TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics and Mechanics
Vol. 55, Issue II, 2012

EXPLANATION, IN EVTD^2 THEORY, OF ENIGMATIC RESULTS ON A SINGLE PARTICLE IN MACH-ZEHNDER INTERFERENCE

Michel CONTE, Ileana ROSCA

Abstract:
This paper continues the other [1] whose principal consequences are adapted for understanding the results of the experiments on two particles in balanced and unbalanced Mach-Zehnder interferometers. The "walkers" (liquid drops) from the very interesting experimentation [2] also constitute one of the bases of these reflections as well as the EVTD^2 entities theory. They rebound on a substrate, of same liquid subjected to intense vibration. The pilot or vide waves of De Broglie – Bohm associated to substratum-substratum (quantic ether) of EVTD^2 entities theory allow to set out coherent explanations of the observed results. The output after the S_2 separator is programmed (without a real choice). It depends on the energetic state proposed to particale to one or the other of sensors, for any travelled path.

1. INTRODUCTION

This paper is a logic continuation of the previous study [1] published in the same number of the Journal. It precedes, also in the same number of the Journal, two possibilities to explain other problems enigmatic as well. They are represented by the experiments of Rauch with a neutron [3] and the non-location of entangled particles in Franson interferometer. [4] Thus, the took into account environment for this thinking experiments is the space-time defined in EVTD^2 theory, [5-10] entirely quantic in time and space. It is composed of cubic volumes juxtaposed, of Planck dimension and these entities are subject to very high frequency vibration (Planck frequency: 10^{43} Hz), which means a very energetic solicitation. The study [1] on strange interference fringes of Young resulting from photon or other particles (liquid drops [2]) directed one by one to the device allowed to lead to some conclusions. Here, will be studied the enigmatic problems of indistinguishable chosen path to an output of a mono particle in balanced and unbalanced Mach-Zehnder interferometers. Currently, there are no plausible explanations that are somehow accepted by physicists. It was proved, in classic physics, that the liquid drops constituting the [2] experiments "walkers" on a liquid substrate subject to strong vibration solicitation accurately depict the interference figures of the single particles behavior through slits of Young. It seems, therefore, from these experiments, those "walkers" rebounds on the liquid substrate cause waves, which can be assimilated to pilot waves. These would direct the "walkers" trajectory over the substrate and through the Young slits to the screen. The quantic space-time defined in EVTD^2 theory is, in a certain manner, comparable with the vibrating substrate of experiments [2]. Shock-impulses on EVTD^2, produced by moving particles in this space-time, thus create wave systems. Normally, these ones must do a guidance of the particles through "areas or channels" of high vibrating energetic. Accordingly the sustainability of these energetic vibrating fields in substratum, this can define a "path memory".

2. REMINDERS ON THE PRINCIPLE OF BRAGG MIRORS AND OF BEAM SEPARATORS

The mirrors and beam separators can be represented, for a used wavelength, by the schema in the figure 1, which illustrate the basic principles of Bragg mirrors and variable rates separators deriving from them. In order to make it more simply, we can take into account only two layers of different optic index n_1 and n_2. The maximum reflectivity is obtained for the wavelength called *of Bragg* that allows calculating different thickness of the n_i optic index material. Then, the phase difference of used wave at the output of its route, through the two layers, will be constant, in value π, because for each crossing of a layer the phase difference is $\pi/2$. The two principal properties of Bragg mirror are:

- for a wave spreading in from a material with high optic index to the one with less index, the reflection on the interface gives no phase difference;
- for a wave spreading in from a material with low optic index to the one with high index, the reflection on the interface gives a phase difference equal to π.

The figure 1 represents different circumstances according to the possible ways on one side and on the other of this layers combination n_1 and n_2 with $n_1 > n_2$. First of all, the transmission n_1 – air to n_2 – air shows the right output wave phase difference will be π. If the wave do not go out but it reflects on the interfaces n_2/air or n_1/n_2 one can see that the output wave (reflected on the left side) will be in the same state of phase as the incident one: 0 or 2π.

