PHOTONICS 2016

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What are the *physical processes* behind a 50% beam combiner behaving as a 0 or 100% reflector/transmitter inside an interferometer?

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*My book: **"Causal Physics: Photon Model by Non-Interaction of Waves"**;*
CRC, 2014. India Edition Rs.1100 .

My paper download site: http://www.natureoflight.org/CP/

My book from Mr. Abhishek Bhardwaj – abhishek.bhardwaj@tandfindia.com

Summary

- **1. The key purpose: Re-energize enquiring minds of the young scientists. This talk leverages classical and quantum optics as the subjects of discussions; specifically the role of the beam combiner in a Mach-Zehnder interferometer (MZ).**
- ***2. What are the physical processes*** **behind a 50% beam combiner in an MZ becoming a 0% or a 100% reflector/transmitter? This happens when the MZ is illuminated by a collimated beam and adjusted for the collinearity of the Poynting vectors for both pairs of the output beams.**
- **3. This raises further question. How can a "single indivisible photon" "interfere with itself", when, operationally and mathematically, we need two signals in the MZ to be simultaneously present on the beam combiner from the opposite sides?**
- **4. We will use experimental demonstrations.**
- **5. Our mathematical model is semi-classical [1-6]. During the moment of transition, the exact "quantum cupful" of energy, $h\nu_{mn}$, is exchanged. But EM wave packets propagate diffractively.**
- ***6. A quantum transition is always a two-step process – a linear dipolar stimulation, followed by a quadratic energy transition.***
- ***7. It is important to visualize the actual physical energy exchange process during an interaction that gives rise to the measurable data*****; which has been discouraged by the Copenhagen School.**

References

[1] E.T. Jaynes and F. W. Cummings, “Comparison of Quantum and Semi-Classical Theories of Radiation with Application to the Beam Masers.”, Proc. IEEE Vol. 51, 89(1963).

[2] **W. E. Lamb, Jr**., *Interpretation of Quantum Mechanics*, (Rinton Press, Inc., 2001).

[3] G. Grynberg, A. Aspect and C. Fabre *Introduction to Quantum Optics: From the Semi-Classical Approach to Quantized Light.* (Cambridge U. Press, 2010). Free download: file:///F:/3_Ref._E-Books_160315/Quantum%20Optics/2012_Semiclas.QM-Grynberg.pdf

[4] Cray, M.; Shih, M.-L. & Milonni, P. W, “Stimulated emission, absorption, and interference”, Am. J. Phys., Vol. **50** (11), pp.1016-2021 (1982).

[5] C. Roychoudhuri, *Causal Physics: Photon Model by Non-Interaction of Waves* (Taylor & Francis, 2014).

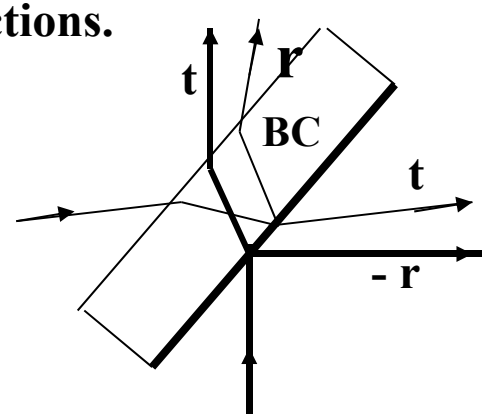
[6] ibid; Ch.5.3, Fabry-Perot response function.

Classical SE

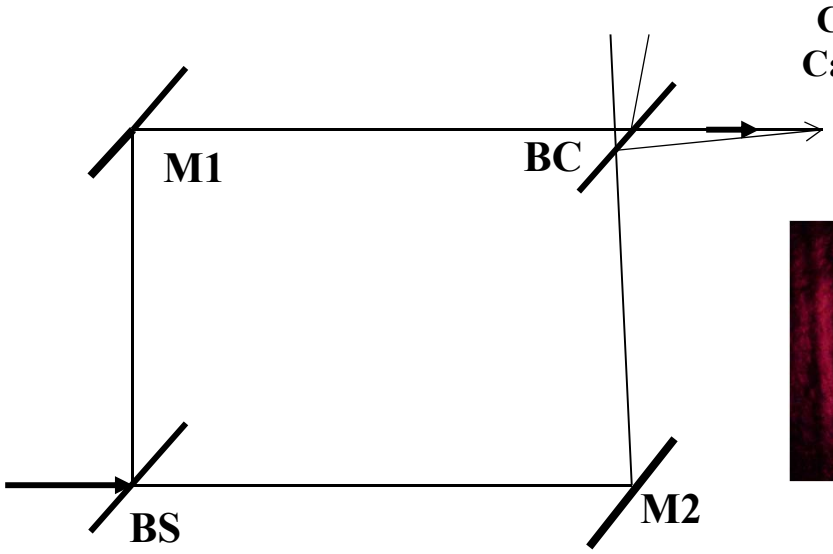
Superposition Effects (SE) of collinearly superposed optical beams with *phase-steady single frequency*

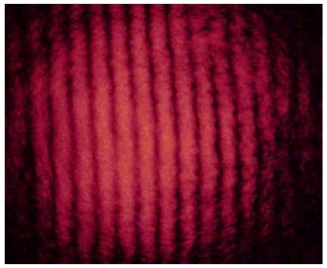
Traditionally we use interferometer in the *"fringe mode"*

If the Poynting vectors are non-collinear, the BC remains constant at 50% for both the directions.



Non-collinear
Poynting vectors





The spatial fringes can be generated only by a detector array when inserted inside the out put beams in either direction.

But deeper enquiry becomes very interesting when the interferometer is in the *"scanning mode"!*

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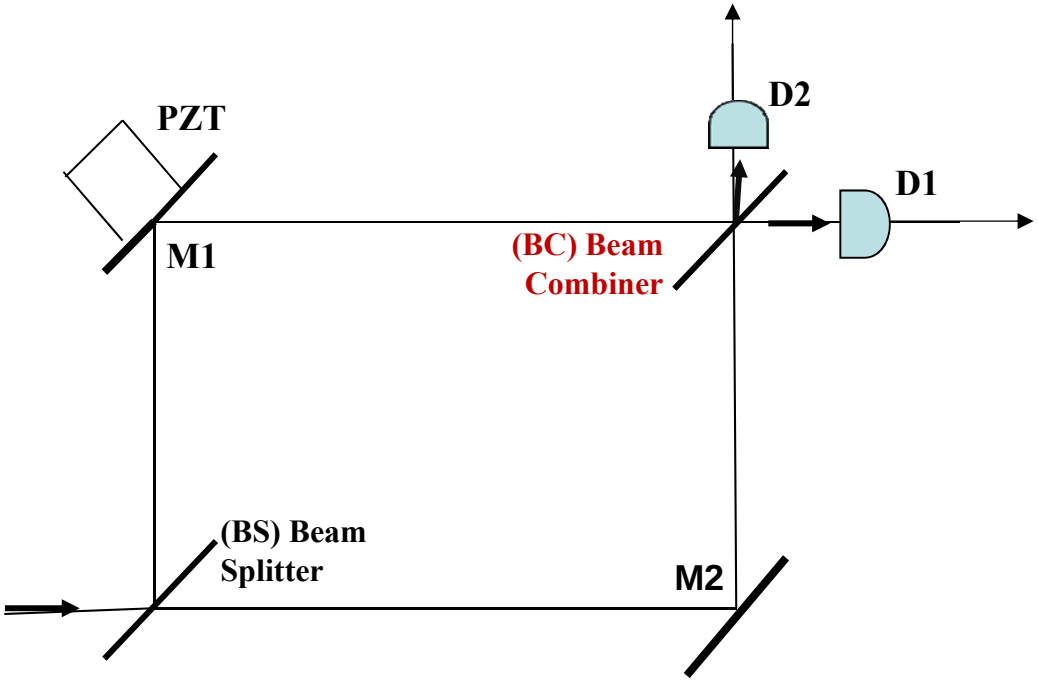
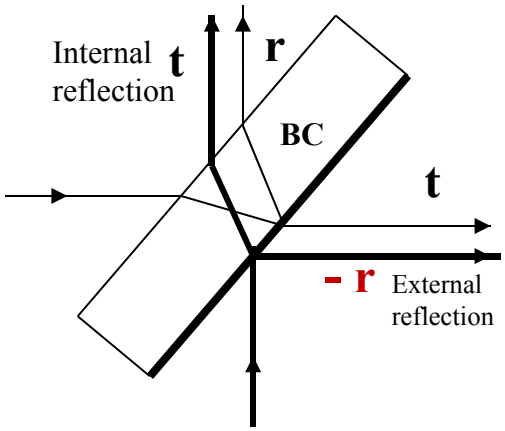
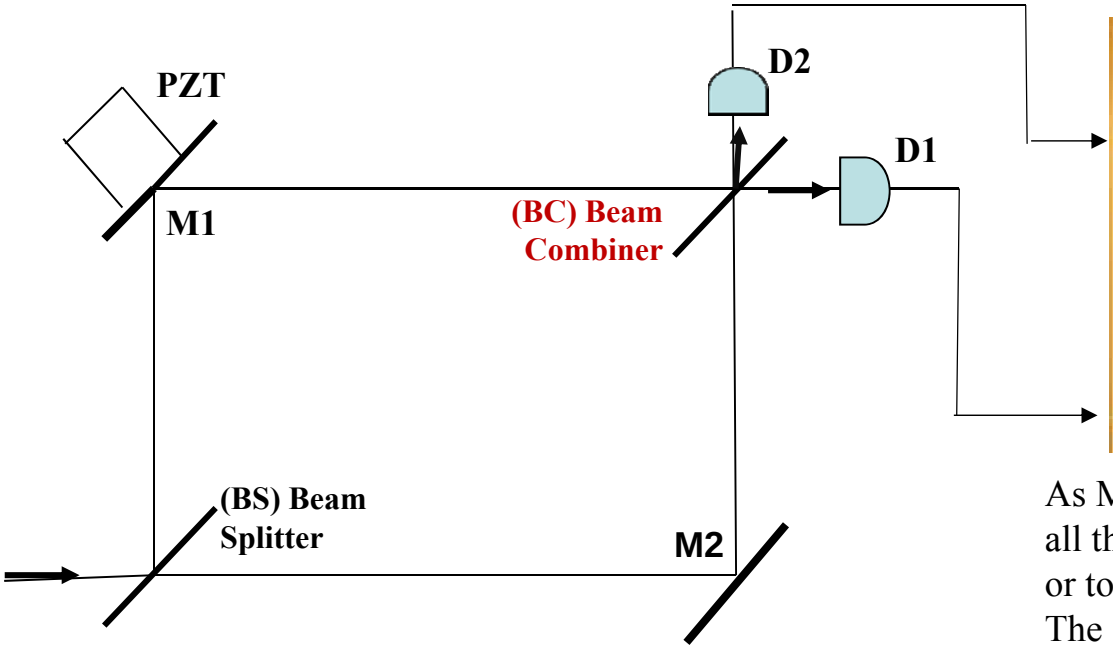
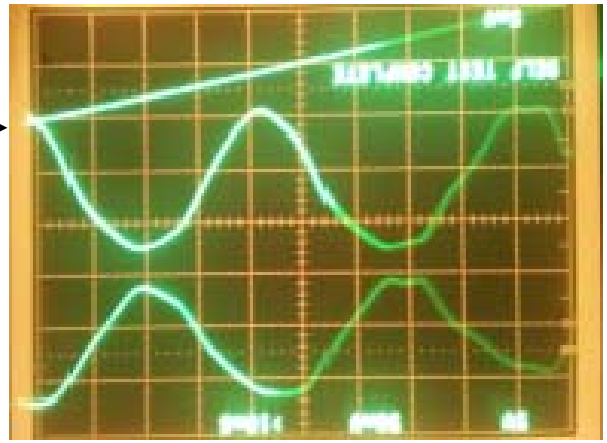




