Explanation of super-luminal velocities in terms of remote metabolism

M. Pitkänen
Dept. of Physics, University of Helsinki, Helsinki, Finland.
Email: matpitka@rock.helsinki.fi.
http://www.physics.helsinki.fi/∼ matpitka/.

Abstract

After the pioneering experiments of Nimtz and his collaborators 1992 a lot of evidence for effective super-luminal signal velocities has been accumulating. The simplest model for the super-luminality and related effects is in terms of remote metabolism associated with detectors and other instruments. Thus these experiments would give a firm grasp on phenomena at the border of dead and living matter.

Contents

1 Introduction

After the pioneering experiments of Nimtz and his collaborators 1992 [1] a lot of evidence for effective super-luminal signal velocities has been accumulating [2, 3]. These findings provide not only a challenge for TGD [TGD, padTGD, cbookI, cbookII] but also a means of developing the new views about time and energy to a more quantitative level. The simplest model for the super-luminality and related effects is in terms of remote metabolism associated with detectors and other instruments. Thus these experiments would give a firm grasp on phenomena at the border of dead and living matter.

Several explanations for the effective super-luminal velocities have been proposed. Quite generally, the explanations are marginally consistent with Maxwell's equations.

1.1 The explanation of super-luminality in terms of photon tunnelling

The explanation of Nimtz [2, 3] for effective super-luminal velocities involves the notion of evanescent wave for which the component of the wave vector in the direction of propagation is by definition imaginary: $k = i\kappa$ so that the wave is exponentially attenuated. For one-dimensional evanescent em waves dielectric constant ϵ as a function of frequency must be negative so that also the energy density becomes negative and Nimtz suggests that this holds true generally. For 3-dimensional waves in waveguide, which are not constant in the transversal degrees of freedom, evanescent waves in vacuum are possible below cutoff frequency ω_c and are generated in a wave guide containing a narrowed portion in the original experiments of Nimtz.

The analogy with the Schrödinger equation allows the interpretation of evanescent waves in terms of photon tunnelling. The semiclassical model relies on the wave equation for non-allowed frequencies not propagating in the waveguide. The model predicts that asymptotically the time τ taken by the evanescent wave of mean frequency f to propagate through a narrowed section of length L of a waveguide does not depend on L and is $\tau \simeq 1/f$ so that arbitrary high effective signal velocities become possible in principle: note however that the exponential attenuation poses strong limitations. This effect is known as Hartman's effect, and generalizes to other geometries and also to electron tunnelling. The prediction is consistent with experiments [1, 2, 3] so that the model provides a reasonable looking phenomenological approach to the situation. The objection is that the solutions describe stationary photon states rather than the process creating them so that the the proposed interpretation of evanescent wave is correct only if the stationary solution codes in itself the process leading to it.

It has been proposed that the effective super-luminal velocities could relate to the breaking of local Lorentz invariance (LLI) [2, 4] involving also quantum non-locality. The breaking of LLI at space-time level is possible in TGD since Poincare invariance is a symmetry of the 8-dimensional imbedding space. The induced metric of space-time surface can have even Euclidian signature, which might serve as the space-time correlate for the negative value of the dielectric constant.

Also the notion of anomalous interference and the notion of hollow wave analogous to the pilot wave of Bohm have been introduced by Cardone and collaborators [4]. The phenomenological notion of hollow wave might allow precise formulation using the notion of many-sheeted space-time.

1.2 The explanation of effective super-luminality in terms of remote metabolism

TGD suggests a microscopic description in terms of many-sheeted space-time by utilizing the new energy concept allowing negative inertial energies. The explanation relies on time mirror mechanism realized in terms of the generalized four-wave mechanism and making possible remote metabolism by sending negative energy phase conjugate photons to the geometric past.

Remote metabolism can explain not only the effective super-luminality but also the effects interpreted in terms of anomalous interference effects [4]. Detector could be seen as a self-organizing system able to suck energy by radiating phase conjugate negative energy photons to some other part of system absorbing them. This is also TGD proposal for the fundamental mechanism behind the ordinary metabolism in living systems and the model predicts that the detectors in the experiments considered behave to some extend like living systems. One can even imagine that a competition for resources occurs and that two systems do their best to suck energy from each other. The general catastrophe theoretic model of remote metabolism developed to explain the behavior of Searl device (see the chapter "The Notion of Free Energy and Many-Sheeted Space-Time Concept" of [padTGD]) provides a starting point for the attempts to model the situation quantitatively.

