FULL SIMULATION OF THE SPECIAL THEORY OF RELATIVITY BY MEANS OF CLASSICAL MECHANICS

V. N. Matveev and O. V. Matvejev
matwad@mail.ru
www.theoryrelativity.com

Based on pre-Einstein classical mechanics, a theoretical model is constructed that describes the behavior of objects in a liquid environment that conduct themselves in accordance with the formal laws of the special theory of relativity. This model reproduces Lorentz contraction, time dilation, the relativity of simultaneity, the Doppler effect in its symmetrical relativistic form, and the twin paradox effects. The model makes it possible to obtain Lorentz transforms and to simulate Minkowski four-dimensional space-time.

All the effects that simulate the effects of the special theory of relativity appear to be absolute in content, but relativistic in form. The relativistic nature of the model and the relativity of the physical effects within the framework of the proposed model are achieved by means of refusing to take the presence of an environment into account and introducing additional conditions. Once such condition consists of replacing the fact of the inequality of the speeds of information dissemination in opposite directions within a moving environment with the assumption of the equality of these speeds.

1. INTRODUCTION

From the moment that it first appeared [1] on up through the present time, Einstein's special theory of relativity has not been viewed as a direct consequence of classical mechanics, and for this reason, no serious attempts have been made to develop a special theory of relativity based on the principals of classical mechanics. True, formal techniques were presented in reference [2] – manipulations or machinations, as the author of this book himself calls them – that make it possible to obtain Lorentz transforms in acoustics. In the work at hand, we demonstrate that a significant number of relativistic effects can be simulated in an environment without manipulations and machinations, the fundamental means for which consist of classical mechanics.

2. SIMULATION OF TIME DILATABILITY WITHIN MOVING ELEMENTS

We will mentally picture a group of barges, R, at rest on the surface of a flat-bottomed water body with a depth of h. Let us suppose that there is a high-speed underwater shuttle with a speed of V that delivers sand from the floor to each of the barges. We will assume that the time required to move sand from the floor onto a shuttle and to offload it from the shuttle onto a barge is negligible as compared the shuttle's time of movement from the barge to the floor and back. Thus, the time required to deliver k shuttles of sand to the barge, Δt, is fixed using the simple formula $\Delta t(k) = 2kh/V$.

We will further assume that a group of barges, R', is also present on the surface of the water body that are drifting on the water in the same direction at a speed of v ($v < V$). A high-speed shuttle is also delivering sand from the floor to each of the drifting barges via the shortest route. In this instance, the vertical component, V_Z (the shuttle submersion and surfacing speed), of the V velocity value is fixed using the formula $V_Z = V\sqrt{1-(v/V)^2}$; thus, to deliver k' boats of sand to a barge moving at a speed of v requires a time of:

$$\Delta t(k') = \frac{2k'h}{V\sqrt{1-(v/V)^2}} \, . \qquad (1)$$

It is clear from formula (1) that the speed of delivery of sand to barges in motion at a velocity of v is $1\big/\sqrt{1-(v/V)^2}$ times shorter than the speed of delivery of sand to barges at rest.

Let us suppose that meters of the quantities of sand reaching the barges and identical clocks with identical faces are placed on the barges. The clocks are set into operation by the sand quantity meters, so that they "tick" at a frequency that is proportionate to the frequency of shuttle movement. The clock hands on the barges drifting at a velocity of v move $1/\sqrt{1-(v/V)^2}$ time more slowly than the clock hands on the barges at rest. We will assume that the speed of movement of the clock hands on the barges at rest equals the speed of movement of the hands on "land-based" clocks – the clocks of outside observers – i.e., we find that the time of t, including its numeric values, also passes identically on the barges at rest. In this instance, we suppose that the clock readings on different barges at rest can differ from one another at a given moment in time (similar to the way that the readings of "land-based" clocks can differ in different time zones) until these readings are no longer synchronized. We will designate the clock reading on a specific barge at rest, r, using the attribute t_r. Unlike our time, t, and the time on the barges at rest, t, we will call the time fixed by the clock readings on barges moving at a speed of v simulated time and will designate it using the attribute t' (with a prime sign). Concerning the simulated time on the drifting barges, t', we will say that it passes more slowly than the time on the barges at rest, t. We will designate the t' clock reading on a specific barge in motion, r', using the attribute $t'_{r'}$ (with prime signs), assuming that, as in the case of the barges at rest, the clock readings on the other drifting barges may differ from one another and from the $t'_{r'}$ readings up until the moment that they become synchronized.

