On the velocity of information transmission and physical actions

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Abstract: *Information* and *physical action* have both similar and different features. Moreover, alike to *physical actions*, that have several kinds, *information* can take also different forms.

There were periods, when the study of the *similarities* in the natures of information and physical action prevailed. As FIS discussions demonstrate, the study of their *differences* was featured recently. (Cf., e.g., the interpretations of thermodynamic and informational entropy.) The paper joins this trend, when it discusses a special property of the *transmission of informations*, namely their *velocity*, compared with the transmission of physical actions.

Some kinds of information are transmitted by the way of a physical process. E.g., signals can be transmitted by light, other electromagnetic waves, by electric current, by (electric) signals mediated via neurones, etc. Their velocity is constrained by physical conditions, like the medium that transmits them, and the limited velocity of light and physical actions.

There is a type of informations where belongs e.g., the information on the 'existence' or 'non-existence'. The paper discusses, that the velocity of transmission of this type of information is not limited by just those physical actions, which actually transmit it. A thought experiment will be presented for demonstration, along with calculation of the velocity of the information transmission. As velocity of any phenomenon is considered to belong to the domain of physics, finally, the paper discusses the physical background of non-constrained velocity transmission of certain types of information.

Alike to *physical actions*, that have several kinds, *information* can take also different forms. Although the noun 'information' has no plural, – at least grammatically, based on its everyday meaning – in its scientific usage one can make distinction between different appearances of this wide-scale phenomenon. One can classify informations in several ways, e.g., by disciplines; by the fact whether it is digital or not, and if not, it can be digitalised or cannot; and according to the carrier of the given kind of information, and within this, according to the way of transmission of the information, etc. In the characterisation of the transmission, its velocity plays a considerable role. In the following, I will deal with a special property of the *transmission of informations*, namely their *velocity.* I discuss it compared with the transmission of physical actions.

Physical quantities (like electric current, heat, etc.) can be transmitted in different ways, basically by conductive and convective ways. We speak about *convective transmission*, when macroscopic matter – carrying the given property – transfers from a point *A* to a point *B* together with the action. In the case of *conductive transmission*, the transmission of an action is not necessarily associated with the transport of the massive matter characterised by the given property (e.g., charge), from a point *A* to a point *B*, where the action is transmitted.

Let us distinguish *informations carried by physical actions*, and *informations of non-physical nature*. To make the latter clear, there is a type of informations where belongs, e.g., the information on the 'existence' or 'non-existence'. Something is somewhere or there is missing (at a given moment). Existence-type information belongs to the non-physical type of information.[1]

Some kinds of information are transmitted by the way of a physical process. E.g., signals can be transmitted by light, other electromagnetic waves, by electric current, by (electric) signals mediated via neurones, etc. Information carried by physical action can be transmitted by the velocity of the given physical action. They can be transmitted both in convective and conductive ways. Their velocity is constrained by physical conditions, like the medium, which transmits them, and the limited velocity of light and physical actions. According to one of the most basic principles of physics, no physical action can be transmitted over the speed of light, and this fixed velocity (*c*) is independent of the system of reference where one investigates or measures it.[2]

[1] To avoid misunderstandings, note that, not all information, described in a digital way by “0” and “1” for example, denotes ‘non-existence’ and ‘existence’; “0” and “1” are only notations, and not measures of information, and “0” does not mean certainly the lack of information, and “1” does not mean its existence in all cases certainly; not all information can be digitalised; and finally – e.g., probabilistic – information, can be characterised in a continuous scale.

[2] There is however a physical situation, when the transmission of a signal can exceed *c*: if a beam of light has a tangential component over the angular velocity *c*, the resultant velocity vector can cause a higher transmission speed, than the angular velocity. Nevertheless, in this case the information (i.e., “the illumination of the target”) cannot be classified among the physical informations, although it is transmitted by a physical action. At the moment it is questionable, whether this phenomenon belongs to the model sketched in the rows 3 and 4 of Table 1, or to the category of the relativity paradoxes.