In the case of the pioneering experiments of Nimtz involving a narrowed portion of wave guide the model would look as follows. When the photons in the wave cavity encounter the narrowed portion they are partially absorbed and excite higher energy states of the atoms and electrons at the walls of the cavity. As the detector has received sufficiently many photons, which have travelled through the narrowed portion of the cavity with light velocity, the detector starts to emit negative energy photons absorbed by the excited atoms which thus return to ground states. The shape of the signal received by detector is changed and the signal peak is shifted to earlier time and this gives rise to effective super-luminal light velocity. According to the figure 4 of [2] the tunnelled signal is not obtained as a time shift of ordinary reference signal but has slightly different shape. In accordance with observations the energy received by the detector is predicted to be larger than expected.

2 Experiments involving super-luminal velocities

The pioneering experiments on super-luminal velocities were done by Nimtz and collaborators in Cologne 1992 [1] using microwaves. The configuration used was a wave guide containing a narrowed portion with cross section less than one half of wavelength in both transversal directions. The finding was that the tunnelling time is asymptotically equal to $\tau \simeq 1/f$, where f is the frequency of the microwave. More generally, photon tunnelling can be realized in wave guides containing a narrowed portion, in the forbidden frequency bands of dielectric hetero-structures analogous to one-dimensional lattices, and also as the frustrated total internal reflection of a double prism, where the total reflection takes place at the boundary from a denser to a rarer dielectric medium [3].

2.1 Standard theoretical description of the findings

The interpretation proposed by Nimtz for super-luminal propagation is in terms evanescent waves representing semiclassically photon tunnelling. The quantum tunnelling of photons was first discussed by Wigner and later by Hartman who deduced the independence of the tunnelling time on barrier thickness [5]. The article of Collins [6] summarizes the model.

Evanescent modes correspond to waves with imaginary wave number not satisfying the dispersion relation of free massless photon. The dispersion relation $\omega^2 - k^2 - \omega_c^2 = 0$ satisfied for free propagation in the waveguide is replaced by $\omega^2 + \kappa^2 - \omega_{c,1}^2 = 0$ in the narrowed portion of the waveguide. The photons satisfying $\omega_c < \omega < \omega_{c1}$ can propagate in the narrowed portion but are attenuated exponentially. The narrowing of the waveguide by a factor x means $\omega_c \rightarrow \omega_c/x$ so that evanescent modes appear, when x satisfies the constraint $x < \omega_c/\omega$.

In Maxwell's theory a system allowing *one-dimensional* evanescent waves must have negative dielectric constant ϵ ($c^2 = \epsilon_0\mu_0 \rightarrow \epsilon\mu < 0$) for the frequencies involved so that d'Alembert type wave equation changes to Laplacian and tunnelling cannot be regarded as a genuine propagation. A possible interpretation is in terms of breaking of Lorentz invariance. According to Nimtz, the evanescent modes seem to represent non-local fields. For one-dimensional propagation the energy density $\varepsilon = \epsilon E^2/2$ by $\epsilon < 0$ would be indeed negative. On the other hand, for 3-dimensional waveguide $\varepsilon < 0$ need not hold true. Evanescent have not been measured directly and they might represent fictitious quantities.

The so called phase time approach identifies the tunnelling time as $\tau = d\phi/d\omega$, where ϕ is the phase change over the barrier. In the examples listed above phase change is vanishing since the wave number is imaginary implying $\phi = 0$. Experimentally it has been found $\tau \simeq 1/f$ and this is believed to be due to what happens at the barrier front boundary. A quantum mechanical model for photon tunnelling originally developed by Wigner and by Hartman predicts phase-time correctly. A semiclassical description is in question since electromagnetic field does not allow interpretation as a probability amplitude.

The tunnelling occurs only below certain length scale L. An interpretation as the size of the region inside which the breaking of Lorentz invariance at space-time level takes place, has been suggested. In the experiments of

Nimtz and collaborators L corresponds to the $8.8 - 9.30$ cm variation range for the penetration length of evanescent wave [1]. Second scale corresponds to an energy threshold of $E_{0,e.m.} = 4.5\ \mu V$ representing the difference of voltages induced in photodiodes in two experiments in which tunnelling occurs/does not occur. In [4] the threshold is interpreted as an energy threshold for the breaking of local Lorentz invariance.