We will assume that the signals from the sand quantity meters in the form of timing pulses proceed not only to the clocks, but also to all the hardware without exception that it located on the barges, thereby setting them into operation at the same rate. The rate of operation (the response rate) of all the hardware on the barges in motion will then be slower than the rate of operation of the hardware on the barges at rest by $1/\sqrt{1-(v/V)^2}$ times.

Let us assume that time intervals of $\Delta t(\Delta n_{time})$ and $\Delta t'(\Delta n'_{time})$ are used as the units of measurement on the barges at rest and the barges in motion, over the course of which the sand quantity meter readings are increased by Δn_{time} and $\Delta n'_{time}$, respectively, so that, being unified and standard, $\Delta n_{time} = \Delta n'_{time}$. In this case, based on our observation results, the Δt time interval and the $\Delta t'$ simulated time interval for any pair of barges in motion relative to one another between two identical events that we recorded will be linked by the correlations

$$\Delta t' = \Delta t\sqrt{1-(v/V)^2} \text{ and } \Delta t = \Delta t'/\sqrt{1-(v/V)^2} \qquad (2)$$

If the unit of measurement of the $\Delta t(\Delta n_{time})$ time on the barges at rest has the same name as the unit of measurement of the $\Delta t'(\Delta n'_{time})$ simulated time on the barges in motion, for example, if both units are called a minute, then according to our observations, it can be said that a minute of simulated time on the barges in motion lasts $1/\sqrt{1-(v/V)^2}$ times longer than a minute of time on the barges at rest.

Let us suppose that accurate documented information (on tangible media) concerning the clock readings on one barge are transmitted to another barge, either directly when these barges meet or by high-speed support boats that cruise on the water surface at a speed of V.

Let us assume that one of the tasks of the hardware on the r and r' barges consists of experimentally confirming the fact of the movement of the r' barge without making contact with the water environment and having information concerning the slowness of the processes on the barge moving through the water environment by means of comparing the passage of time or the rates of hardware operation on the r and r' barges. As strange as it may be, it is impossible to solve this seemingly simple problem under the conditions specified.

First of all, it is not possible to ascertain the slowness of the rate of operation on the barge in motion using any of the instruments that are a part of the hardware on each barge in motion due to the synchronism of the operation of these instruments with the operation of the other instruments and devices. Neither is it possible to ascertain slowness by documentarily tracking the processes on a barge in motion from a barge at rest when a speedboat is used to transfer documented information on operations from barge to barge. If the barges are inertial and they generally do not meet directly, or they only meet once, it is then necessary to transfer information at a distance using a boat at least one time. However, due to the finiteness of the boat's speed, there is a delay in receiving information from the other barge, and a document indicating, for example, the clock reading on the other barge reaches this barge when the clock reading on that other barge is not the same as it was at the time that the boat was dispatched from it. The consequence of this effect is such that, during the transfer of information by boat, it is only possible to obtain symmetrical results that do not make it possible to detect the difference in the clock running rates on the barge at rest, r, and the barge in motion, r'. For example, in making one of the r and r' barges noninertial, if a repeat meeting is ensured for the barges, time dilation then occurs on the noninertial barge, which may also be the r barge, and does not univocally confirm the fact of the r' barge's movement. Or, if boats are dispatched from the r barge to the r' barge with a frequency of f_r, and boats are dispatched from the r' barge to the r barge with a frequency of $f'_{r'}$ (in simulated time) that numerically equals the f_r frequency, then, as is easy to demonstrate, when the barges draw close, the $f'_{r'\leftarrow r}$ and $f_{r\leftarrow r'}$ boat arrival frequencies for the r' and r barges, respectively, are fixed by the symmetrical formulas $f'_{r'\leftarrow r} = f_r \sqrt{1+v/V} / \sqrt{1-v/V}$ and $f_{r\leftarrow r'} = f'_{r'} \sqrt{1+v/V} / \sqrt{1-v/V}$. Being similar to the formulas for the relativistic Doppler effect, these formulas do not make it possible to detect the difference in the clock rate on the r and r' barges.