On the other side, the study of transmissions and reflections, in the case of right incidence on layers combination, shows that for transmission air-n_2-n_1-air the phase difference equal to π (identical to opposite case). But, for all reflections on the interfaces n_2/n_1 and n_1/air, the reflected waves out coming from the right side have an identical phase difference equal to π.

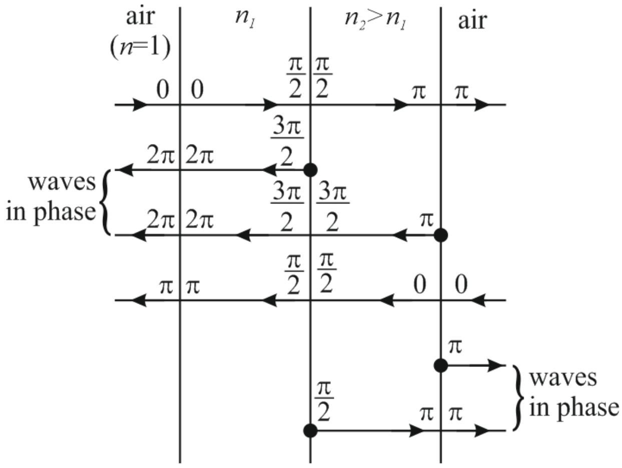

Fig. 1. Phase differences evolution for different transmission and reflections in Bragg mirrors or separators.

Thus, *transmission, in any sense of crossing, will always a phase difference equal to p relative to the incident wave,* while, *the reflected waves on the two sides of layers combination, will get out either in phase, either in opposite phase*. These characteristics, following the four possibilities to use such separators, will be applied in balanced and slightly unbalanced Mach-Zehnder.

3. BALANCED MACH-ZEHNDER IN A QUANTIC SPACE-TIME IN EVTD[2]

Balanced Mach-Zehnder interferometer, represented in figure 2 is composed by arm or equivalent paths. The layer figured in black in separators S_1 and S_2 represents the placement of the material having the greater optic index (n_2) from the figure 1. In fact, this interferometer is a relatively simple case, in comparison with other cases, because it is crossed, by one on the other of possible path, by a single photon. However, thus obtained results are surprising because all detected particle arrive at the output RT-TR and never at TT-RR. Till now, no representative explanation has been proposed. Despite our attempts in [10] we have, however, put the bases of reasoning, but we lacked the information on the detailed characteristics of beam separators. Thus, following our previous approach [1], we propose that associated waves (pilot or vide waves) to a moving particle or photon would result from shock-impulses on EVTD[2] of quantic space-time, during their displacements. We can even add that, in case of immobile corpuscle, the associated waves do not exist. More, *the associated wave is electromagnetic:* there is no doubt for the electromagnetic photon because *it stokes again, on its trajectories, electromagnetic entities of quantic substratum (quantic ether).* For mass corpuscle, the shock-impulses give associated wave that are, neither more nor less, *undulating deformations of vibrating electromagnetic field (positive and negative phase) that spread in the same medium, the substratum.* Thus, in interferometers the photonic associated waves spread in the same manner.

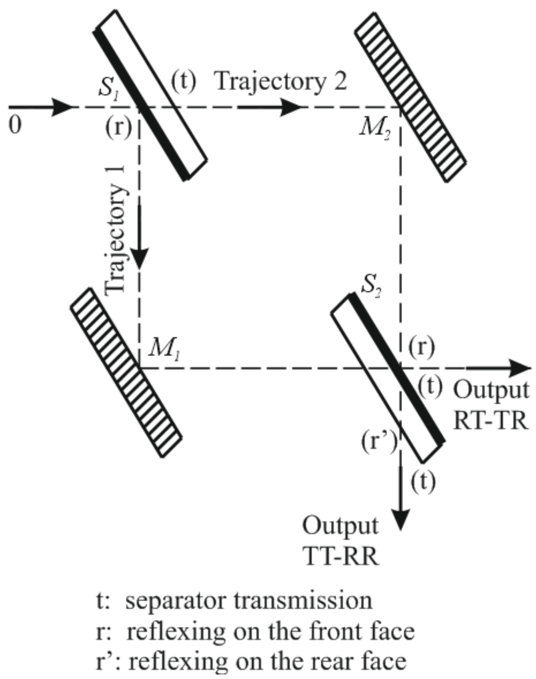

Fig. 2. Balanced Mach-Zehnder interferometer with its paths and the two possible outputs.