2.2 TGD based explanation of effective super-luminality in terms of remote metabolism

The general TGD based description of the effective super-luminal propagation is based on time mirror mechanism realized in terms of a generalization of the four-wave interaction involving standing wave composed of two waves propagating in opposite directions and waves representing incoming wave and phase conjugate wave. Phase conjugate negative energy photons would propagate inside negative energy massless extremals (MEs, topological light rays). Time mirror mechanism makes possible remote metabolism, and it is assumed that detector is able to remotely metabolize by sending negative energy photons to the walls of the wave guide whose atoms have been excited by the photons which have been excited.

In the following the consideration is restricted to the experiment [1] of Nimtz in which waveguide contains a narrowed portion.

a) When the photons with frequencies below the cutoff frequency of the narrowed portion of the waveguide encounter the narrowed portion they are partially absorbed and excite higher energy states of the atoms and electrons at the walls of the cavity. When the detector has received sufficiently many photons, which have travelled through the narrowed portion of the cavity with the normal light velocity, the detector starts to emit negative energy photons absorbed by the excited atoms which thus return to ground state. The shape of the detector signal changes and the peak of the signal received by the detector is shifted to an earlier time. According to the figure 4 of [2] the shape of the signal indeed changes. The outcome is an effective super-luminality.

If the change of the shape is such that it corresponds in the frequency domain to the phase shift induced by the translation $t \rightarrow t - \Delta\tau$ in the argument of the Fourier component $exp(i\omega t)$, with $\Delta\tau$ given as the difference

$$\Delta\tau(\omega) = \tau_R - \tau = \frac{L}{c} - \frac{2\pi}{\omega} \qquad (1)$$

of the real time τ_R taken to propagate through the barrier and of the semiclassical tunnelling time $\tau(\omega)$, the theory makes same predictions as the semiclassical approach.

b) The prediction is that the detected signal is somewhat stronger than predicted by the standard theory. This has indeed been observed and is formulated in [4] in terms of the effective energy threshold, which corresponds to the voltage difference $E_{0,e.m} = E_B - E_A \simeq 4.5\ \mu\text{V}$, where A (B) corresponds to the situation in super-luminal propagation occurs (does not occur). Why this should be the case, is not obvious in the semiclassical model.

2.3 Could strong breaking of local Lorentz invariance occur at the space-time level?

The quantum-classical correspondence states that many-sheeted space-time realizes also the phenomenological smoothed out descriptions of the physical system using a hierarchy of larger space-time sheets: many-sheeted physics performs self-mimicry. This philosophy might apply also to the description of photon tunnelling.

In TGD Poincare invariance corresponds to the symmetries of the imbedding space and TGD predicts the possibility of space-time sheets with Euclidian signature of metric and thus a dramatic breaking of local Lorentz invariance at space-time level. The physical interpretation of these space-time sheets has remained open. In spirit of quantum classical correspondence one can wonder whether the induced metric could have Euclidian signature for the standing microwave space-time sheet so that the negative value of dielectric constant $\epsilon(\omega)$ necessary for one-dimensional evanescent waves would have a direct space-time correlate in TGD framework. Even the effectively one-dimensional approximate description of the situation with length scale resolution larger than the transversal size of the narrowed portion of the waveguide could have this kind of space-time correlate.

If the standing microwave space-time sheets with Euclidian signature of the induced metric are vacuum extremals, the resulting flexibility gives good hopes about the correspondence with the tunnelling interpretation of the evanescent waves. Of course, TGD description remains a bundle of ideas and precise quantitative model is not yet possible.

2.4 Alternative explanation in terms of drift of negative energy MEs does not work

A second explanation imaginable in TGD framework would rely on the drift of the negative energy MEs generated at the end B of narrowed portion and send to the end A and to the direction of the geometric past quantum jump by quantum jump so that the field pattern inside MEs would shift towards geometric past and effectively move with super-luminal velocity. This would imply effective super luminal group velocity for the classical fields inside ME and also for the pattern of coherent photons. In this case the effective super-luminal light velocity would be most naturally constant irrespective of the length of the narrowed region. This is not consistent with the experimental findings. Note that the variant of this mechanism for positive energy MEs could provide the space-time correlate for the reduction of light velocity in dielectrics.