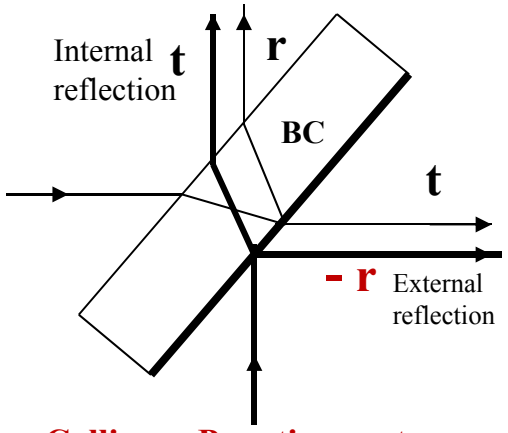
Collinear Poynting vectors on BC. Scanning fringe mode.

What are the physical processes behind a 50% beam combiner becoming a100% transmitter, or a reflector?





As M1 is scanned (straight inclined line on top) all the energy of both the beams could go to D1 or to D2, depending upon the phase conditions. The 50% BC effectively oscillates between being a 100% reflector or a 100% transmitter.



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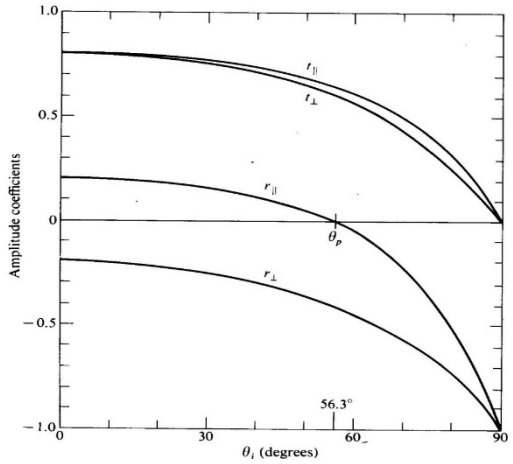


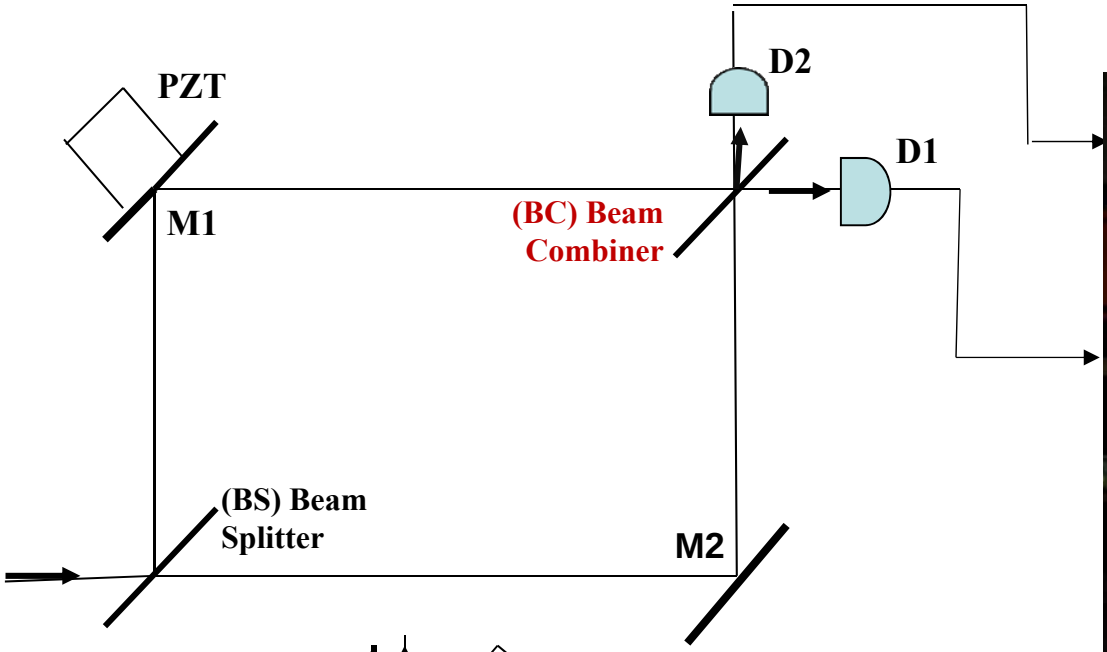
Note "pi" phase shift between external and internal reflection.

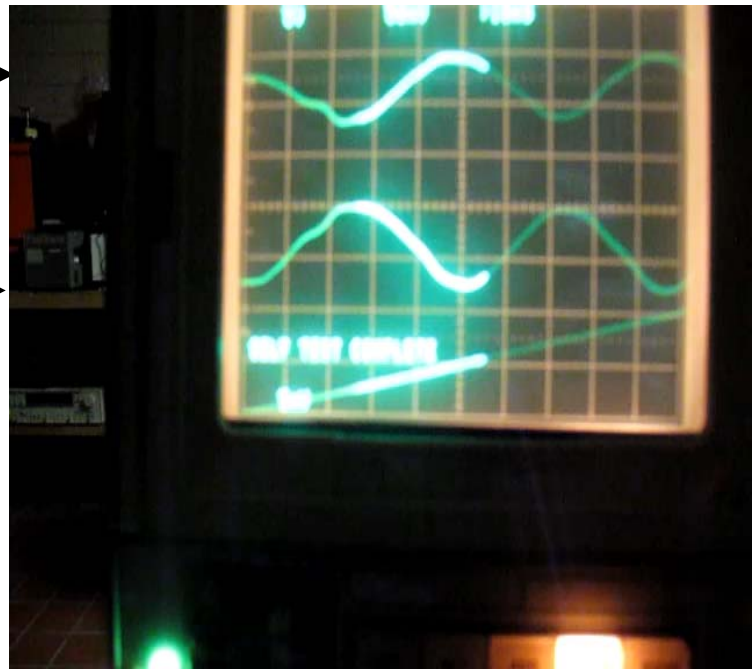
From Hecht

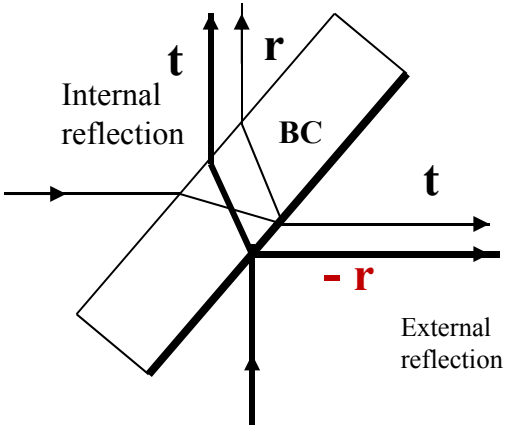
Video: Oscilloscope voltage display

How does a 50% beam combiner becomes 100% transmitter, or a reflector?

The interferometer is in the "scanning mode"!