We shall limit the study to a photon sent to piecemeal and will shall maximum simplify the conditions of its associated wave in function of its displacements beginning from the source *O*. in the case took as example, for reasoning, we shall assume that this photon associated wave, which is also electromagnetic, will be *incident on S_1 in zero reference phase.* Same, simply to outlined, we suppose that the same length of four paths 1 and 2 portions corresponds to an entire number of this associate wavelength. Thus, at the ends of each portion, for example, for output S_1 and input M_1, we shall find the same state of phase for the concerned wave. It remains to follow different phase shifts at the levels of optical elements of the 1 and 2 paths, to the arrivals on S_2. As we already show on transmissions and reflections on different inputs of Bragg separators, we shall have for the path 1 a phase difference equal to π, as a consequence of the reflection on S_1. In agreement with the previous assumption on the arms and sections geometry, the phase of incident wave on mirror M_1 will be in the same phase state π. As a result of the new reflection on M_1, the incident phase will differ from π; it becomes that, equal to $(\pi+\pi)=2\pi$ or, more, *0* which means in phase with the incident reference phase on S_1. *The wave that arrives as incident on S_2 will be, also in assumption, in phase 0*. Concerning the path 2 of emergent wave in transmission through S_1, it will differ of π and this state of phase will be incident on the mirror M_2. After reflection on M_2 the state of phase differs again of π. Thus, at the output from M_2 to S_2 the state of phase have differed of $(\pi+\pi)=2\pi$ or, more, *0,* which will be, again, incident on S_2. In summary, *the two vibrating states of twin associated waves of paths 1 and 2 are incident on S_2, each on its side, in the same state of phase.* Now, we must infer the levels of their reciprocal interference on every output. The wave coming from the trajectory 1 to the output TT-RR must be reflected on S_2, but often, according to Bragg mirror characteristics, it follows that incident wave will not be in difference of phase in this case of reflection and, thus, it will emerge under 0 state of phase. Also coming to TT-RR, the wave coming on the trajectory 2 must be transmitted through S_2 and, it follows that the incident wave will be in difference of phase of π and, thus, the 0 incident phase will have, at emergence, equal to $(0+\pi)=\pi$. Therefore the overlay of two emergent wave of trajectories 1 and 2 that are *opposite in phase, cause a strong diminution of vibrating and energetic state of the target output TT-RR*. This will not favor the end of photon route to this output in the case when the other one is more energetic. In fact it is the case in conformity with the obtained results, which can be validate by: the phase 0 of the wave from trajectory 1 on S_2 will give in transmission to RT-TR the emergent wave with a phase difference of π, while the wave with phase 0 of trajectory 2, after reflection on S_2 will have a phase difference of π through RT-TR. Thus, it is proved that *the two emergent waves will be in phase (π), which will give by constructive superposition a resulting wave highly energetic.* There is no doubt that the photon arriving to S_2, ***by one or the other path****, will be preferentially oriented to the output RT-TR* ***in all cases.*** As Mach-Zehnder is symmetric, taking into account any phase at the input to S_1, will always finish by two in phase waves on S_2. Concerning the most attractive output RT-TR for each photon arriving, the result will be always identical. *We arrive to the same conclusions as for paper [1]:* ***the most energetic paths guide the photon and particles trajectories when the meet a road bifurcation.***

