# Definition of Wave-Corpuscle Interaction Suitable for Simulating Sequences of Physical Pulses

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**Abstract.** This study presents a logic definition for the interaction between waves and corpuscles suitable for simulating the action of a sequence of electromagnetic waves upon corpuscles. First are defined the classes of measuring methods based on the wave aspect of matter and on the corpuscular aspect of matter, using considerations about a possible memory of previous measurements (operators). A suitable algorithm associated to this formalization is applied on adjoining space-time intervals, so as the space-time validity of certain assertions to be proved. The results are applied for defining the wave-corpuscle interaction in a logic manner.

## 1 Introduction

As it is known, basic concepts in physics connected with interaction are the wave and corpuscle concepts. In classical physics the corpuscle term describes the existence of certain bodies subjected to external forces or fields, and the wave concept describes the propagation of oscillations and fields. In quantum physics, these terms are closely interconnected, the wave train associated to a certain particle describes the probability of a quantum corpuscle (an electron or a photon) to appear; the results of certain measurements performed upon the quantum particle are described by the proper value of the operators corresponding to the physical quantity to be measured. However, certain intuitive problems connected with measurement procedures on closed-loop trajectories in special relativity and non-commutative properties of operators in quantum physics imply a more rigorous definition of measurement method and of the interaction phenomena, classified from the wave and from the corpuscular aspect of matter, so as to avoid contradiction generated by terminological cycles [1]. This study presents consequences of logic definition for the class of measuring methods based on the wave aspect of matter and for the class of measuring methods based on the corpuscular aspect of matter upon interaction phenomena, using

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considerations about a possible memory of previous measurements (operators) in case of a sequence of received pulses; it continues in a rigorous manner intuitive aspects presented in [2]. It is shown that measurements methods based on transient phenomena (waves) do not imply a memory of previous actions, while methods based on non-transient phenomena imply the existence of certain quantity which keeps its previous value after the end of a measuring procedure. Then a suitable algorithm associated to this expressive pattern classes (similar to those presented in [3]) is applied on adjoining space-time intervals, so as the space-time validity of certain assertions to be proved and to define in a rigorous manner the interaction between a set of pulses and a corpuscle.

## 2 Aspects Connected with Measurements on a Set of Pulses Received on Adjoining Space-Time Intervals

As it is known, the special relativity theory considers that the Lorentz formulae describe the transformation of the space-time coordinates corresponding to an event when the inertial reference system is changed. These formulae are considered to be valid at any moment of time after a certain synchronization moment (the zero moment) irrespective to the measuring method used. However, there are some problems connected to the use of mechanical measurements on closed-loop trajectories. For example, let us consider that at the zero moment of time, in a medium with a gravitational field which can be neglected (the use of the galileean form of the tensor $g_{ik}$ being allowed) two observers are beginning a movement from the same point of space, in opposite directions, on circular trajectories having a very great radius of curvature. After a certain time interval, the observers are meeting again in the same point of space. For very great radii of curvature, the movements on very small time intervals can be considered as approximative inertial (as in the case of the transverse Doppler effect, where the time dilation phenomenon was noticed in the earth reference system which is approximative inertial on small time intervals). The Lorentz formulae can be applied on a small time interval $\Delta t(1)$ measured by one of the observers inside his reference system, and it results (using the Lorentz formula for time) that this interval corresponds to a time interval

$$\Delta t'(1) = \frac{\Delta t(1)}{\sqrt{1 - \frac{v(1)^2}{c^2}}} \tag{1}$$

in the reference system $S_2$ of the other observer, which moves with speed $v(1)$ as related to the reference system $S_1$ on this time interval. So the time dilation phenomenon appears. If each observer considers the end of this time interval ($\Delta t(1)$ or $\Delta t'(1)$ ) as a new zero moment (using a resynchronization procedure), the end of the second time interval $\Delta t(2)$ (with the new zero moment considered as origin) will correspond to a time moment