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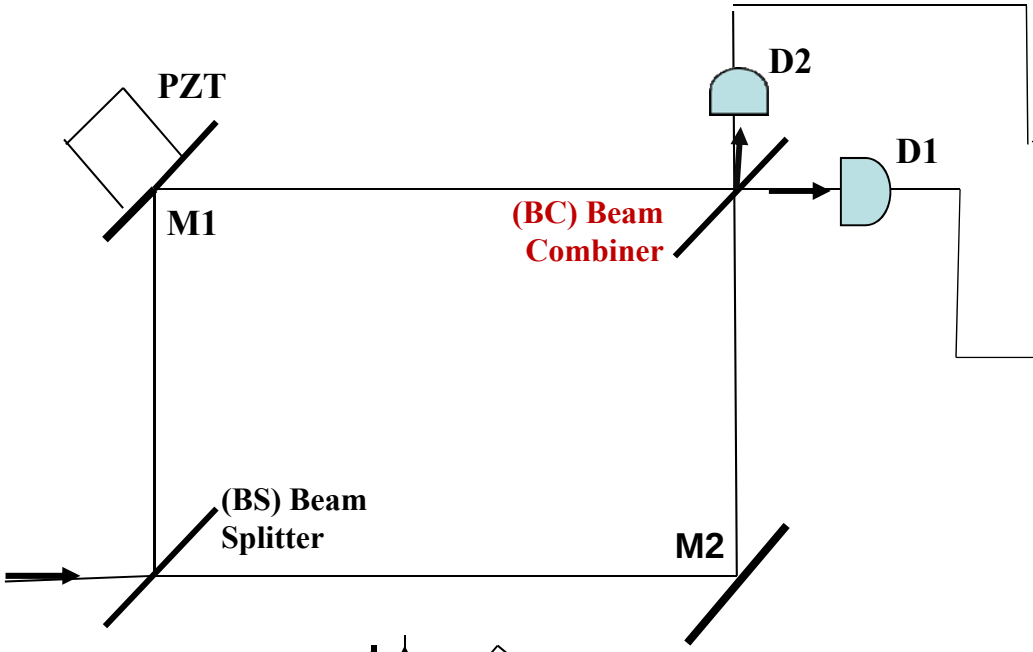
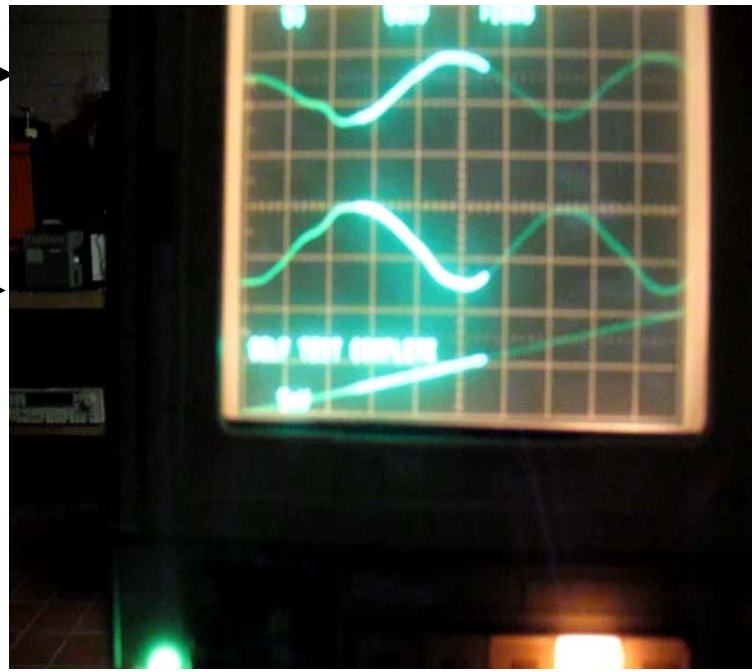
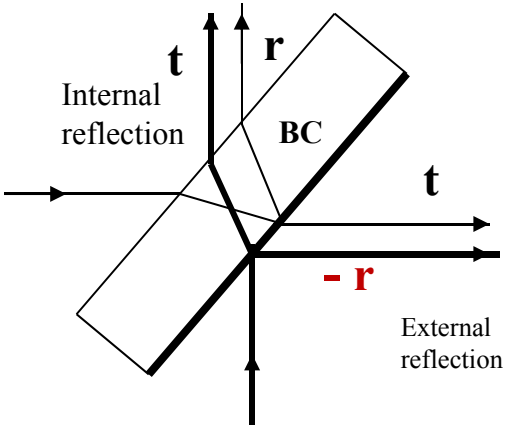




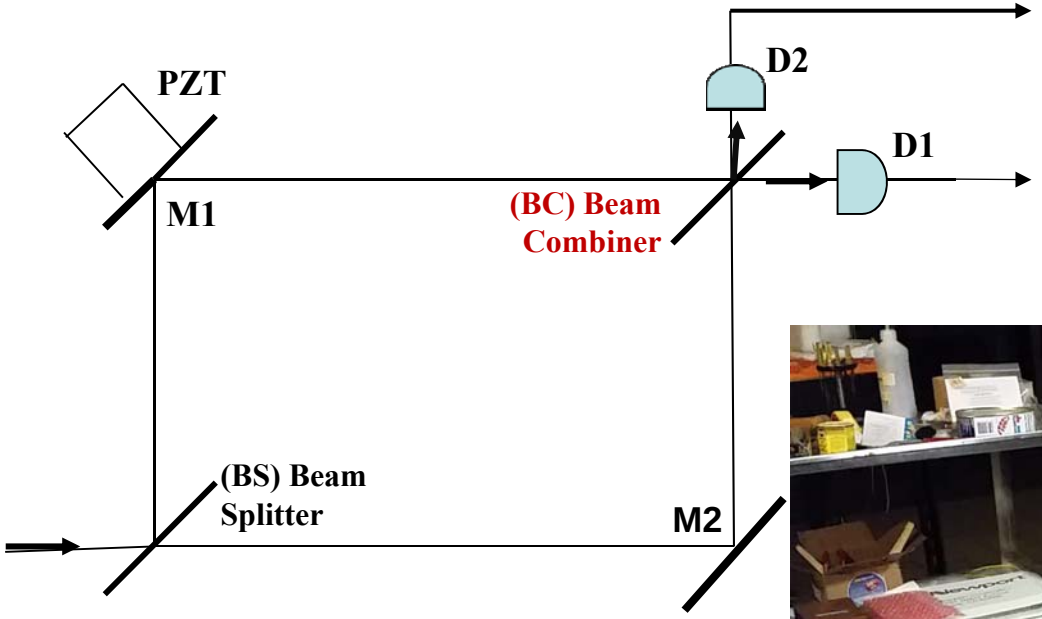


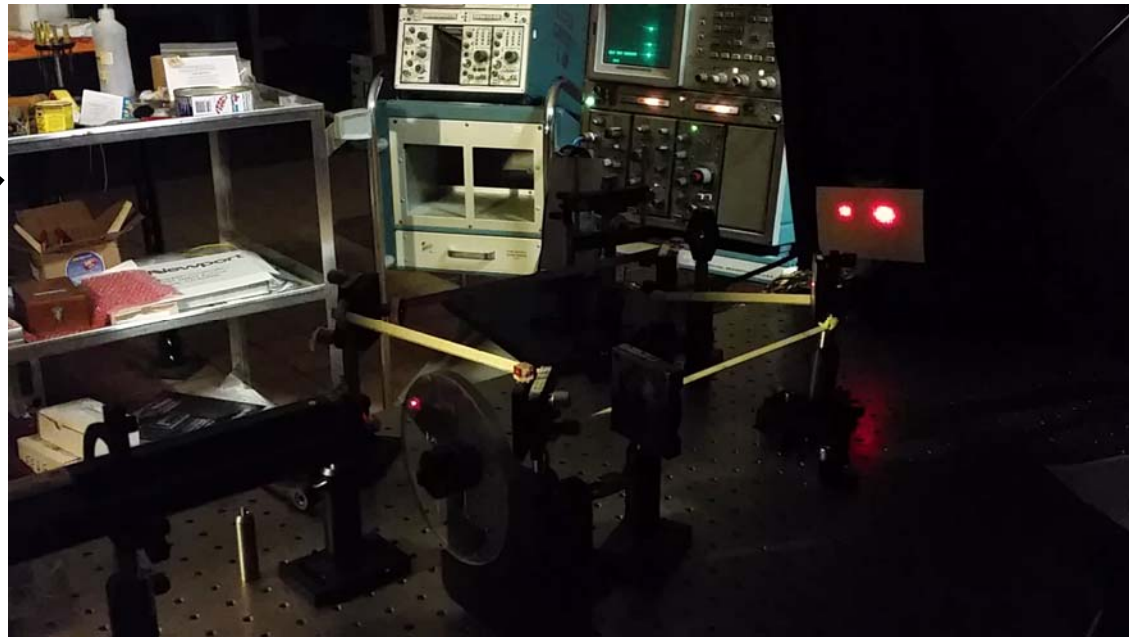
Collinear Poynting vectors on BC. Scanning fringe mode.