3 Experiments believed to involve anomalous interference

The experiments of Cardone and coworkers [4] stimulated my own interest in the super-luminal propagation, a possible breaking of LLI, and non-locality. The experiments of Cardone were motivated by the notion of hollow wave analogous to the notion of pilot wave of Bohm. Hollow wave would not carry energy but would represent a deformation of Minkowski metric and its interaction with photons would somehow induce anomalous interference effects.

3.1 The experimental arrangement

The experimental arrangement discussed in more detail [4] (see Fig. 3.1) is following.

a) The geometry of the experimental arrangement can be described in terms of a configuration of vertical lines V_1, V_2, and V_3 order from left to right and horizontal lines H_1, H_2, H_3 ordered from top to bottom. There are two identical sources S_1 and S_2 of IR photons, three identical slits F_1, F_2, F_3 and three identical detectors A, B, C (photodiodes sensitive to IR light).
i) S_2, F_3, C was in the intersection of V_i, $i = 1, 2, 3$ with the line H_3 in this order. C was in front of F_3 and detected photons from S_2.
ii) F_2, B was at the intersection of V_i, $i = 2, 3$ with H_2 in this order.
iii) S_1, F_1 and A was at the intersection of V_i, $i = 1, 2, 3$ with H_1 in this

order. The vertical line V_3 containing the detectors A and B could be moved in horizontal direction to five different positions.

b) F_2 was outside the cone of maximal intensity for the radiation from S_1 and in geometric optics approximation no photons was predicted to go through F_2. The expectation was however that the "hollow waves" accompanying photons emitted by S_2 could propagate through F_2 and induce anomalous interference effects.

c) The geometric arrangement was such that B was predicted to detect nothing in the geometric optics approximation and this was found to be the case. Detector A was expected to detect only photons from S_1: indeed, when S_1 was off and S_2 on, no signal was detected.

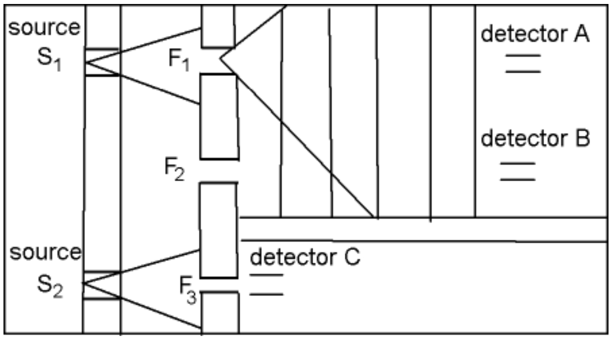

Figure 1: Schematic representation of the experimental arrangement of Cardone and collaborators.

3.2 Findings

Standard Maxwell's theory would predict that detector A should give same signal in the following situations:
i) S_1 on and S_2 off
ii) S_1 on and S_2 on.
What was found that when the distance d of the detector A from S_1 (on the same line parallel to x-axis) satisfied $d < 4$ cm, the two situations were different. The energy threshold defined as the difference of voltages in the detector A in situation i) and ii) was $\Delta_A(1-3) = 2.3\ \mu V$ for $d < 4$ cm. The proposed interpretation was in terms of anomalous interference effects caused by "hollow waves" accompanying photons and diffracting through

the slit F_2.

3.3 TGD based model of remote metabolism as explanation of the effects

The general model of remote metabolism would look like follows.

a) The basic building blocks are negative and positive energy MEs containing phase conjugate IR photons. Although not separately mentioned in [4], there are reasons to believe that the presence of the slit F_2 is necessary for the effect to occur. The interpretation would be that the standing microwave space-time sheet diffracts through F_2. Also negative energy IR photons would tunnel through F_2. Previous considerations allow to consider the possibility that hollow waves correspond to space-time sheets with an Euclidian signature of the induced metric so that physics itself would provide description of the situation with length scale resolution of the order of beam width. What is highly interesting that the critical distance d corresponds to the p-adic length scale $L(k) = 2^{(k-151)/2}L(151)$, $L(151) = 10$ nm for $k = 195$.

b) In order to develop the model further, a rough picture about the functioning of the detector A is necessary. When a photon is detected by A, it creates an electron hole pair in the active region of the photodiode. Conduction electron starts to move towards the n layer of the diode (cathode) whereas hole moves towards the p layer (anode).