$$\Delta t'(2) = \frac{\Delta t(1)}{\sqrt{1 - \frac{v(2)^2}{c^2}}} \tag{2}$$

measured in the other reference system $S_2$ which moves with speed $v(2)$ as related to system $S_1$ on the time interval $\Delta t'(2)$ (with the new zero moment considered as origin). As related to the first zero moment (when the circular movement has started) the end of the second time interval appears at the time moment

$$t_2 = \Delta t(1) + \Delta t(2) \tag{3}$$

for the observers situated in reference system $S_1$, and at the time moment

$$t'(2) = \Delta t'(1) + \Delta t'(2) = \frac{\Delta t(1)}{\sqrt{1 - \frac{v(1)^2}{c^2}}} + \frac{\Delta t(2)}{\sqrt{1 - \frac{v(2)^2}{c^2}}} \tag{4}$$

for the other observer.

Due to the fact that

$$\Delta t'(1) > \Delta t(1) \tag{5}$$

and

$$\Delta t'(2) > \Delta t(2) \tag{6}$$

it results that

$$t'(2) = \Delta t'(1) + \Delta t'(2) > \Delta t(1) + \Delta t(2) = t(2) \tag{7}$$

and thus a global time dilation for the time interval $\Delta t(1) + \Delta t(2)$ appears. The procedure can continue, by considering the end of each time interval

$$\Delta t(1) + \Delta t(2) + \ldots + \Delta t(i)$$

as a new zero moment, and so it results that on all the circular movement period, a time moment

$$t(k) = \sum_{i=0}^{k} \Delta t(i) \tag{8}$$

(measured by the observer in reference system $S_1$) corresponds to a time moment

$$t'(k) = \sum_{i=0}^{k} \Delta t'(i) = \sum_{i=0}^{k} \frac{\Delta t(i)}{\sqrt{(1 - \frac{v_i^2}{c^2}}} \tag{9}$$

(measured by the observer situated in reference system $S_2$), which implies

$$t'(k) > t(k) \tag{10}$$

By joining together all these time intervals $\Delta t(i)$ we obtain the period of the whole circular movement $T$. While the end of this movement is represented by the end of the time interval $\Delta t(N)$ in the reference system $S_1$, it results that $T$ can be written under the form

$$T = t(N) = \sum_{i=0}^{N} \Delta t(i) \tag{11}$$

(considered in the reference system $S_1$), and it results also that this time moment (the end of the circular movement) corresponds to a time moment

$$T' = t'(N) = \sum_{i=0}^{N} \Delta t'(i) \tag{12}$$

measured in the reference system $S_@$. While

$$\Delta t'(i) = \frac{\Delta t(i)}{\sqrt{1 - \frac{v(i)^2}{c^2}}} > \Delta t(i) \tag{13}$$

it results

$$T' > T \tag{14}$$

If the time is measured using the age of two twin children, it results that the twin in reference system $S_2$ is older than the other in reference system $S_1$, (having a less mechanical resistance of bones) and it can be destroyed by it after both observers stop their circular movements. However, the same analysis can be made starting from another set of small time intervals $\Delta_n t'(i)$ considered in the reference system $S_2$ which corresponds to a new set of time intervals $\Delta_n t(i)$ considered in the reference system $S_2$ (established using the same Lorentz relation) and finally it would result that the period of the circular movement $T'$ measured in system $S_2$ corresponds to a period $T$ greater than $T'$ considered in reference system $S_1$. If the time is measured using the age of two twin children, it results that the twin in reference system $S_1$ is older than the other in reference system $S_2$, (having a less mechanical resistance of bones) and it can be destroyed by it after both observers stop their circular movements. But this result is in logic contradiction with the previous conclusion, because a man can not destroy and in the same time be destroyed by another man.

As a first attempt of solving this contradiction, one can suppose that Lorentz formulae are valid only for electromagnetic phenomena (as in the case of the transversal Doppler effect) and not in case of mechanical phenomena. But such a classification is not a rigorous classification, being not suitable for formal logic. In next section we will present a more rigorous classification of phenomena used in space-time measurements, which can be used for *gedanken* experiments using artificial intelligence based on formal logic.