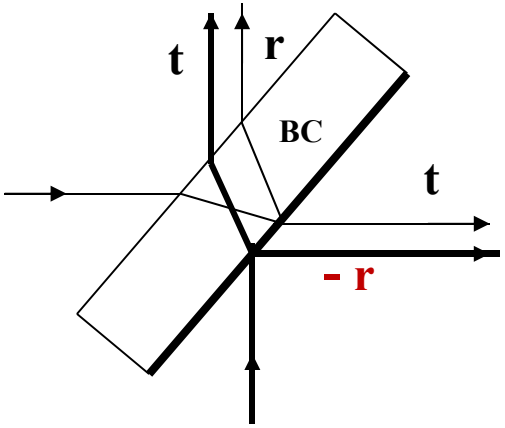
The dipolar behavior of classical molecular clusters, under the influence of oscillating electric vectors from the opposite sides of a boundary layer, DETERMINES which way the wave energy can propagate and in in what quantity!

Video: Direct oscillating intensity display
How does a 50% beam combiner becomes 100% transmitter, or a reflector?

The interferometer is in the "scanning mode"!







Collinear Poynting vectors on BC. Scanning fringe mode.

Learning to distinguish between SP & SE

Standard mathematical Superposition Principle (SP) does not represent any physical interaction process.

Generalized SP: $$E_{total} = \sum_n E_n(\nu) \equiv \sum_n a_n(t)\exp(i2\pi\nu_n t)$$

Huygens-Fresnel $$U(P_0) = \frac{-i}{\lambda}\iint_\Sigma U(P_1)\frac{\exp(ikr_{01})}{r_{01}}\cos\theta\ ds$$

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Re-write SP as a physical process; which would lead to measurable Superposition Effect (SE).

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SP is not a measurable (observable) phenomenon for EM waves!

It would be prudent not to draw too much physical conclusions out of it!

Learning to distinguish between SP & SE

Observable Superposition Effect is a Quadratic Energy Exchange Process.

Mathematical rule can fool us!

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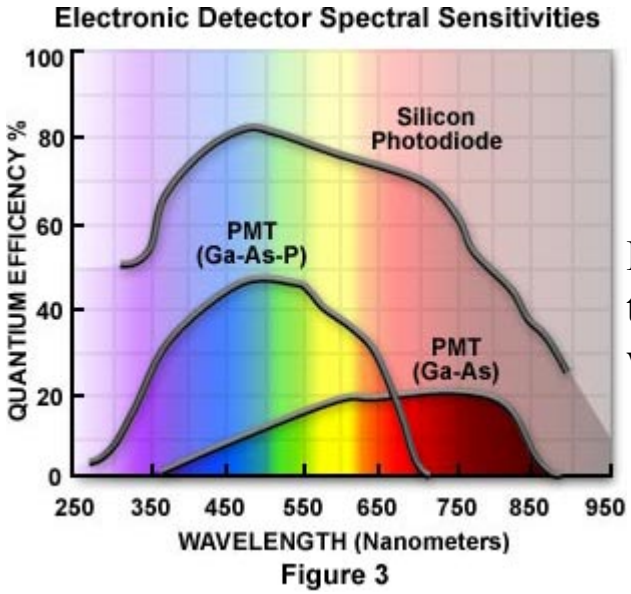

Figure 3

From the web

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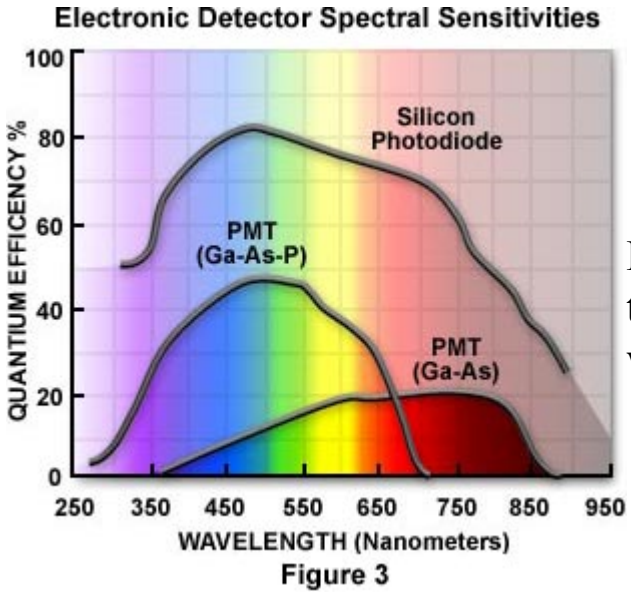

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Only for an extremely narrow band of frequency, can one assume the constancy of the linear dipolar stimulation factor, and re-write:

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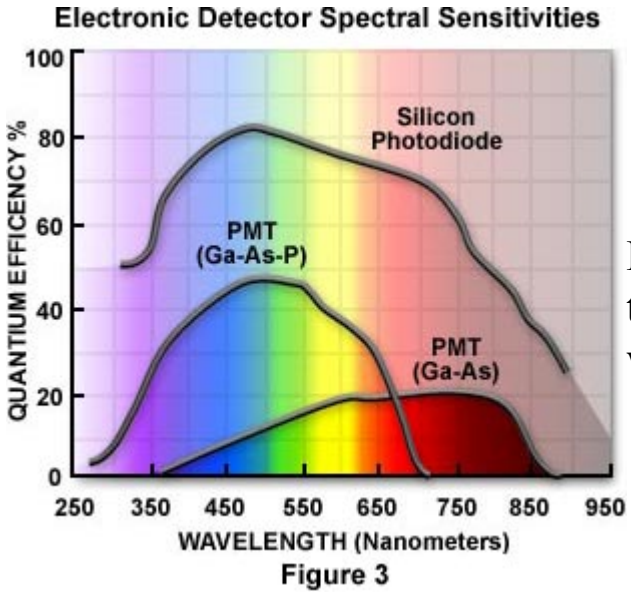

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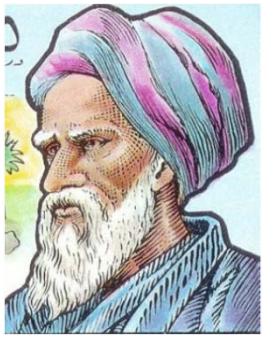
Does this imply ***waves can sum themselves***, or operate on each other and re-organize their spatial and temporal energies? Can human mathematical rule dictate nature how she ought to behave?, ***Or, her causal rules dictate how humans should learn to re-organize their logical thinking and mathematics?***

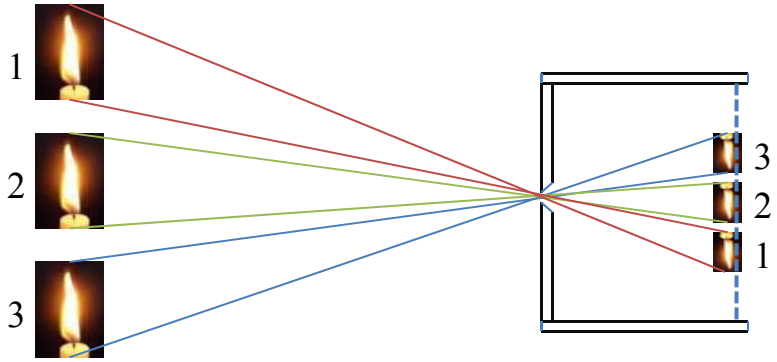
Non-Interaction of Waves (NIW)

NIW is a generalized property of all propagating wave phenomenon



~965-1040

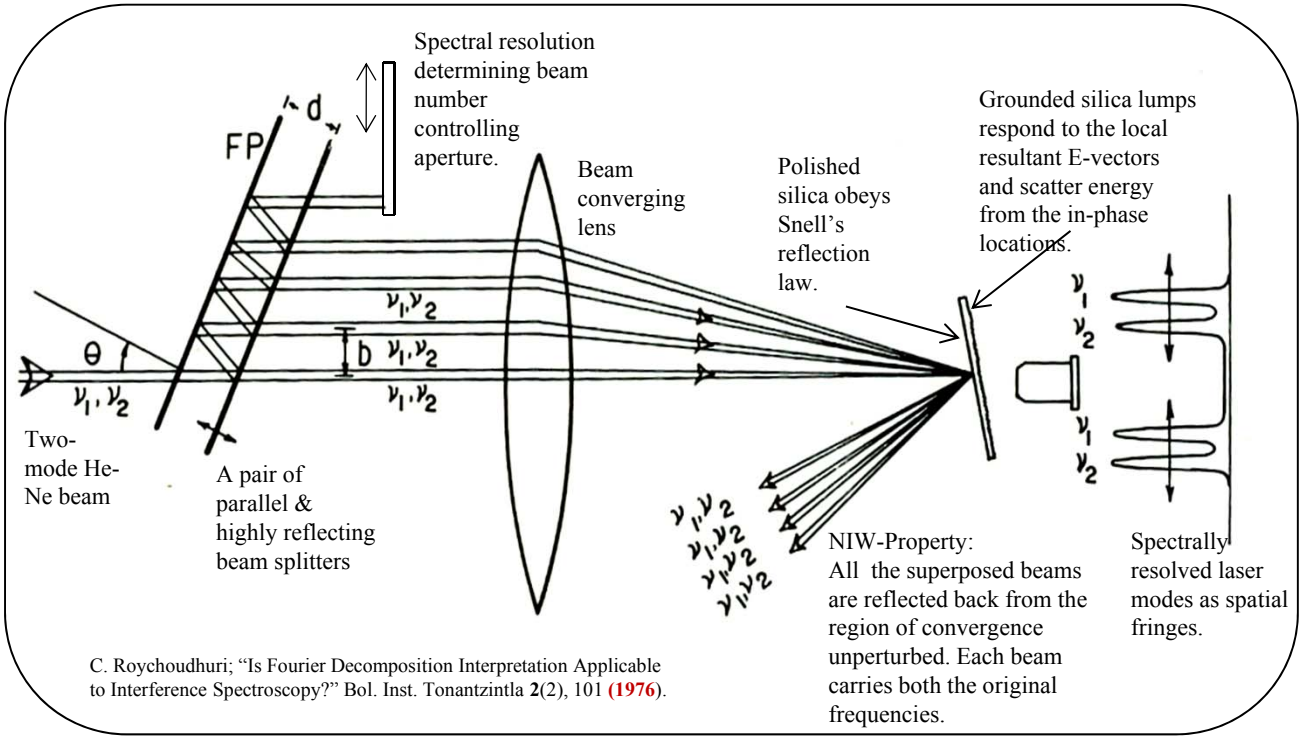
Alhazen's experiment



Light does not interact with light!

