100 ns. The Δt histograms of figure 8 were from DSO screen captures.

Data of figure 8-a was a two hour true-coincidence control test with the two detectors at right angles to each other and with the 241Am centrally located. Only the chance rate was measured, assuring that only one alpha was emitted at a time. 4π solid angle capture was not attempted because it requires a specially made thin source. However, the right angle arrangement is adequate, and it is well known how 241Am decays. Any sign of a peak is a quick way to see if chance is exceeded. A background coincidence test of 48 hours with no source present gave a zero count. Data of figure 8-b taken Nov. 13, 2006 was from the arrangement of figure 7 using two layers of 24 carat gold leaf suspended over the front of detector 1. Mounted at the rim of detector 2 were six 1μCi 241Am


What *is* a Photon?

A. F. Kracklauer

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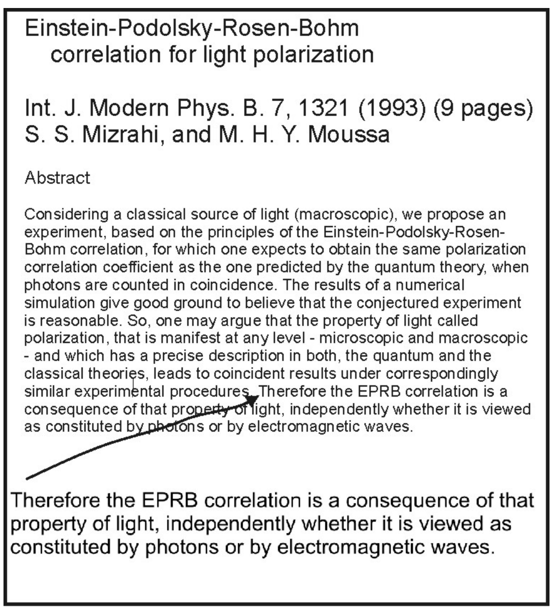
3. PHOTON NONLOCALITY

Figure 1. Schematic of a fully classical setup to produce pulses correlated in polarization but with a random bias angle. This setup is parallel to the envisioned EPR-B setup.

Figure 3. Excerpt from Kracklauer, SPIE paper [22].


Einstein-Podolsky-Rosen-Bohm correlation for light polarization

Int. J. Modern Phys. B. 7, 1321 (1993) (9 pages)
S. S. Mizrahi, and M. H. Y. Moussa

Abstract

Considering a classical source of light (macroscopic), we propose an experiment, based on the principles of the Einstein-Podolsky-Rosen-Bohm correlation, for which one expects to obtain the same polarization correlation coefficient as the one predicted by the quantum theory, when photons are counted in coincidence. The results of a numerical simulation give good ground to believe that the conjectured experiment is reasonable. So, one may argue that the property of light called polarization, that is manifest at any level - microscopic and macroscopic - and which has a precise description in both, the quantum and the classical theories, leads to coincident results under correspondingly similar experimental procedures. Therefore the EPRB correlation is a consequence of that property of light, independently whether it is viewed as constituted by photons or by electromagnetic waves.

Therefore the EPRB correlation is a consequence of that property of light, independently whether it is viewed as constituted by photons or by electromagnetic waves.

Figure 4. The experiment quoted in Kracklauer [23].

sources facing detector 1 and shaded from detector 2. Every coincident pulse pair was perfectly shaped. $R_c = 9.8x10^{-6}$/s, and $R_e/R_c = 105$ times greater than chance.

From the CPU program and data used in the test of figure 8-b, data is re-plotted in figure 9. Figure 9 depicts each pulse-height as a dot on a two dimensional graph to show coincident pulse-heights from both detectors. The transmitted and reflected pulse-height singles spectra were carefully pasted into the figure. We can see that most of the alpha pulses (dots) are near the half-height marks,

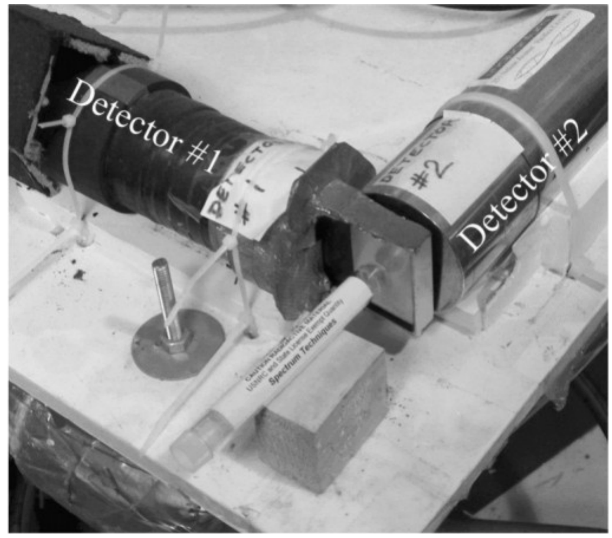


Figure 5. Two sodium iodide gamma-ray detectors in tandem geometry. Detector 1 is a custom-made 4 mm thick slab.