c) Detector A emits negative energy phase conjugate IR photons absorbed by S_2. The emission of negative energy photon from A means that electron becomes a conduction electron so that electron-hole pair is generated and a positive contribution to the voltage of the photodiode is generated. The absorption of photon by S_2 induce a transition of some atomic system in S_2 to a lower energy state without an emission of positive energy IR photon.

d) The "energy threshold" characterizes how efficiently photodiode at A generates negative energy photons and how effectively they are absorbed by S_2 and is a property of photodiode and photon source rather than of possible exotic interactions such as anomalous interference.

e) The model makes several predictions. Negative energy photons can be absorbed when their energies are sub-thermal so that mechanism might not work for photons with sub-thermal energies. The prediction is that the presence of the detector C is not necessary for the mechanism to work. The number of photons detected by the C should be changed by the negative of the amount that the energy detected by A is changed.

4 The experiments involving crossed photon beams

In [4] the privately communicated preliminary experimental results of Ranfagni and coworkers are analyzed. The experimental arrangement is illustrated in figure 4. The primary microwave photon beam A_1 generated by a microwave antenna antenna splits into two beams A_{11} and A_2. A_{11} is amplified by a second microwave antenna. A_2, the secondary beam, propagates inside a waveguide, is modulated at 1500 Hz frequency by a chopper and passes to the detector. Either A_1 or A_2 is attenuated.

A_{11} and A_2 cross each other orthogonally and apart from very small interference predicted by QED (photon photon scattering), the effect of A_{11} to the detector should vanish.

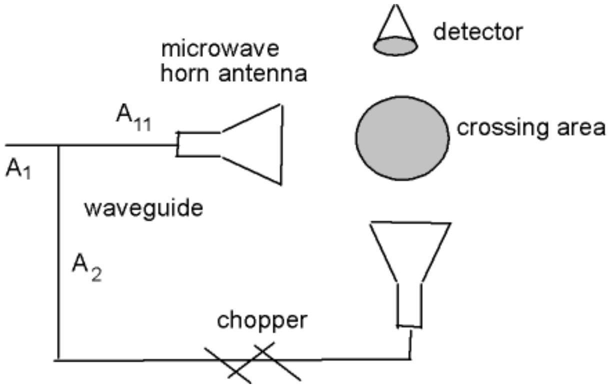

Figure 2: Schematic representation of the experimental arrangement of Ranfagni and collaborators discussed in [4].

4.1 Findings

The experiment demonstrates that the signal generated by photons in detector A depends on whether A_1 or A_2 is attenuated. The experimenters interpret the finding in terms of an anomalous interference involving "hollow waves".

Figure 7 of [4] depicts the voltage of detector A as function of attenuation and polarization for A_1 and A_2 attenuation. If A_2 is attenuated, the voltage of the photodiode as a function of attenuation stays positive. If A_1 is attenuated, signal changes sign somewhat below 10 dB but approaches in both cases asymptotic value of 5 μV above 30 dB of the size of the crossing beam region is less than 8-9 cm *resp.* 4 cm for microwave *resp.* IR photons. Asymptotic situation corresponds to a single photon condition. There is no detectable dependence on beam energy but photon polarization affects somewhat the situation.

The laser variant of the experiment performed by Meucci and coworkers uses IR light without modulation and a similar effect is detected.

4.2 An overview of the TGD based model

The picture behind the TGD based model is following.

a) The propagation of the microwave through a resistor in microwave circuit is the simplest manner to achieve attenuation. Electrons absorb the microwave energy and dissipate it. Attenuation is a process analogous to a detection since photon is absorbed also now.

b) There is a competition between detector D and attenuator A about energy. In the case of A_2 attenuation D wins and sucks more energy from A_2 than A_2 from D: photodiode voltage is positive. For A_1 the situation is opposite in a critical range $[8, 30]$ dB of attenuation strength A so that the voltage of the photodiode becomes negative. Conduction electrons in the photodiode annihilate with holes and a negative voltage contribution is generated. Asymptotically detector wins in both cases and this explains positive 5 μV voltage at large values of attenuation A.