## 3 A Rigorous Definition of Wave and Corpuscle Concepts and of Wave-Corpuscle Interaction

The logical contradiction presented in previous section appeared due to the fact that an element with internal memory has been used. The indication of this element has'not been affected by the resynchronization procedure. In modern physics such an element with internal memory is connected with the corpuscular aspect of matter, with a body. On the contrary, a measuring procedure based on an electromagnetic or optic wave-train is a transient phenomenon. The synchronization of clocks is possible only after the wave-train arrives at the observer. Excepting a short time interval after the reception the received wave-train doesn't exist inside the observer's medium, so there isn't any space area where a physical quantity which characterizes the wave to cumulate. That's the reason why a correct solution of the twins paradox must be based not on the association of electromagnetic (or optic) phenomena with the Lorentz formulae, but on the association of the Lorentz formulae with wave phenomena describing the propagation of a wave inside the observers reference systems. The wave class is more general than the class of electromagnetic and optic waves (we can mention the wave associated with particles in quantum mechanics). Besides, in the most general case, the interaction between two reference systems appears under the form of a field, not under the form of a material body. Moreover, this aspect implies an intuitive interpretation for the dependence of the mass of a body inside a reference system.

Using the formal logic, all we have shown can be presented in a rigorous manner.

A) We define the notion of "propagation"phenomenon in two inertial reference systems (the system where the event takes place and the system where a signal generated by the event is noticed)

**Definition 1.** *It exists a set of adjoining space intervals* $\{S_0, S_1, \dots, S_n\}$*, a set of adjoining time intervals* $\{T_0, T_1, \dots, T_n\}$ *in a certain reference system; it exists a set of physical quantities* $F_u = \{F_{u1}, F_{u2}, \dots, F_{um}\}$ *and a set of relations* $R_{10}, R_{21}, \dots,$ *so as*

$$F_u(S_1, T_1) = R_{10} F_u(S_0, T_0),\ F_u(S_2, T_2) = R_{21} F_u(S_1, T_1), \dots$$

*and*

$$\{F_u(S_0, T_0) \neq 0,\ F_u(S_0, t) = 0\, for\, t \notin T_0\} \Longrightarrow$$

$$\{F_u(S_1, T_1) \neq 0,\ F_u(S_1, t) = 0\, for\, t \notin T_1\} \dots \Longrightarrow$$
$$\{F_u(S_n, T_n) \neq 0,\ F_u(S_n, t) = 0\, for\, t \notin T_n\}$$

It can be noticed that we described a propagation phenomenon having a finite existence inside the reference system, the number of intervals being finite.

B) We define the notion of corpuscle inside a certain reference system

**Definition 2.** *It exists a set of adjoining space intervals* $\{S_0, S_1, \dots, S_n, \dots\}$*, and a set of adjoining time intervals* $\{T_0, T_1, \dots, T_n, \dots\}$ *in a certain reference system; it exists a set of physical quantities* $F_c = \{F_{c1}, F_{c2}, \dots, F_{cm}\}$ *and a set of relations* $R_{10}, R_{21}, \dots,$ *so as*

$$F_c(S_1, T_1) = R_{10} F_c(S_0, T_0),\ F_c(S_2, T_2) = R_{21} F_c(S_1, T_1), \dots$$

*and*

$$\{F_c(S_0, T_0) \neq 0,\ F_c(S_0, t) = 0\, for\, t \notin T_0\} \Longrightarrow$$

$$\{F_c(S_1, T_1) \neq 0,\ F_c(S_1, t) = 0\, for\, t \notin T_1\} \ldots \Longrightarrow$$

$$\{F_c(S_n, T_n) \neq 0,\ F_c(S_n, t) = 0\, for\, t \notin T_n\} \Longrightarrow \ldots$$

It can be noticed that these relations are describing a phenomenon which can possess an unlimited evolution in time and space inside the reference system; it can be also said that the phenomenon has its own existence, it exists by itself.