3. SIMULATION OF THE CONTRACTION OF THE DISTANCE BETWEEN MOVING ELEMENTS

We will tie the Σ and Σ' Cartesian coordinate systems to the groups of barges at rest, R, and in motion, R', respectively, with mutually parallel axes of X and X', Y and Y', and Z and Z'. We will align the Z and Z' system axes perpendicular to the water surface and the X and X' in the direction of movement of the group in motion, R', while we will trace the Y and Y' axes perpendicular to the X, X' and Z, Z' axes, which it is acceptable to do in orthogonal Cartesian coordinate systems. We will assume that the hardware of each of the barges, the makeup of which includes the boats attached to each barge, is capable of independently measuring the distance from a given barge to specific points of the coordinate system tied to it without the involvement of the hardware of the other barges and without the synchronization of the clocks on the different barges. The distance is measured without using long rulers and tape measures. Let us suppose that, within the Σ coordinate system, the hardware of a barge, r, located at the origin of coordinates, O, determines the distance from the O coordinate origin to a certain arbitrarily positioned point, a, within the Σ system in the following manner. A speedboat is dispatched from barge r to point O, which, upon arriving at point a, goes back to point O. The boat trip time there and back, Δt_{OaO}, is determined using the clock readings on barge r at the moments of the boat's departure and return, then the distance is calculated using the expression $\frac{1}{2}\tilde{V}\Delta t_{OaO}$, where $\tilde{V}$ is the average speed of the boat along the route from point O to point a and back. It stands to reason that, within the Σ system, the average speed, $\tilde{V}$, equals the V velocity value. We will designate the distance between point O and point a that the hardware of barge r measures in this manner using the attribute $l(½\Delta t_{OaO})$. We will designate this same distance, but one that we measured or calculated by any available means, using the attribute l_{Oa}. The $l(½\Delta t_{OaO})$ distance and the l_{Oa} distance only differ from one another in the means by which and the location at which they are determined.

We will assume that, within the Σ' coordinate system, the hardware of barge r', which is located at a coordinate origin of O', determines the distance from the O' coordinate origin to point a' of the Σ' system in precisely the same way that this is done in the Σ system. Let us suppose that a value equaling the product of $\frac{1}{2}\tilde{V}'\Delta t'_{O'a'O'}$ is by definition regarded as the distance measured in this way in the case at hand, $l'(½\Delta t'_{O'a'O'})$. Here, $\tilde{V}'$ is simulated; i.e., it is expressed by way of the simulated time, t', the average speed of the boat en route from point O' to point a' and back numerically equals the $\tilde{V}$ velocity value, and consequently the V velocity value, while $\Delta t'_{O'a'O'}$ is the simulated time of movement of the boat along the $O'a'O'$ route. We will call the distance that the hardware of barge r' determines in this manner the simulated distance, $l'(½\Delta t'_{O'a'O'})$.

If a speedboat moves along the Y' axis between point O' and a point lying on the Y' axis with a coordinate of y' (we will call this point the y' point), the V_Y component of the boat's speed, V (the speed of movement of the boat along the segment of a straight line that connects points O' and y'), which we extrinsically fix, will then equal $V\sqrt{1-(v/V)^2}$. Based on our calculations, the conventional distance, $l_{O'y'}$, that we fix between points O' and y' of the moving system, Σ', equals $\frac{1}{2}V\sqrt{1-(v/V)^2}\Delta t_{O'y'O'}$, while according to data from the hardware of barge r', the simulated distance, $l'(½\Delta t'_{O'y'O'})$, between points O'