4. UNBALANCED MACH-ZEHNDER – UNDERSTANDING OF ITS DIFFERENT CYCLIC RESULTS

The modified by modular elongation portion of trajectory 1 is represented in figure 3. The unbalanced Mach-Zehnder contains on one portion a device allowing the modular elongation of one of paths. The results of one photon arrivals by piecemeal to one of the outputs are, even more surprising than in the case of the balanced interferometer. Indeed, as soon as the length of trajectory 1 is very slightly elongated, it induces the apparition of some photons at the output TT-RR. When the extension is increased, the effect is increased by decreasing the arrivals to RT-TR. For a certain elongation length *L*, all arrivals are to TT-RR. If elongation is continued, the previous state of arrivals reverse gradually, and for a difference of *2L,* we find al particles to the output RT-TR; so the cycle can begin again. For an attempt to explain these results, we shall do the same approach, as in the case of balanced Mach-Zehnder, adapted to new conditions of the device. The geometry will be adopted with the exception of portion S_1 - M_1 where four supplementary mirrors M_3, M_4, M_5 and M_6, will be added. For a simple reasoning, the paths S_1 - M_3 and M_6 - M_1 are equal to the distance *a*. the modular routes $M_3 - M_4$ and $M_5 - M_6$ are identical to *b*. The distance $M_4 - M_5$ is equal to *c*. So, one side of the interferometer square remains equal to *2a+c,* and *2b* represents the elongation.

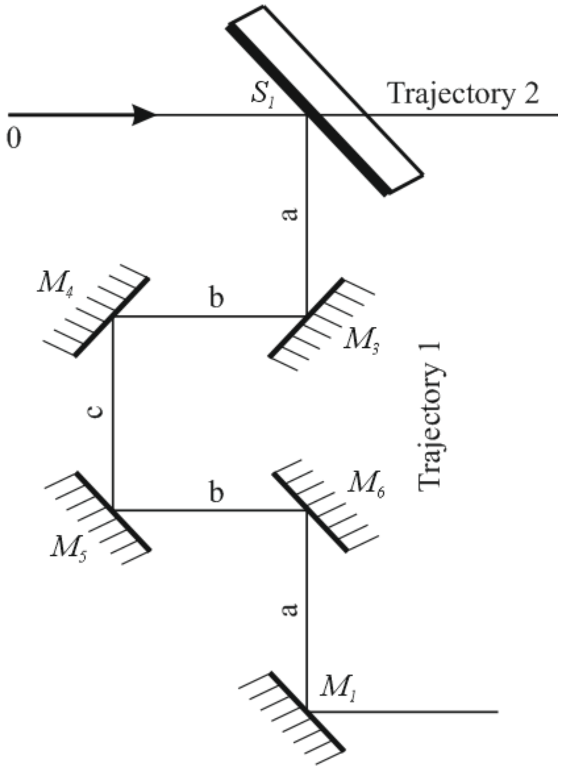

Fig. 3. Portion of Mach-Zehnder trajectory 1 allowing the modular elongation of the path.

We adopt, again, a 0 phase as reference for the associated wave incident on S_1 from the source *O.* As for the previous balanced case, finally, at the output of trajectory 2, we shall find a phase 0 for the twin wave arriving incident on S_2 because there is no modification of this path. The elongated path must be then studied. At the beginning, for $b=0$ we are in the balanced case. *Let's assume that the associated wavelength has the value* λ_a. We shall the particular cases when *b* is an odd multiple of λ_a /4, which means, $L/2=b=(2p+1)\,\lambda_a\,/4$. By simplification, we adopt an initial value of $p=0$, wherefrom, $b=\lambda_a/4$ (for $p=0$ and multiples, the conjunctures will return to same results). The multiples evolution of the state of phase on the elongated trajectory 1 will be, then, the following.

By reflection on S_1 we pass from an incident 0 phase to a π emergent phase.

Let's assume that the values of the distance *a* are those ensuring a phase opposition at the extremities of each of them, while at the extremity of distance *c* will be agreement of phase.

On the mirror M_3 the incident phase will have the values 0 or 2π. The new reflection will impose a phase modification in M_3 emergence with the value π.

Further, it will be a phase of $\pi+\pi/2=3\pi/2$ for the incident wave on mirror M_4. In fact, it is placed at a distance $\lambda_a/4$ in rapport to M_3, and this will induce a supplementary path phase difference of $\pi/2$.