demonstrating particle-energy conservation. However, the six dots circled clearly exceed particle-energy conservation. Counting just these 6, we still exceed chance: R_e/R_c = 3.97. This is a sensational contradiction of QM because it circumvents the argument that a particle-like split, such as splitting into two deuterons, is somehow still at play. Several other materials were tested in transmission and reflection geometries to reveal the usefulness of this matter-wave unquantum effect in material science. It is not necessary to use gold to exceed chance. However, many materials tested just gave chance.

6. APPENDIX III

On, 22.05.2012, 01:54, Eric Reiter wrote: Dear Dr Juffmann Regarding your recent article, "Real-time single-molecule imaging of quantum interference," I have performed calculations on your data that do not make sense to me.

1. Let's calculate the fall of a particle. We can use $(1/2)gt^2$, where t = time = distance/velocity. For a fast particle (eq 3):

$$H = \left(\frac{9.8}{2}\right)\sqrt{\left(\frac{2m}{340m/s}\right)} = 169x10^{-6}m \qquad (3)$$

For a slow particle (eq 4):

$$H_{slow} = \left(\frac{9.8}{2}\right)\sqrt{\left(\frac{2m}{440m/s}\right)} = 1x10^{-3}m \qquad (4)$$

Hslow - Hfast = 830 micrometers. But you show only 240 micrometers. Therefore the difference in falls should be 3.4 times larger than you show.

2. I used a multiple slit diffraction simulation tool to test what the intensity profiles should be. I found

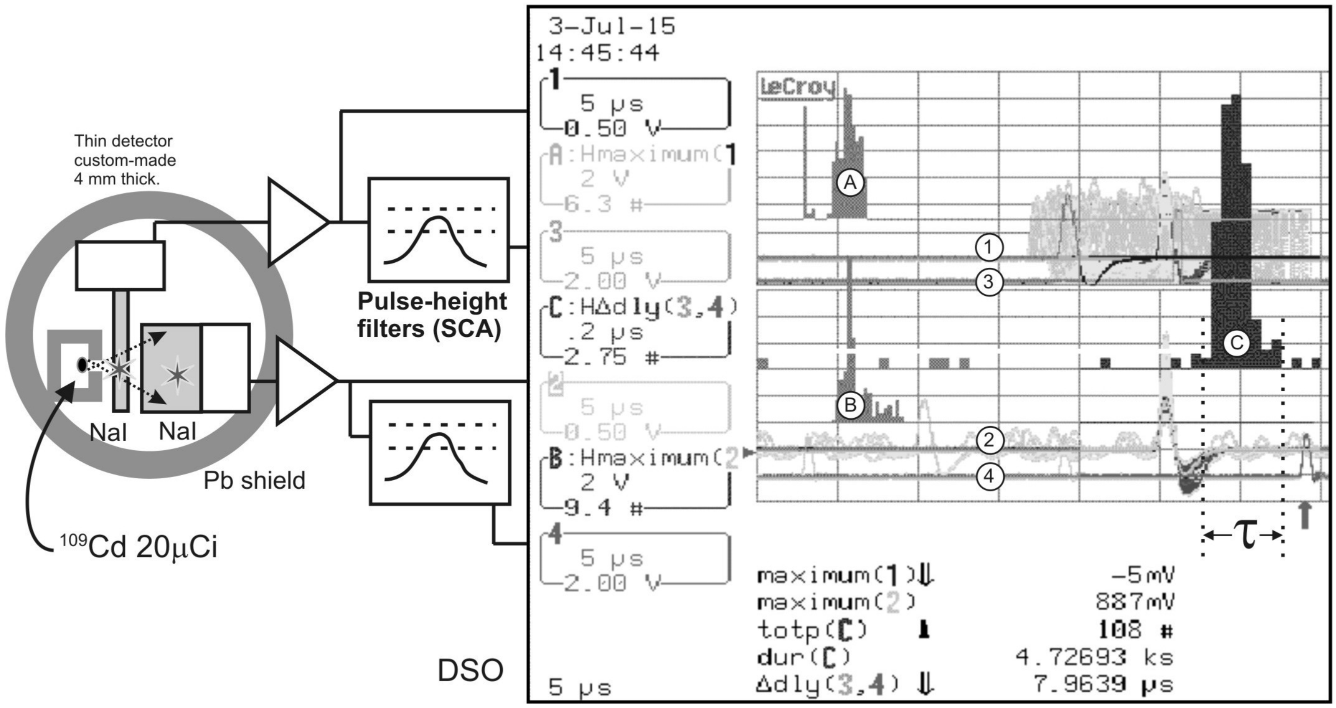


Figure 6. Gamma-ray experiment in tandem geometry using 109Cd. Counters and computer interfaces are not shown. DSO screen is annotated.