Nature of information	Carrier of information	Transmission of information	Velocity of transmission
Physical	Physical action	Convective	Limited
		Conductive	Limited
Non-physical	Physical action	Convective	Limited
		Conductive	Limited
	Non-physical	Conductive	Not limited

Table 1

Non-physical nature, e.g., existence-type kinds of information can also be transmitted by physical actions. Transmission of non-physical type information by physical actions can be done both in convective and conductive ways. However, there is a difference.

Non-physical nature information can be transmitted not only by physical actions. This is a peculiarity of non-physical nature information. This type of transmission is executed in conductive way. The essence: since this type of information transmission is not carried by a physical action, the velocity of its transmission is not limited by the velocity of light (cf., also Footnote 2). One can transmit – at least existence-type – information from a point *A* to a point *B* in a conductive way, at a speed not limited by the velocity of light.

Let us imagine the following thought experiment. There are 6 chairs in a row in a nursery school, and there are 5 pupils sitting on the chairs. The chair on the left side is empty. The information is, that ‘a chair is empty’. This is an existence-type information, it expresses the missing (i.e., non-existence) of a child on a chair.

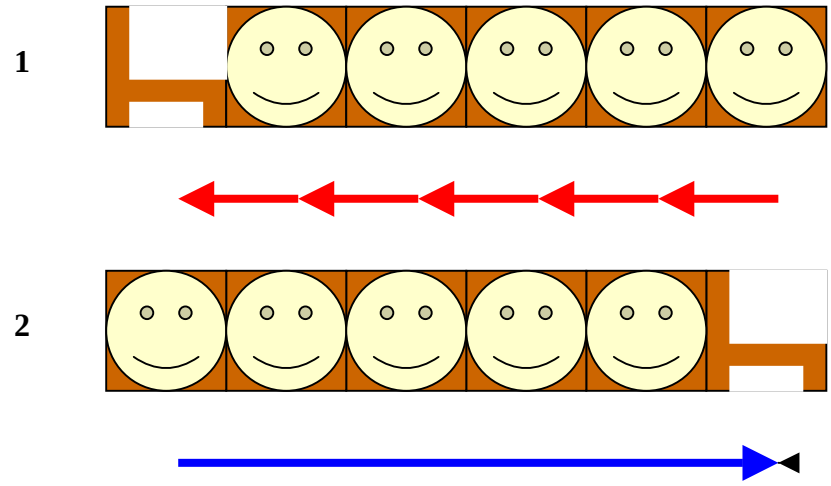

Figure 1

The kindergarten teacher applauds and according to a convention, all children move to sit on the chair left to them. The signal (i.e., the applause) reached all children simultaneously, and all they shifted in the distance of one chair to the left. What happened with the information? The empty chair is now on the right end of the row. During the time while the 5 children

moved to the left in the distance of the width of one chair, the information ‘the empty chair’ shifted the distance of 5 chairs width to the right. Obviously, the velocity of the information was five times higher, than that of the simultaneous physical move of the children in the opposite direction. It is not difficult to imagine the experiment with more children.

This non-physical information transmission is a different kind of conduction, than physical conduction. In physical sense there is no “real conduction”. There is a difference. This kind of conduction demands to meet two conditions:

(a) to have the intermediate elements, since, the “conduction” is mediated by the “one unit shift” of the intermediate elements (and the centre of mass of the whole system shifted only one unit);
(b) to transmit a simultaneous signal to each of the intermediate elements. (This means, this is an energy consuming way of transmitting the information so quickly, this is the price of the speed.)

Note, that this experiment is quite different from the conductive transmission of electric current, when each atom in a crystal lends an electron to its neighbour. In that case, the signal ‘to lend one of your electrons to your next neighbour’ reaches the atoms consecutively, when they have received the signal from their previous neighbour. In our case, the children lend their places to their neighbours simultaneously.