As a result of reflection on M_4, the supplementary path phase difference of π from the incident phase will induce a phase difference of $\pi+3\pi/2=2\pi+\pi/2$, which means $\pi/2$ at the emergence from M_4.

As mentioned above, the length *c* is the one ensuring the same incident phase on the mirror M_5. After reflection, a wave having a supplementary phase difference of π will emerge, wherefrom: $\pi/2+\pi=3\pi/2$.

The wave arriving on M_6 has already travelled the distance *b* and, consequently, this will induce, as before, a supplementary phase difference of $\pi/2$ giving, in rapport with the reference, $3\pi/2+\pi/2=2\pi$ (agreement of phase).

This wave in phase arrives incidentally on mirror M_6 and after reflection on it, the phase becomes globally equal to π.

It will be followed by a supplementary phase difference equal to π and, in accord with the adopted characteristic *a*, the incident wave on M_2 will be in phase ($\pi+\pi=2\pi$). The new reflection on M_2 gives a phase π, which will be met similarly, according to pre-established convention, in incidence on the separator S_2.

Thus, this time, contrarily to the balanced case, the phase of twin associated waves will be in opposite phases (*0* and π) in incidence on S_2.

It follows that, by the same procedure, it *is possible to check that, this time, the output TT-RR is favored by an in phase superposition of emergent waves and, which will guide the photon to the most energetic*. Consequently, in output RT-TR, the phases are in opposition, wherefrom, its trajectory is low energetic this time.

For elongation values on two sides of precise value of $b=\lambda_a/4$ there are reciprocal gains and losses of energetic states on the two outputs, which directs the outputs preferentially to one over the other in a complementary manner.

It is possible to highlight that on the elongated path with *2b*, a phase difference of $\pi/2$ was induce for each *b* and, both and so, for the elongation *2b* in comparison with the balanced interferometer, the phase difference of elongated path induces a state of phase equal to π. The four supplementary mirrors introduce their four reflections, which make turn the wave phase of 4π what does not introduce a phase disagreement.

Therefore, is only the changing of b that influences the phase's variations of incident waves on S_2 on the elongated trajectory 1.

5. CONCLUSION

The corpuscles associated waves would then be a consequence of their movement in the space-time quantic defined by the EVTD[2] entities theory. It was not until then, in accord with their paths conjunctures, these electromagnetic associated waves can initiate waves that would prove being guiding ones.

Preferred orientations of trajectories, in case of alternative, will be imposed by the state of greater energy of one of them and, this will by rather an obligation that a choice. Indeed, a single micro-particle, in the same time, of low energy is made it dependent on energetic fluctuations of it a spreading medium.

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Explicația, în teoria EVTD^2, a rezultatelor enigmatice din interferența unei particule singulare in interferența Mach-Zehnder

Rezumat: Această lucrare urmează publicația [1] ale cărei principale consecințe sunt folosite în încercarea de înțelegere a rezultatelor obținute asupra interferenței unei particule unice în interferometrele Mach-Zehnder echilibrate şi neechilibrate. EVTD^2. „Călătorii" (stropi de lichide) din foarte interesantele experimente [2] constituie o bază de reflexie ca şi teoria entităților EVTD^2. Ei reculează pe un substrat din acelaşi lichid supus la o vibrație intensă. Undele pilot sau vide ale De Broglie-Bohm asociate substratului - substratum (eter cuantic) din teoria EVTD^2 permit enunțarea unor explicații coerente asupra rezultatelor constatate. Ieşirea, după separatorul S_2 este programată (fără o alegere veritabilă). Ea depinde de starea energetică care este propusă particulei în drumul său spre unul sau altul dintre captori, indiferent de drumul pe care ea îl parcurge.

Michel Conte, Ph.D., Honorary Professor of Transylvania University of Brasov, michelconte13104@gmail.com
Ileana Roşca, Ph.D., Professor, Transylvania University, Fine Mechanics and Mechatronics Department, ilcrosca@unitbv.ro , Phone: 0040 744317171, 18/A/10, Bd. Gării, Braşov, Romania,