and y' equals $\frac{1}{2}\tilde{V}'\Delta t'_{O'y'O'}$. Since $\Delta t'_{O'y'O'} = \Delta t_{O'y'O'}\sqrt{1-(v/V)^2}$ according to formula (2), while $\tilde{V}'$ by definition equals V, then

$$l'(\tfrac{1}{2}\Delta t'_{O'y'O'}) = l_{O'y'}. \qquad (3)$$

According to our data, during the movement of a speedboat between point O' and a point with a coordinate of x' that lies on the X' axis (the x' point), the speeds of movement of the boat in the opposite directions relative to these points equal $V - v$ and $V + v$. When the conventional distance between points O' and x' equals $l_{O'x'}$, the time of movement of the boat from point O' to point x' and back, $\Delta t_{O'x'O'}$, equals $l_{O'x'}/(V - v) + l_{O'x'}/(V + v)$; i.e.

$$\Delta t_{O'x'O'} = \frac{2l_{O'x'}}{V(1-v^2/V^2)}. \qquad (4)$$

The conventional average sped of movement of the boat along the X' axis relative to points O' and x' along the route there are back, $\tilde{V}_{X'}$ equals $2l_{O'x'}/\Delta t_{O'x'O'}$, or taking the previous equation into account,

$$\tilde{V}_{X'} = V(1-v^2/V^2). \qquad (5)$$

According to our calculations, the conventional distance between points O' and x' of the moving system Σ, $l_{O'x'}$, equals $\frac{1}{2}\tilde{V}_{X'}\Delta t_{O'x'O'}$, while according to the calculations of the hardware on barge r', the simulated distance between them, $l'(½\Delta t'_{O'x'O'})$, equals $\frac{1}{2}\tilde{V}'\Delta t'_{O'x'O'}$. Since $\tilde{V}_{X'} = V(1-v^2/V^2)$ according to formula (5) and $\Delta t_{O'x'O'}$ equals $\Delta t'_{O'x'O'}\big/\sqrt{1-(v/V)^2}$ according to formula (2), then

$$l'(\tfrac{1}{2}\Delta t'_{O'x'O'}) = l_{O'x'}\big/\sqrt{1-(v/V)^2}. \qquad (6)$$

4. SYNCHRONIZATION OF *R* AND *R′* GROUP (Σ AND Σ' SYSTEM) CLOCKS

We will imagine that the readings of the R group clocks are synchronized in such a manner that they are identical at any moment of our time, t. We will designate the group R time fixed by these readings that are identical for all the group R barges using the attribute t_R. Let us assume that the group R' clocks are also synchronized in such a manner that the sameness of the clock readings on the various R' group barges is ensured at any moment in our time. We will designate the group R' synchronized time using the attribute $t'_{R'}$. Furthermore, we will assume that at a moment in time when the O and O' coordinate origins of the Σ and Σ' systems are located at a single point, the clocks of the barges in both groups will have a zero reading. Thus, it follows from formula (2) that the R and R' group clock readings at any subsequent moment in time at any point within the water body will be linked to one another by the correlations

$$t'_{R'} = t_R\sqrt{1-(v/V)^2} \text{ and } t_R = t'_{R'}\big/\sqrt{1-(v/V)^2} \qquad (7)$$

Not being dependent upon coordinates and unequivocally corresponding to one another, the t_R and $t'_{R'}$ clock readings ensure the single-valuedness (the "absoluteness") of simultaneity in both barge groups. When synchronized clocks are present in the R and R' groups, it is possible to measure distances, lengths, and coordinates in each of these groups not only using the pseudolocation method, but also via the conventional means of combining and comparing them to one another, or using proper length units. Taking into account the fact that $l(O'x') = x–vt$, where x is the coordinate of point x' in the Σ system, and assuming that $l'(½\Delta t'_{O'x'O'}) = x'$, then from equation (6) we obtain the forward transform of the coordinates