Unperturbed, inverted images are formed, even though different candle light are crossing through each other at the pinhole.

My first experiment to realize Non-Interaction of Waves (NIW-Property)

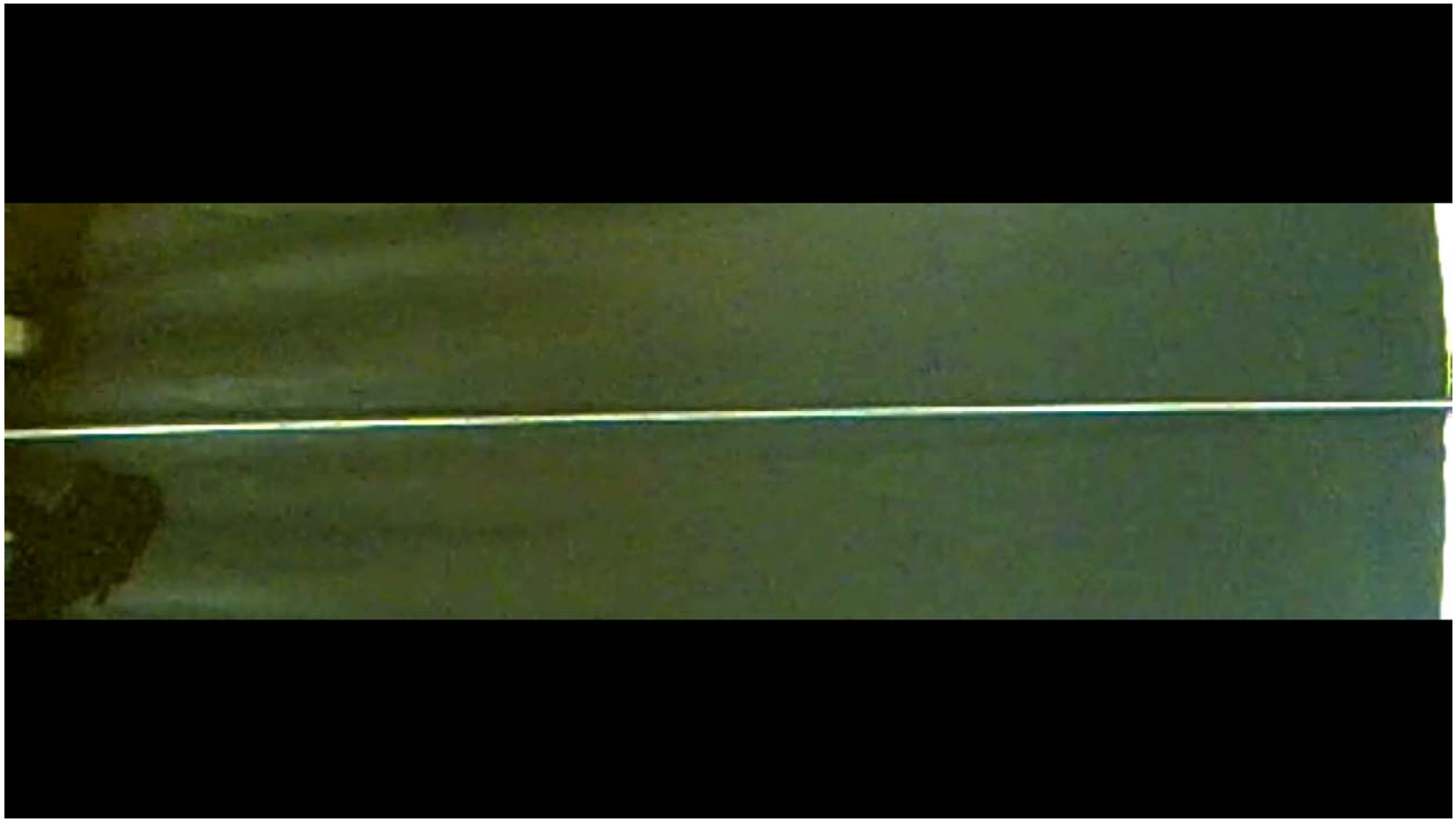


C. Roychoudhuri; "Is Fourier Decomposition Interpretation Applicable to Interference Spectroscopy?" Bol. Inst. Tonantzintla **2**(2), 101 **(1976)**.

Waves (excitation) of water surface-tension field pass through each other without interacting.-(1)

Appreciation: (i) Michael Ambroselli, my PhD student, for video recording and processing.

Waves (excitation) of spring-tension field pass through each other without interacting

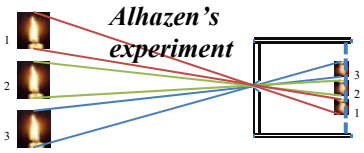


Appreciation: (i) David Park, a high school student for diverting me to use spring instead of rope. (ii) Michael Ambroselli for video recording and processing.

We have been neglecting daily observations, early experiments, early postulates & current diffraction theory; all supporting Non-Interaction of Waves (NIW).

But modern interpretations of optical phenomena ignore NIW in favor of mystical & pedantic duality!
Evidence based science, properly theorized, is the best knowledge for now. But it must be challenged continuously for its evolution!!


~965-1040



Light does not interact with light!


1629-1695

Huygens: A wave is a perpetually propagating set of secondary wavelets, **that evolve through each other without interacting with each other.**


1642-1727

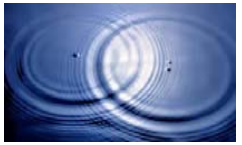
Newton: Light is "corpuscular" in its nature of emission, albeit displaying interference effects later. :


1773-1829

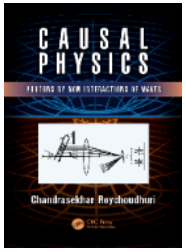
Young: Originator of the famous double-slit superposition effect & re-establish the wave nature of light


1788–1827

Fresnel: Mathematically framed Huygens' principle. The integral automatically incorporates Huygens' non-interaction of wavelets.

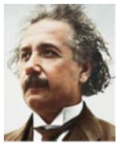


Observable since ancient times! Water wave circles evolves through each other unperturbed.




1858-1947

Planck: The father of light emission as a quantum (Planck's Law), also underscored the NIW-property of light.


1879-1955

Einstein: 1905-Photons are "Indivisible quanta". But said in1955 –"What are light quanta?"


1894-1974

Bose: In his QM-derivation of Planck's Law, the photon number stays same in each "box", implying photons do not interact with each other.


1892-1987

De Broglie: Interaction of particles are guided by their associated "Pilot Waves"! Established "duality" as a new knowledge!!


1902-1984

Dirac: Mathematically quantized waves as photons, as Fourier modes of the "vacuum". Forced to conclude "different photons do not interfere"!

To appreciate the deeper implications of the NIW-property in current and long-term applied and basic physics, see the book, "Causal Physics: Photon Model by Non-Interaction of Waves", CRC. 2014.

Quantum SE

A photo detector picks up the necessary *"quantum cupful"* of energy from all the stimulating light waves proportional to the square of the individual amplitudes.

If resonant, all the field amplitudes contribute to the "Quantum Cupful" of energy transfer!

Recall the SE equation for a very narrow band of frequencies:

$$D_{Det.} \equiv \left|\Psi_{total}\right|^2 = \chi^2 \left|\sum_n E_n(\nu)\right|^2 = \chi^2 \left|\sum_n a_n(t)\exp(i2\pi\nu_n t)\right|^2$$

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Consider now the simple case of two beam superposition:

$$D = \Psi^*\Psi = \chi^2 \left|\sum_n E_n(\nu)\right|^2 = \chi^2 (a_1^2 + a_2^2)\left[1 + \frac{2a_1 a_2}{(a_1^2 + a_2^2)}\cos 2\pi\nu\tau\right]$$

If we validate our data with our "working" mathematical theory; how can we claim that the detector absorbed the necessary hν ("quantum cupful") of energy only from one of the beams as an indivisible "light quanta"?