c) Generalized four-wave interaction occurs most naturally in the detector and in the attenuator. Standing microwave space-time sheet and IR MEs with negative energy correspond to the four waves involved. The size of the region in which four wave interaction occurs is determined by the size of the crossing region. The wavelength and width of the standing waves between detector and attenuator corresponds to the critical length parameter L, which corresponds to a microwave wavelength in both variants of the experiment. Negative energy IR photons propagate between attenuator and detector along the wave guide A_2. The branching of the A_1 induces also a branching of the beam of negative energy photons.

d) These length scales L corresponds to the p-adic length scale $L(197)$ for microwave photons and $L(195)$ for IR photons. This suggests that the microwave frequencies involve correspond to p-adic length scales. p-Adic frequencies are indeed expected to define "miracle frequencies" in TGD Universe and I have already proposed that these frequencies and corresponding p-adic codes might be used by more advanced civilizations of the geometric future to communicate with the civilizations of the geometric past (including ourselves). What is interesting that the attenuation need not make possible this kind of communications since time reflection of the signal back from geometric past instead of time transmission does involve attenuation.

e) The catastrophe theoretic model is inspired by the general model for Searl effect based on remote metabolism. Qualitatively the model is characterized by the numbers of state and control parameters. The voltage of photodiode of the detector is in the role of the state variable so that cusp, swallowtail, and butterfly are the candidates for the elementary catastrophes involved. At least $V = 0$ and $V \neq 0$ at the one photon limit represent steady states so that cusp catastrophe and less probably, the dual of butterfly catastrophe having both two steady states provide a possible model of the situation. Note that butterfly reduces to cusp in subregion of the parameter space.

4.3 The identification of the control variables

Consider now the possible control variables.

a) The attenuation of the beam A_1 or A_2, denote it by A, is certainly a relevant dimensionless control parameter. From figure 7 of [4] one finds that the sign of V changes rapidly as a function of attenuation A below 10 dB and stays negative in certain range of values of A for F_1 attenuation. For A_2 attenuation V preserves its sign. This suggests an idealization in terms of a discontinuous dropping from the upper sheet of cusp to the lower sheet so that A would be identifiable as the normal factor of the cusp.

b) The index $i = 1, 2$ telling whether the primary or secondary beam is attenuated is also a natural control variable. The naive expectation is that some fraction of the beam of negative energy photons from A_1 leaks out when the secondary beam branches from A_1. It however turns out that "time refraction" in which negative energy signal is amplified in the branching must occur in order to explain the experimental findings.

c) The dimensional control parameters are following.

i) The width L of the beam is certainly a control parameter and determines the size of the crossing region, which as such has no relevance in TGD framework since anomalous interference is not assumed to be the underlying mechanism. The wavelength $\lambda = c/f$ of the photon beam is second candidate for a control parameter. The distance d from the detector to the attenuator also distinguishes between A_1 and A_2 attenuation. Together with the attenuation strength A this would make four control variables. The overall size of the system, call it X, is a further control variable which can be however eliminated if scaling invariance holds true by taking X as a length unit.

ii) The critical value of L is reported to be the same for $d = d_1$ and d_2. When L is below the critical value L_{cr} a steady state $V \neq 0$ becomes possible. Below it $V \rightarrow 0$ corresponds to the steady state at the one-photon limit. Hence L plays the role of the splitting factor of cusp catastrophe. The critical value of L for IR photons and microwave photons differs by a factor of order two (change of p-adic miracle wavelength) so that there is a weak dependence on the wavelength and λ acts as a non-trivial control parameter. In the first approximation one can forget λ as an active control variable.

iii) The variable d representing distance between attenuator and detector is a candidate for a further control variable. The experiments do not allow to decide whether d is a relevant control variable.

The minimum option is based on the identification of A, L, and discrete variable i as control variables.

4.4 A more detailed specification of the catastrophe theoretic model

The equation for the charge of the photodiode modelled as a capacitor reads as

$$\begin{aligned}\frac{dQ}{dt} &= C(V)\frac{dV}{dt} \\ &= I_B(A) + I_D(V,A,L,\lambda) - I_A(A,i,L,\lambda) \equiv F(V,A,L,i,\lambda) \ . \quad (2)\end{aligned}$$

Here $I_B(A)$ denotes the contribution of the beam of photons. In the absence of new physics it would be the only term at the right hand side. I_B is obviously proportional to A:

$$I_B(A) = A \times I_B(A=1) \ ,$$

and thus decreases with attenuation. I_D corresponds to the current due to the spontaneous generation of negative energy photons by detector and received by attenuator. I_A is the corresponding current induced by the attenuator competing with the detector about energy resources. The first guess is that A_1 and A_2 differ in the sense that part of the beam of the negative energy photons from attenuator A_1 can split into two beams: hence the functional form of I_A is different for $i = 1$ and $i = 2$.