$$x' = (x - vt_R)\big/\sqrt{1-(v/V)^2} \qquad (8)$$

The simulated velocity, v', of point O in the Σ' system equals $-x'_O/t'_{R'}$, where x'_O is the coordinate of point O in the Σ' system. Hence, taking x' and $t'_{R'}$ from formulas (7) and (8), we obtain the correlation $v' = v/(1-v^2/V^2)$. Substituting $v = v'(1-v^2/V^2)$ in formula (8), we obtain the transform

$$x\Big/\sqrt{1-(v/V)^2} = x'+v't'_{R'}. \quad (9)$$

Let us suppose that in the groups at rest and in motion, R and R', the distances $l(½\Delta t_{space})$ and $l'(½\Delta t'_{space})$ of the standards constructed from pairs of barges are respectively used as the distance measurement units. We will assume that time intervals of Δt_{space} and $\Delta t'_{space}$ are required in order for a speedboat to traverse each of these distances there and back, so that the numerical values of these intervals are standardized and equal one another.

If the $l(½\Delta t_{space})$ distance unit of the standard at rest has the same name as the $l'(½\Delta t'_{space})$ simulated distance unit of the standard in motion, for example, if both units are called a kilometer, then by analogy with formulas (3) and (6), the simulated and conventional lateral kilometers will equal one another, while the simulated longitudinal kilometer in motion will be $1\Big/\sqrt{1-(v/V)^2}$ times shorter than the conventional kilometer at rest.

5. SIMULATION OF THE SYMMETRY OF RELATIVISTIC EFFECTS

In order to ensure the conditions of synchronism that are accepted in the special theory of relativity, it is necessary to simulate the synchronization of the R' group (Σ' system) clocks in such a manner that the speeds of movement of a boat from the O' coordinate origin to point x' and back to the O' coordinate origin are identical. It is not difficult to demonstrate that the equality of the boat's speeds in opposite directions within the Σ' system can be achieved if, at the moment of the boat's arrival at point x', $t'_{R'}$, the reading of the clocks at this point equal not $t'_{R'}$, but rather $t''_{R'}$, which is $x'v/V^2$ shorter than $t'_{R'}$; i.e., if the equality $t''_{R'} = t'_{R'} - x'v/V^2$ is ensured. In this instance, the v'' and V'' velocities expressed through a time of $t''_{R'}$ will respectively equal the v and V velocities; i.e., $v'' = v$ and $V'' = V$. Taking this into account, from formula (9) and the previous arguments, it is easy to obtain the transforms

$$x = (x'+v''t''_{R'})\Big/\sqrt{1-(v''/V'')^2}, \; y = y', \text{ and } t_R = (t''_{R'}+x'v''/V''^2)\Big/\sqrt{1-(v''/V'')^2}, \quad (10)$$

then the transforms

$$x' = (x-vt)\Big/\sqrt{1-(v/V)^2}, \; y' = y, \text{ and } t''_{R'} = (t_R - xv/V^2)\Big/\sqrt{1-(v/V)^2}. \quad (11)$$

Transforms (10) and (11) are symmetrical and do not differ from the Lorentz transforms, producing all the consequences that stem from this. The R and R' group hardware, which perceives its own proper longitudinal kilometer and its own proper second as representative, perceives the geometric dimensions of the objects of another group, including the dimensions of the kilometer standard, as contracted and the time as dilated.

6. CONCLUSION

The model proposed in the work at hand for simulating the special theory of relativity reveals the possibility of using the fundamentals of classical mechanics to simulate relativistic laws in an environment, which are described using constructs taken from the world environment. The question of the existence of a world environment itself is not addressed in this work, since the possibility of simulating the relativistic phenomena of a nonether world in an environment does not serve as proof of the existence of ether.

REFERENCES

1. Albert Einstein. On the Electrodynamics of Moving Bodies. Annals of Physics, Vol. IV, No. 17, pp. 891–921 (1905).
2. B. Boss. Lectures in Mathematics. Volume 11: Equations in Mathematical Physics. *Librokom* Book House Publishers, Moscow, 2008.