Note also, whereas in the case of a real physical conductive transmission, a signal from outside (e.g., an electric potential difference causing a gradient in the system) is conveyed only to the two ends (points *A* and *B* in Figure 2) of the considered linear system, our experiment assumed that a simultaneous signal was conveyed directly to each elementary object composing the system (condition [b] above).

The situation differs also from the case, when the child, sitting on the right end of the row, stands up and walks to the left end, and sits on the empty chair. He executes a physical movement, and now the ‘information’ is carried by a physical action. He executes a convective way of transmission, and does not demand a signal-induced correlated action of several agents.

Let us generalise this thought experiment. Imagine $(n+1)$ places and n symbolic objects. Let n be a high number, and the objects relatively small, with a length l_0. The length of the line, that the $(n+1)$ objects occupy be $L' = (n+1)l_0$, the length between the middle points of the first and last sections be $L = nl_0$. Let the information be, that ‘a section of l_0 length of the line is not occupied by an object’. In this case, a lamp assigned to that section is lighting. All the lamps assigned to the occupied sections, are switched off.

Let us transmit a signal to each object. Arrange the transmission in such a way, that all objects receive the signal simultaneously (e.g., if we use cables, they should be of identical length). The convention is, that as soon as an object receives the signal, it moves in the same direction (e.g., to the left) along the line at a velocity v_0 in an l_0 distance. In this way, all objects will occupy the previous place of their neighbours. If there was an empty section somewhere at the left end of the line at the point *A* (the lamp assigned to that section was lit), now there will appear an empty section on the right end of the line at point *B*, and its lamp switches on.