The asymptotic steady states satisfy

$$\frac{dQ}{dt} = F(V) = 0 \ . \quad (3)$$

This gives an expression of V as a zero of the function appearing at the right hand side. The dependence of C on V does not matter in the adiabatic situation. Since there is only one state variable involved, one can always write the right hand sided $F(V)$ as a gradient of a potential function Φ:

$$F(V) = \frac{d\Phi}{dV} \ , \quad (4)$$

so that catastrophe theory applies and irrespective of the form of potential the situation is diffeomorphic with a butterfly catastrophe with additional discrete control variable i and expected to reduce to cusp catastrophe in the range of control variables studied in the experiments.

From the behavior of V as a function of A one can deduce the following.

a) If d would appear as an argument of I_D asymptotics would not be the same for $d = d_1$ and $d = d_2$ unless one has $I_D(d_1) \simeq I_D(d_2)$ for large values of A. Hence it seems that I_D does not depend on d. The dependence of $I_A(A, i, ..)$ on i is reflected in the difference of the graphs of $V = f_{A_i}(A)$, $i = 1, 2$ as function of attenuation.

b) I_A must be negligible at the limit $A \rightarrow 0$ of high attenuation since the asymptotic value of V does not depend on whether A_1 or A_2 is attenuated. Too strong an attenuation would mean that the attenuator is not anymore able to emit appreciably negative energy photons. $I_A \propto A(1-A)$ is the first guess for I_A. For 30 dB attenuation one would have $A = 10^{-3}$ so that I_A would be indeed small.

In principle the model based on the emission of negative energy photons is able to reproduce the observed behavior for V. $I_B \propto A$ decreases as the attenuation increases whereas the current I_A induced by the generation of negative energy photons from the attenuator increases when the attenuation parameter increases since the probability for generation of negative energy photons is expected to grow with the size of attenuator and thus with $1-A$. Thus the observed change of sign of V for A_1 attenuation can occur for

$$\begin{aligned} I_D(A, ..) &< I_A(A, i = 1, ...) \ , \\ I_B(A) &< I_A(A, i = 1) \ . \end{aligned} \quad (5)$$

The condition

$$I_A(A,1) \quad > \quad I_A(A,2) \tag{6}$$

must be satisfied and could relate to the branching of the primary beam and less probably with the value of the parameter d. This condition is not consistent with the expectation that $I_A(A,1)$ is a fraction of $I_A(A,2)$. Branching should induce an amplification of the negative energy signal. This would suggest that the branching corresponds to a "time refraction" in which the refracted part of the signal corresponds to positive energy photons.

References

[TGD] M. Pitkänen (1995) *Topological Geometrodynamics* Internal Report HU-TFT-IR-95-4 (Helsinki University). http://www.physics.helsinki.fi/∼matpitka/.

[padTGD] M. Pitkänen (1995) *Topological Geometrodynamics and p-Adic Numbers.* Internal Report HU-TFT-IR-95-5 (Helsinki University). http://www.physics.helsinki.fi/∼matpitka/padtgd.html.

[cbookI] M. Pitkänen (1998), *TGD inspired theory of consciousness with applications to biosystems.* http://www.physics.helsinki.fi/∼matpitka/cbookI.html.

[cbookII] M. Pitkänen (2001), *Genes, Memes, Qualia, and Semitrance.* http://www.physics.helsinki.fi/∼matpitka/cbookII.html.

[1] A. Enders, G. Nimtz (1992), J. Phys. I (Paris) 2, 1693.

[2] G. Nimtz (1998), *Super-luminal Signal Velocity*, arXiv:physics/9812053.

[3] G. Nimtz (2001), *Super-luminal Tunneling Devices*, arXiv:physics/0204043.

[4] F. Cardone *et al*, Phys. Lett. A 326 (2004), 1-13.

[5] Th. Hartman (1962), J. Appl. Phys. 33, 3427.

[6] S. Collins, D. Lowe and J. Barker (1987), J. Phys. C 20, 6213.

[7] A. Ranfagni *et al* (1993), Phys. Rev. E 48, 1453.