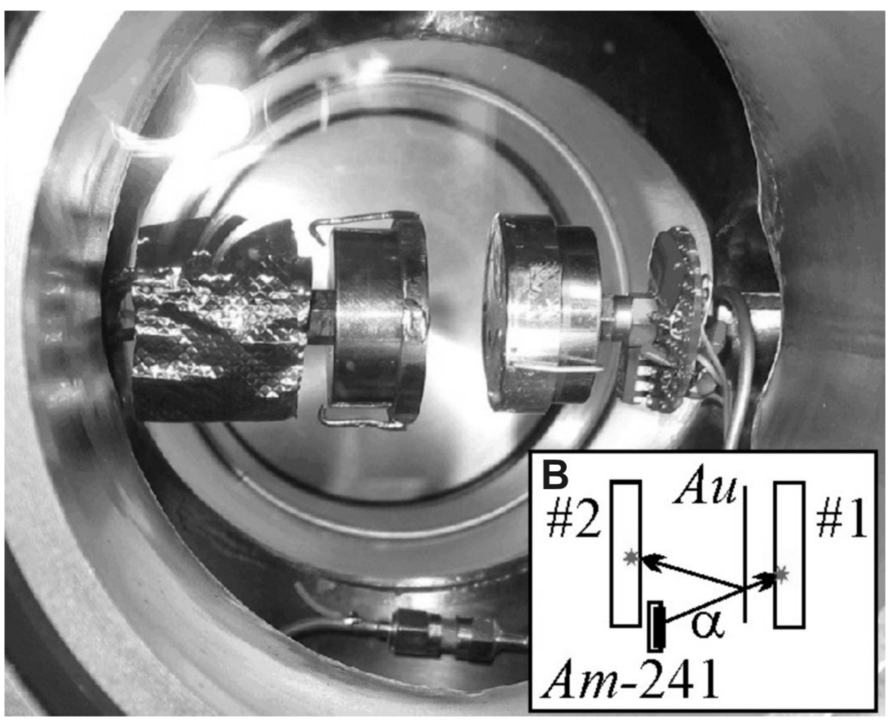


Figure 7. Alpha Ray Experiment

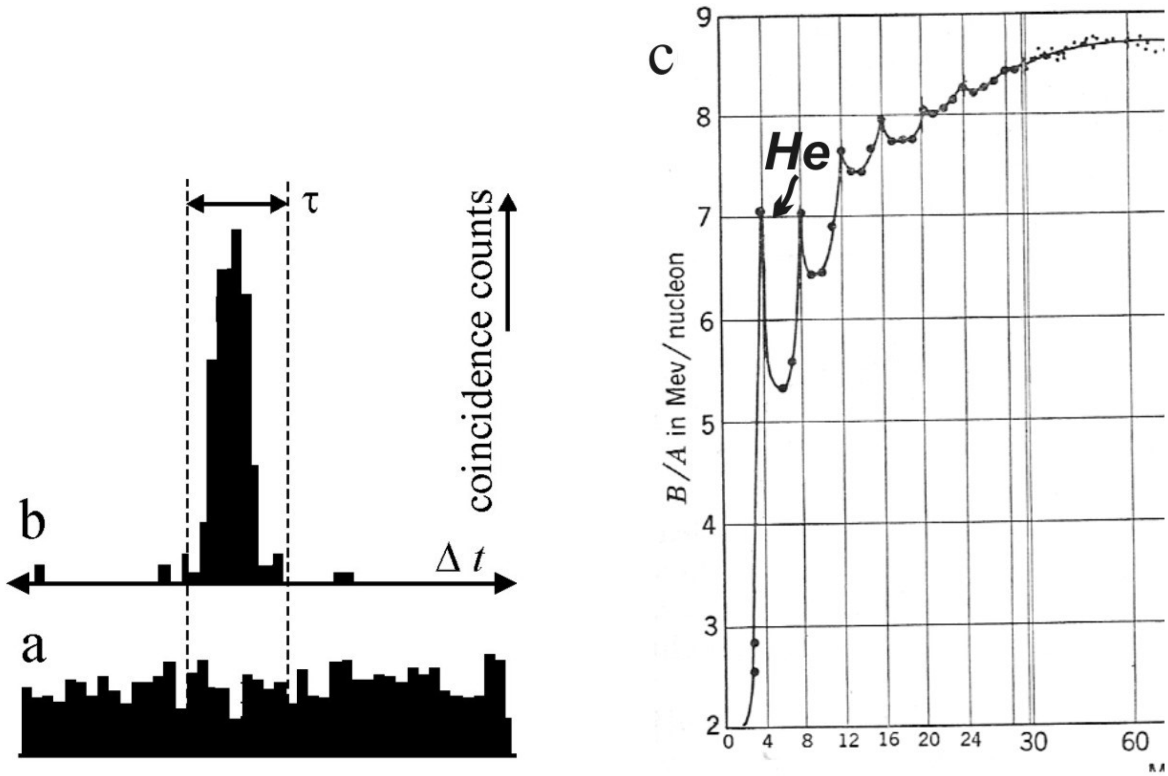


Figure 8. a: true-coincidence "sandwich test" histogram. b: alpha-ray coincidence histogram. c: binding-energy per nucleon [25].

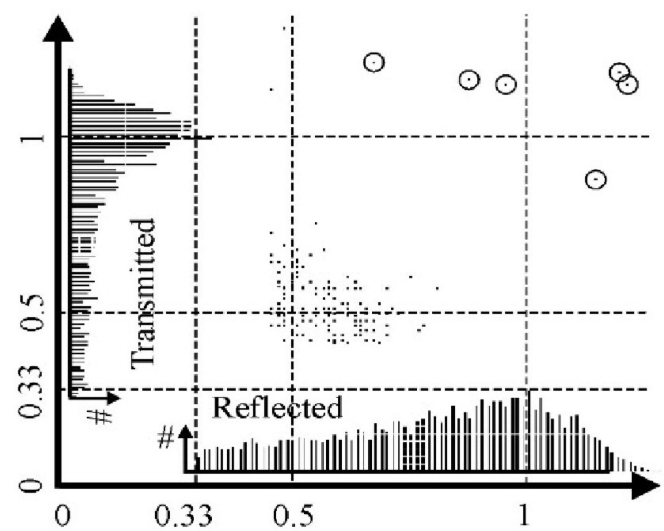


Figure 9. The computer controlled experiment of figure 8 with pulse-height pairs on each detector plotted X-Y.

your first order fringes were a few times brighter than they should be for the given wavelength/slit-width and wavelength/slit-spacing ratios. The tool I used is http://wyant.optics.arizona.edu/multipleSlits/multipleSlits.htm. Though this tool has fewer slits than yours, I found this did not change the intensity ratios.

3. Given the dimensions of your instrument, the velocity resolution should cover 0.43 of the sensor plane by the following calculation: The slit height is 100 micrometers, and the projection to the sensor plane should make this $2/(2-0.56)$ larger, that is 138 micrometers at the sensor plane. But the sensor plane is 320 micrometers high. Since $138/320 = 0.43$, a particle of any given velocity could land anywhere in a vertical segment of height that is 0.43 of the screen height. So the first order fringes should have been very noticeably widened as the fringes descend, by this apparently poor velocity resolution.
4. In the published movies of the detector plane, the intensity profiles of the fringes have edges that seem to rise and fall too abruptly. Also, the intensity profile of each fringe, especially the central fringe, in the movie looks flat. Fringes should have peak-like profiles.