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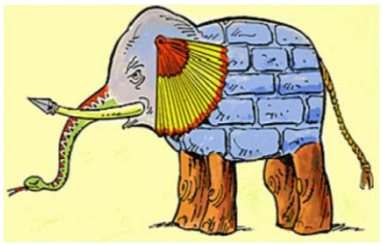
$$= 2\chi^2 a^2\left[1 + \cos 2\pi\nu\tau\right] \text{ if } a_1 = a_2 = a$$

It is good to know the ancient thinking of great philosophers

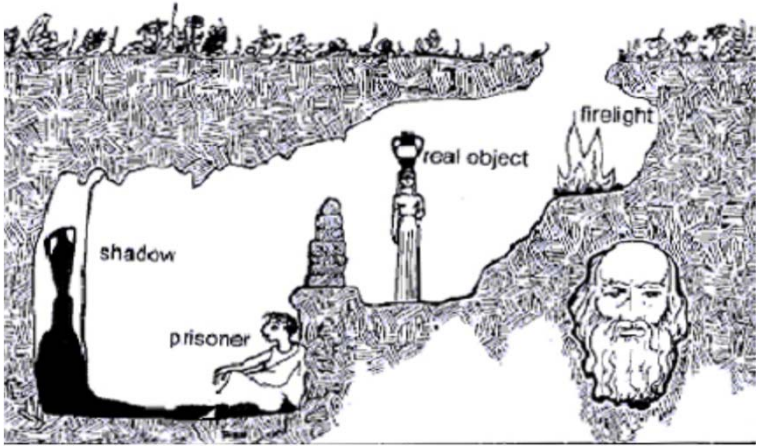
Some 6-thousand years old Indian allegorical story: We are all "blind". The model of the Cosmic Elephant derived out of our individual sensorial input is quite limited. But ***collaborative synthesis brings out somewhat better reality***.

Detailed reality invisible to blinds.

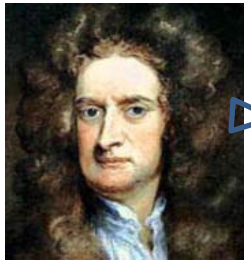


Model from synthesis of multitudes of observed data.

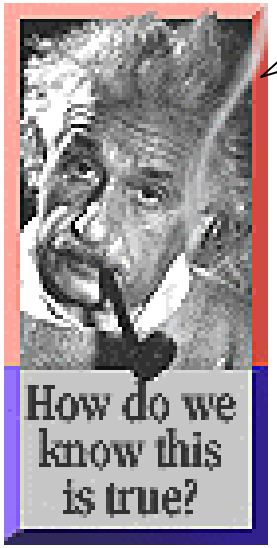
Plato's (~428-348 BC) allegorical story of interpreting reality behind the shadows cast by external light by cave-dwelling people. ***Experimental evidence does not contain all the truth!***



It is also good to know the modern thinking of great physicists



"If I have seen further than other men, it is by standing on the shoulders of giants."



".....After 50 years' of brooding over the question of what are light quanta; I still do not understand it!"

Why did we miss the Non-Interaction of Waves; and postulated non-informative "wave-particle duality"?

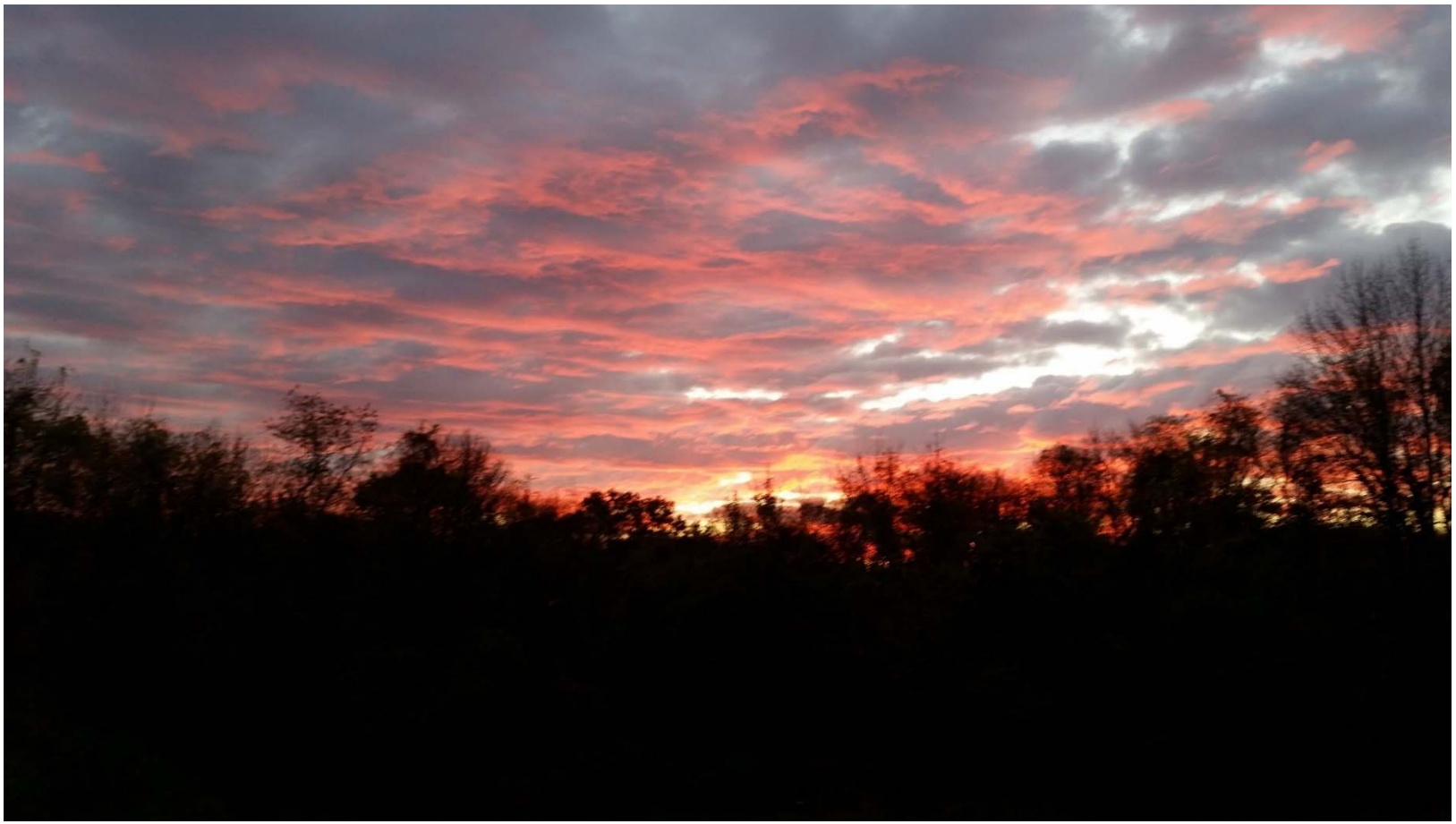
Permanent Information Challenge!

Evidence based science is *THE* best science; but it is always incomplete.

Our data gathering Measurement Process can never gather complete information about any of the interactants in our experiments.

Are these red wave packets or red "indivisible light quanta"?
We must overcome our "Messiah Complex"!
Our enquiry must continue.

My paper download site: http://www.natureoflight.org/CP/



6AM, November 5, 2016. My Backyard Deck

Quantum SE

How Einstein missed the opportunity to formulate Quantum Mechanics in 1905!

He only had to assign the "observed quantumness" in the photoelectric data to the (a) *quantum mechanically bound electrons*; which execute dipole-like oscillation when stimulated by the E-vector (b) *resonant to the frequency v*!

Then, the history of physics would have been radically different!

A proper theory for the Photo-Electric Effect

All electrons in any medium are bound to positive charged ions; and hence susceptible to dipolar stimulation by E-vectors of EM waves:

$$\psi = \chi(\nu_q)E(\nu_q)$$

Un reality, there are always innumerable wave packets:

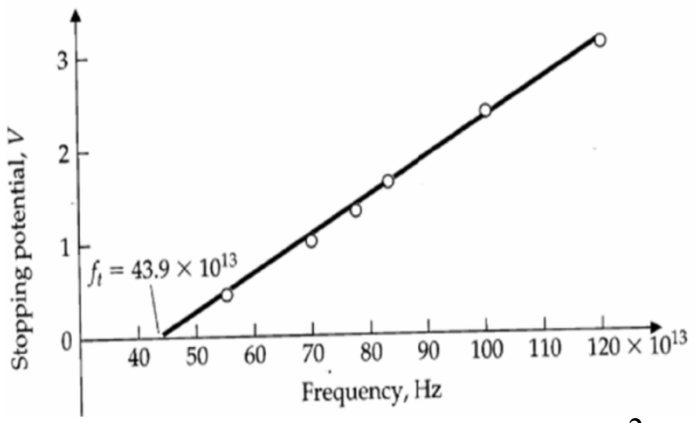
$$\psi_{res.} = \sum_q \chi(\nu_q)E(\nu_q)$$

The energy exchange with the field is given by:

$$\left\langle \left|\psi_{res.}\right|^2 \right\rangle = \left\langle \left|\sum_q \chi(\nu_q)E(\nu_q)\right|^2 \right\rangle \equiv \left\langle h\nu_q \right\rangle$$

Einstein's relation now can be accommodated as:

$$\left\langle h\nu_q \right\rangle = \left\langle \left|\sum_q \chi(\nu_q)E(\nu_q)\right|^2 \right\rangle = \left\langle \phi_{work\ fn.} + (1/2)m\mathrm{v}_{el.}^2 \right\rangle$$



$$h\nu = \phi_{work\ fn.} + (1/2)m\mathrm{v}_{el.}^2$$

Einstein's Measurable data Modeling Epistemology

For a very narrow band of optical frequency, the polarizability factor can be treated as a constant:

$$\left\langle h\nu_q \right\rangle = \left\langle \left|\sum_q \chi(\nu_q)E(\nu_q)\right|^2 \right\rangle = \chi^2 \left\langle \left|\sum_q E(\nu_q)\right|^2 \right\rangle$$