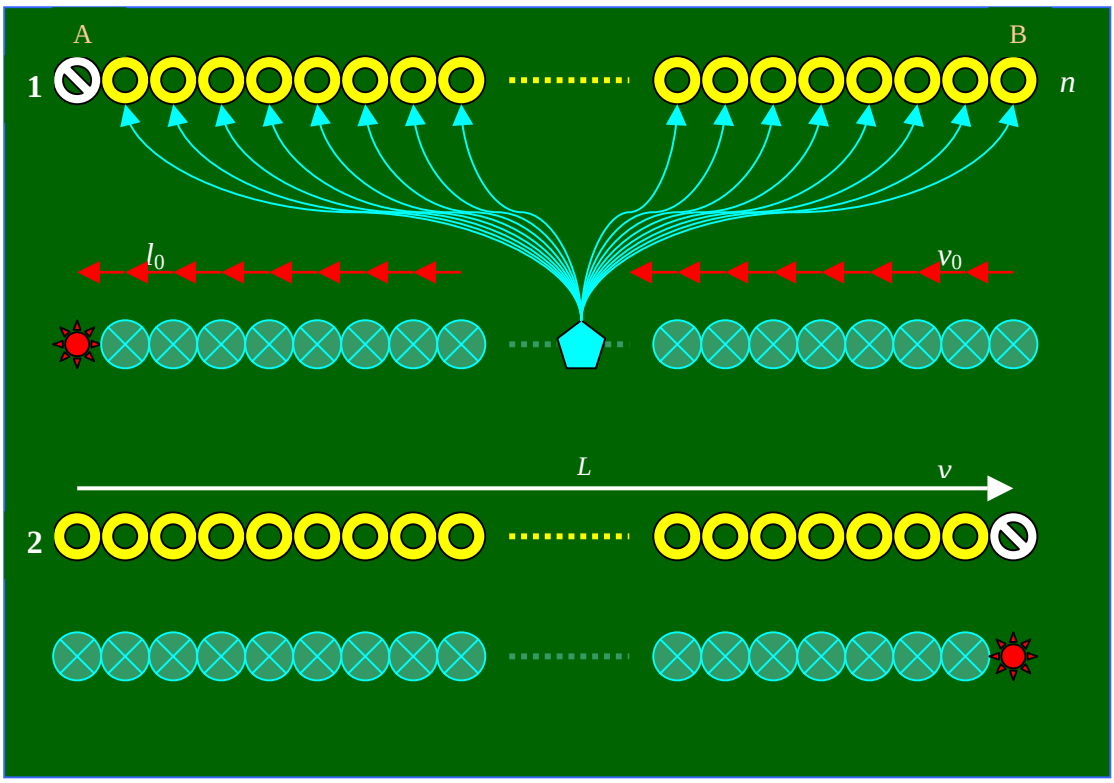

Figure 2

The information moved from the left end of the line to the right end. What was the velocity of the information while it got in point *B* from point *A*?

The duration of this event coincides with the duration, while an object occupies the place of its neighbour at distance l_0: $t = \frac{l_0}{v_0}$. Now the velocity of getting the information from *A* to *B*, at distance $L = nl_0$ is:

$$v = \frac{L}{t} = \frac{nl_0}{\frac{l_0}{v_0}} = nv_0$$

If v_0 is relatively small compared to the *c* velocity of light – e.g., $v_0 = \frac{c}{N}$, where *N* is a large number, and if *N* is large enough, the classical law $v_0 = \frac{l_0}{t}$ can be applied – the velocities v_0 can be added *n* times without applying the Lorentz transformation, for there is physical transport only to an l_0 distance at a non-relativistic velocity v_0.

In this case

$$v = nv_0 = \frac{n}{N}c \qquad (1)$$

In an extreme case, assume that the line between *A* and *B* is divided to very many small sections, where $n > N$ (i.e., $\frac{n}{N} > 1$). Then $v > c$, that means, in principle the transmission velocity of the information may exceed even the velocity of light. This thought experiment demonstrates that the velocity of transmission of this type of information is not limited by just those interim physical actions, which actually locally transmit it.

Demonstrate the reality of this thought experiment on a laboratory-size numeric example. Let it be $l_0 = 1\mu\text{m} = 10^{-6}\text{m}$, $L = 10\text{m}$, and $v_0 = 300\frac{\text{m}}{\text{s}} \approx 10^{-6}c$. Then $n = \frac{L}{l_0} = 10^7$ and $N = 10^6$, consequently $\frac{n}{N} = 10$ and $v = \frac{n}{N}c \approx 10c$.

Summing up, *physical objects and actions cannot, but information can be transmitted in this way* (cf., the bottom row of Table 1). *The presented example shows, that the nature of information differs essentially from the nature of physical objects and physical actions, and that non-physical information can behave* (e.g., be transmitted) *in a quite different way, than those subjects to the laws of physics. Therefore, the laws governing the behaviour of information must be studied separately, according to their own nature, and physical analogies* (although they exist) *must be handled with much care.*

To remain in the pragmatic reality, the >*c* transmission is an extreme, possible example. It exemplifies only, that there is a phenomenon, where the velocities are summed up not according to the Lorentz rule, while *the information was transmitted with a different velocity than the transmitting physical phenomenon* (this is why I called it non-physical transmission). There exist applications in lower velocity systems (where, of course, the application or the non-application of the Lorentz transformation does not play a role). E.g., a control system of a railway network, where a sensor is placed under each section of rail, and gives the signal to the control room, whether there is a wagon over it, or isn't. A lamp is “on” at the control panel board, when the rail section is empty, and it is “off”, when a train is exercising a pressure on the section. The signs move from the front of the train to the tail of the train on the panel board by the described way.

Velocity of any phenomenon is considered to belong to the domain of physics. Therefore, the question is open whether there are physical systems, in which one can convey a simultaneous signal to many, distant objects of the system, and thus to transmit information, that may then induce a physical event? If there are, the investigation can lead to set up new paradoxes or explain old ones. Non-local physical theories are potential candidates, where the discussed situation could be investigated.