   Unless I have made several silly errors, there is something going on other than quantum interference. Please consider a control test to eliminate the possibility that you are looking at a shadow pattern that has been magnified by a charge deflection effect at the slits. It would be very easy for the slits to become charged to deflect dye particles in a manner similar to a cylindrical lens. A simple test would be to introduce a voltage control wire to the slits. An even simpler test would be to shade half of the slit array to see if a half side of the fringe pattern disappears. Whether or not a focus effect was like a positive or negative lens, half of the fringe pattern would disappear. A focused shadow would explain the anomalies I point out. Thank you for your consideration and I hope to hear from you. Eric S Reiter, Unquantum Laboratory

Dear Mr. Reiter, concerning your considerations:

1. The equations are of course right, but our source emits molecules in all directions. Thus a flight parabola is defined by three source, the grating (which is only written onto a $100\mu m$ high window) and the height on the detection plane. Thus it is wrong to simply enter the distance source-detection plane into the calculations, since in the plane of the grating all molecules pass at the same height.
2. Your observation is right. The high intensity of the higher interference orders is due to the van der Waals interaction between the molecules and the grating wall. This is mentioned several times in our paper.
3. Please don't forget, that also the grating is only $100\mu m$ high and that, especially for the slow molecule, the projection is a non valid approximation.
4. I don't agree. Regarding the high transversal coherence in our experiment the shape of the fringes is in agreement with the theoretical predictions.

Best regards, Thomas Juffmann

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