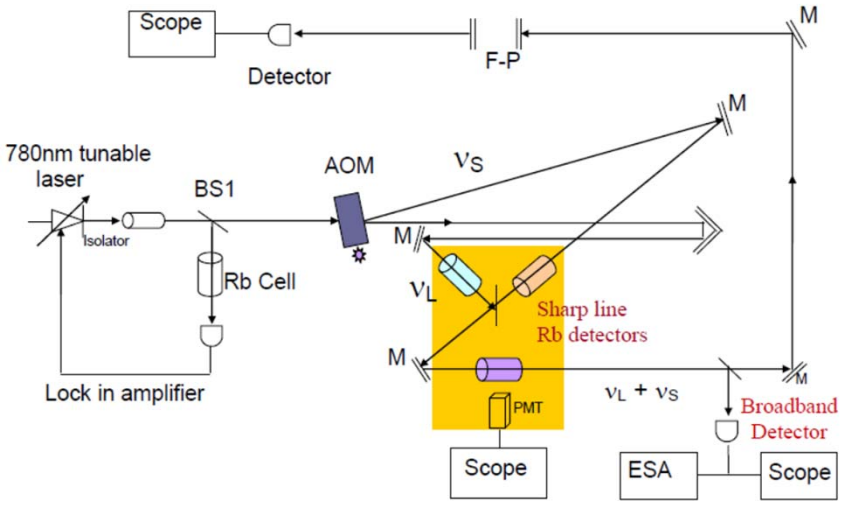
This mathematical rule is counter to modeling physical processes in nature. If we ignore modeling physical processes; we end up ASSUMING wave amplitudes can sum themselves and can also execute the square modulus process. This is a grand mistake of current physics!!

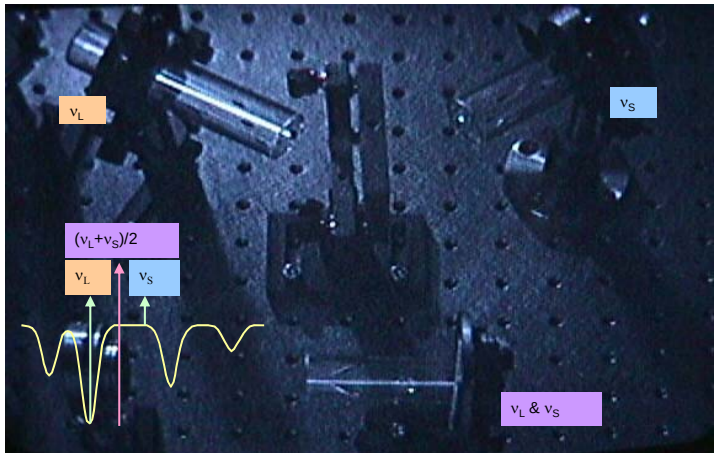
See my book, "Causal Physics".

Quantum SE

Superposition Effects of collinearly superposed optical beams with phase-steady two *frequencies*

Two collinearly superposed, phase-steady optical beams do not sum themselves as two mathematical Fourier sinusoids are supposed to do.





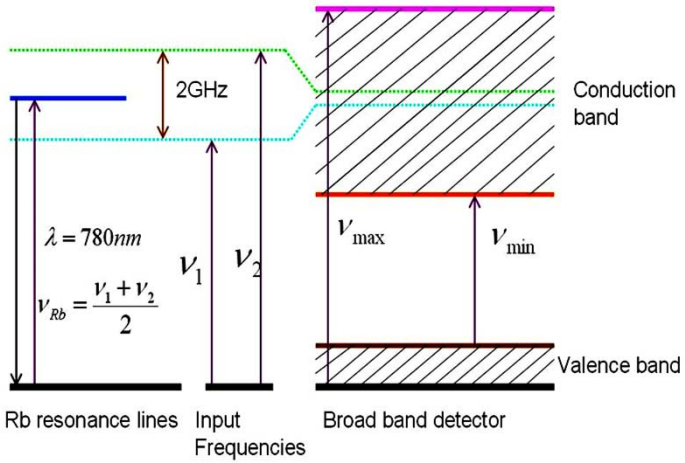
In reality, the **narrow-band atomic dipoles** recognize only the original carrier frequencies.

D. Lee and C. Roychoudhuri, Optics Express **11**(8), 944-51, (2003), "Measuring properties of superposed light beams carrying different frequencies".

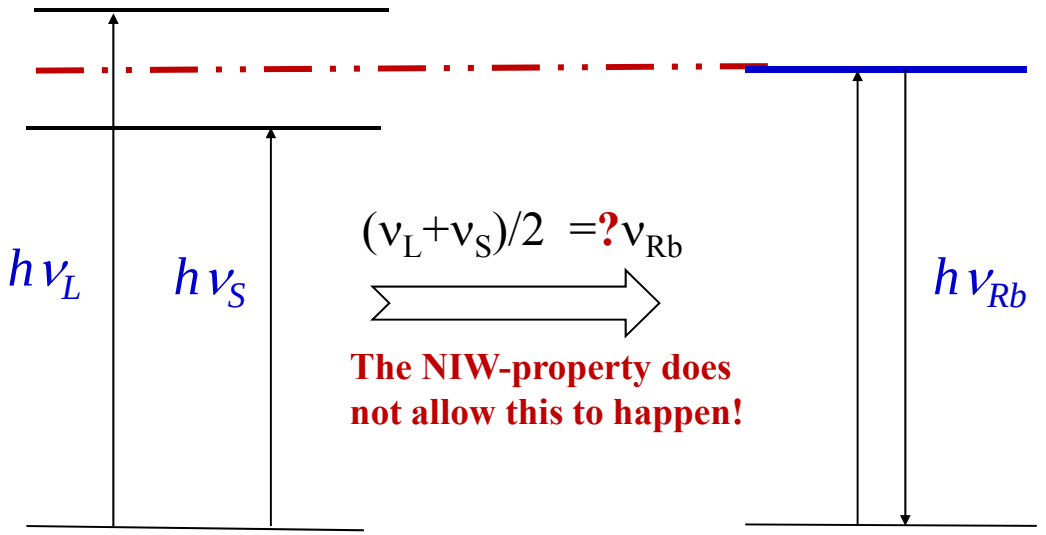
Fourier synthesis does not take place for light-atom interactions

$$a_{total}(t) = a\cos 2\pi\nu_1 t + a\cos 2\pi\nu_2 t$$

$$= 2a\cos 2\pi\frac{\nu_1-\nu_2}{2}t.\cos 2\pi\frac{\nu_1+\nu_2}{2}t$$



Why could not we excite the Rb atoms to resonance fluorescence?



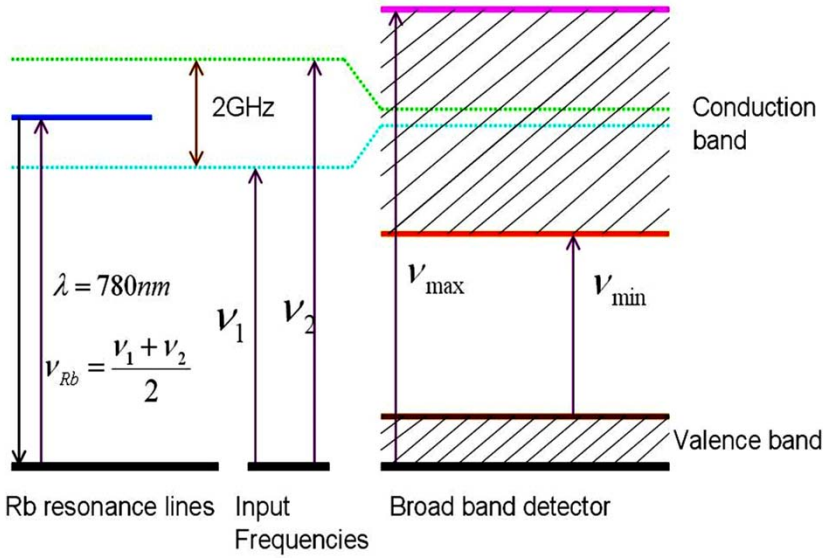
Effective energy levels of two phase-steady optical beams.

Resonance levels of two-level Rb atom

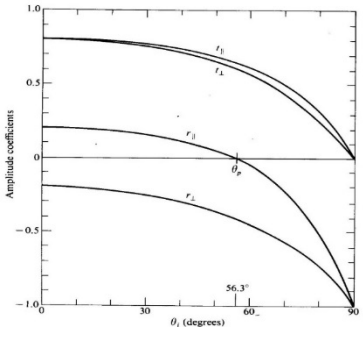
Fourier synthesis does not take place in free space. Light-light-atom energy transfer is quadratic.

$$I(t) = \left| {}^{(1)}\chi a e^{-i2\pi\nu_1 t} + {}^{(1)}\chi a e^{-i2\pi\nu_2 t} \right|^2$$
$$= 2\,{}^{(1)}\chi^2 a^2 [1 + \cos 2\pi(\nu_1 - \nu_2)t]$$
$$= 2\,{}^{(1)}\chi^2 a^2 [\text{slow detector circuit}]$$

The photo electric process being quadratic, the broad-band dipole complexes make electron transfer only at the beat (difference) signal.



The phenomenon of the capability of re-directing energy of both the beams into one or the other direction is built into classical electromagnetism. "Single photon interference" effectively denies this easily observable property!!