C) We define the emission of a wave-train $U_e$ in a reference system and its transformation in another train when it interacts with the observers's medium

**Definition 3.** *It exists an area $S_{0e}$ and a time interval $T_{0e}$ in the reference system where the emission takes place so that*

$$F_{ue}(S_{0e}, T_{0e}) \neq 0,\ F_{ue}(S_{0e}, t) = 0\, for\, t \notin T_{0e}$$

*It exists a space area $S_{0r}$ and a time interval $T_{0r}$ in the observer's reference system, and a relation $Tr$ so that*

$$F_{ur}(S_{0r}, T_{0r}) = Tr\left[F_{ue}(S_{0e}, T_{0e})\right],$$

$$F_{ur}(S_{0r}, T_{0r}) \neq 0,\ F_{ur}(S_{0r}, t) = 0\, for\, t \notin T_{0r}$$

So it exists a certain physical quantity characterizing the body which is influenced by the received wave train even after this wave train has disappeared (it exists a memory of the previous measurements).

D) We define the transformation of a sequence of received pulses $\Sigma_k Ue_k$ in a sequence $\Sigma_k Ur_k$ , k = 1...n after interaction with the observers'reference system, by considering that each pulse (wave-train) is transformed in an independent manner by the material medium of the observer's reference system, according to its specific Lorentz transformation

**Definition 4.**

$$Ur_k = L_k\left[Ue\right]_k$$

$$\Sigma_k Ue_k = \Sigma_k Ur_k$$

*where $L_k$ represents the Lorentz transformation performed upon the $Ue_k$ wave by the system, with the interaction moment of this wave with the material medium of the observer considered as zero moment of time (synchronization moment) for the Lorentz transformation $L_k$.*

E) We define the interaction between a sequence of pulses and the material body of the observer's reference system (a corpuscle) as an interaction function $Int$ between the material medium and each transformed pulse $Ur_k$ corresponding to a received pulse $Ue_k$, the mass $m$ of the body measuring the influence of the received wave-train $Ue_k$ upon the body.

**Definition 5.**

$$\frac{1}{m} = Int\left[Ur_k\right] = Int\left[L_k\left(Ue\right)_k\right]$$

When Lorentz transformation $L_k$ doesn't generate a pulse $Ur_k$ (for example when the relative speed between the material body and the wave is equal to $c$, the speed of light in vacuum), the mass $m$ is equal to $\infty$ , which means that no interaction due to the received pulse $Ue_k$ exists (an idea appeared at Marin Preda College, which connects the notion on infinite mass with the absence of interaction). So $m = \infty$ for a body inside a reference system $S$ shows that we can't act upon the material body using wave pulses emitted in system $S$; however, changes in the movement of the body (considered in system $S$ ) due to other external forces seem to be allowed.

All previous definitions implies the necessity of using distinct memory areas for each pulse, if we intend to simulate sequences of optical pulses. By interaction with a certain material medium, each pulse is transformed according to Lorentz formulae, and the modified parameters of each pulse must replace the previous informations in the memory cells. For wave trains considered inside the material medium, a method to simplify the use of the memory cells (appeared at Nicolae Iorga College) would consist in considering the wave as a mixture of two certain states (similar to a rectangular wave), each state corresponding to a certain set of parameters stored in a memory cell; thus a small number of coefficients (for multiplying each state before adding them) would be able to describe the wave evolution with a very good approximation. Such an aspect is similar to Heisenberg representation in quantum theory (where state of a particle is always the same and the operators change in time) and it will be studied in the future.

## 4 Conclusions

This study has presented a logic definition for the class of measuring methods based on the wave aspect of matter and for the class of measuring methods based on the corpuscular aspect of matter, using considerations about a possible memory of previous measurements (operators). It has been shown that measurements methods based on transient phenomena (waves) do not imply a memory of previous actions, while methods based on non-transient phenomena imply the existence of certain quantity which keeps its previous value after the end of a measuring procedure.

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