Summation of the amplitudes

$$d_{right}(\tau) = a_1 r e^{i2\pi\nu(t+\tau)} + a_2 t e^{i2\pi\nu t}$$

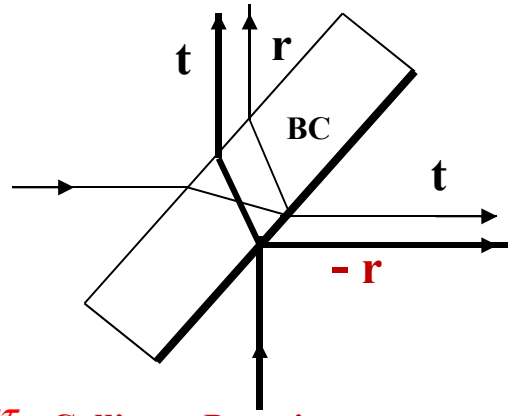
$$d_{up}(\tau) = a_1 t e^{i2\pi\nu(t+\tau)} + a_2 r e^{i2\pi\nu t}$$

Apparent energy

$$D_{\text{right}}(\tau) = \left|d_{\text{right}}\right|^2 = a_1^2 r^2 + a_2^2 t^2 + 2a_1 a_2 tr\cos 2\pi\nu\tau$$

$$D_{\text{up}}(\tau) = \left|d_{up}\right|^2 = a_1^2 t^2 + a_2^2 r^2 + 2a_1 a_2 tr\cos 2\pi\nu\tau$$

$$D_{total}(\tau) = D_{\text{right}}(\tau) + D_{\text{up}}(\tau) = a_1^2 + a_2^2 + 4a_1 a_2 rt\cos 2\pi\nu\tau$$



Collinear Poynting vectors on BC. Scanning fringe mode.

Real energy

$$D_{total}^{real}(\tau) = D_{\text{right}}(\tau) + D_{\text{up}}(\tau) = a_1^2 + a_2^2 = 2a^2 \quad (\text{for } a_1 = a_2 = a)$$

$$d_{right}(\tau) = a_1 (re^{i\pi}) e^{i2\pi\nu(t+\tau)} + a_2 t e^{i2\pi\nu t}$$

$$D_{\text{right}}(\tau) = \left|d_{\text{right}}\right|^2 = a_1^2 r^2 + a_2^2 t^2 - 2a_1 a_2 tr\cos 2\pi\nu\tau$$

A 50% beam combiner re-directs all energy of both the beams in the "up" direction, zero in the right. The physical properties of the boundary layer is critically important!

$$D_{\text{right}}(\tau = 0) = \left(a_1 r - a_2 t\right)^2 = 0, \text{ when } a_1 / a_2 = t / r.$$

$$D_{up}(\tau = 0) = 2a^2; \text{ when } R{=}T{=}0.5 \text{ and } a_1 = a_2 = a.$$

Permanent Information Challenge! –(1)

1. ***Measurables Are Physical Transformations:*** We can measure only physical transformations that take place in our instruments. The velocity recession of the most distant galaxy is calculated by using Hubble's hypothesis using the measured red shift of the characteristic atomic spectral lines that appear as detector currents in a spectrometer attached to a telescope focused on the galaxy of interest. But, in this model, the measured red shift is hypothesized as Doppler shift. (See Chapter 11 for alternate explanation.)
2. ***Proceeded by Energy Exchange:*** There are no transformations without energy exchange. (Energy from the light collected from the galaxy and dispersed by the spectrometer is absorbed by photo detector array, which produces the signal as photocurrent.)
3. ***Guided by Forces of Interaction:*** Energy exchange, and consequent transformations, must be guided by an allowed force of interaction. (Light beam induces dipolar undulation on the quantum mechanically bound discrete photoelectrons via electromagnetic force. So the discreteness in the emergence of photoelectrons does not validate that photons are indivisible particles.)
4. Must Experience Physical Superposition: Interactants must be within each other's sphere of influence to be able to interact under the guidance of an allowed force to exchange energy and undergo transformations. Thus, all interactions producing transformations must be local in the sense that the interactants must be within each other's sphere of influence. (Only during the moment of direct physical illumination by a light beam, or a pulse, can one observe the emission of a photoelectron. Superposition effects cannot be nonlocal.)

Permanent Information Challenge! –(2)

5. Through Some Physical Stimulation Process: Although invisible, all transformations are preceded by some real physical stimulation process before the interaction can be consumed through energy exchange. Our conscious and systematic attempts to understand and visualize these invisible stimulation processes provide us with a logical tool that can directly connect us with the ontological reality, albeit through many iterative steps. We have been significantly underutilizing this IPM-E tool. For photo detection, it is the dipolar stimulation, induced in the photo detector by the oscillating E-vectors of the incident light, which corresponds to a peak at the ontological reality.

6. Always Requires a Finite Duration: Transformations in the interactants from one specific state into another specific state requires "quantum compatibility sensing dancing period" between interactants before they can acknowledge the force of interaction as a legitimate stimulation and then exchange energy and then undergo the measurable transformation (transition). (Photoelectron release requires stimulation for at least one cycle to establish the resonance between dipolar undulation frequency of the bound electron and the stimulating frequency of the incident light beam.)

7. Impossibility of Interaction-Free Transformation: The above set of self-consistent logical arguments clearly implies that we cannot observe any measurable transformation unless the entities under study interact with each other under the guidance of some allowed force operating between them. (The detecting dipoles cannot release photoelectrons unless the incident light directly impinges on the detector.)

Permanent Information Challenge! –(3)

8. Perpetual Information Retrieval Problem: Our theory-constructing enterprise suffers from perpetual information retrieval problem for the following reasons: First, we have not succeeded in constructing any instrument that has 100% fidelity in transferring all the quantitative data (information) it generates as secondary transformations induced by the primary transformations experienced by our chosen interactants. For example, the high-frequency information regarding a photocurrent gets cut off by the slow time constant of the associated LCR circuit. Second, we have never succeeded in setting up an experiment where the interactants can experience all the allowed forces that could introduce various measurable transformations in the same experiment helping us to construct a unified theory with all the forces in nature. So, we are unable to gather all the four force-related properties of any entity in any single experiment.

9. Information out of Transformations: Useful information is always limited by our subjective human interpretation of some observable transformation. The interpretation may be reproducible, but it does not exist independent of a physical transformation triggered in an experiment. In other words, information is what we make out of our observations, and hence, it is very subjective as it depends on who interprets it. The objective part lies with the interaction process that exist hidden within the interactants and is determined by the allowed force of interaction between them. Thus, the root behind our Measurement Problem is the loss of some real information and

What are the implications of the NIW-property in Physics?

The wide ranging implications allow wide ranging thesis problems. (1)

1. Replace Einstein's "indivisible quanta" by Planck's divisible classical wave packet, while accepting the reality that binding energies of all photo electrons are quantized in all materials: Our instruments can register only "clicks" because released photo electrons are discrete.

2. Replace Dirac's statement, "A photon interferes only with itself", by "A detector's simultaneous stimulations due to multiple excitations engender superposition effect". Frequency resonant detectors are at the root of engendering superposition effects, whether classical or quantum.

3. Replace Dirac's photon as an "Infinite Fourier mode of the vacuum" by "Classical time-finite wave-packet mode of the vacuum enforced on the CTF, excited by electrical dipoles like radio antenna, atoms and molecules.

4. Replace Born's interpretation of as an abstract "mathematical probability amplitude" by "real physical undulatory stimulation of internal structure of particles". This also eliminates the need for de Broglie's "Pilot Waves".

5. Replace de Broglie's "pilot wave" by "internal harmonic frequency proportional to its kinetic energy". A principle of nature should not diverge under realistic conditions. De Broglie relation diverges as the speed of a particle tends to zero: $\lambda = h / p \rightarrow \infty$ as $v \rightarrow 0$.

6. Drop "Bell's In-equality theorem" as the guide to accept completeness of QM formalism. It does not mathematically model the physical process of SE in interferometry and hence it promotes the acceptance of non-causal concept of non-locality in superposition effects without having any foundation in modeling nature.

7. Replace Heisenberg's "Uncertainty Principle" by "information retrieval problem". It is not a principle of nature. It is the human limitation of extracting all possible information about any natural entity we try to study.

The wide ranging implications allow wide ranging thesis problems. (2)

8. Replace Einstein's "Relativistic Doppler Effect" by "Classical Doppler Effect". Doppler shift suffered by a wave packet as it emerges out of a moving source is real and persists as it propagates through CTF. Different moving sensors will perceive this same wave packet as having different carrier frequencies. Consistent success of the QM rules behind spontaneous and stimulated emissions require this proposed modification.

9. Replace Hubble's cosmological redshift as due to "Relativistic Doppler Shift" by a better physical phenomenon to accommodate the measured distance dependent cosmological redshift. It could be that the CTF is mildly dissipative. The postulate, "Expanding Universe" may have to be revised.

10. Replace "wave-particle duality" by separate physical realities for waves and for particles. We should not convert our lack of knowledge, clearly implied by the word *duality*, into a definitive new knowledge as if that is the rule of nature.

11. Replace "4-D Space" by "3-D Space". We have not yet found any physical entity that has continuously running time as one of its measurable physical parameters and influences the temporal evolution of everything else. Primary parameters of a theory should be directly measurable physical parameter of some physical entity. We always measure frequency of some physical object and invert it to obtain a reference *time-interval*. Such frequencies are physically alterable, but not the running time.

Thank you for your attention !