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Einstein's Time Dilation is an Effect of Clock Synchronization

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Towards the end of the 19th century, many physicists attempted to mathematically account for the motion of charged particles relative to the ether using Maxwell's theory. It was found for example that the inertia of charged particles depends on their velocity relative to the ether. Some interesting theoretical studies of the electrodynamics of moving charges was carried out by Lorentz. To simplify his calculations, Lorentz introduced some new variables, for instance the "local time" $t' = t - \frac{v\,x}{c^2}$. Lorentz: *"...The form of this expression suggests the introduction of a new independent variable instead of t ..."* To be able to introduce this variable, magnitudes of the order $\frac{v^2}{c^2}$ were neglected in the calculation [1].

Poincaré found the idea of "local time" ingenious [2] (*"...The most ingenious idea was that of local time..." 1904*) and developed the so-called Lorentz transformation by considering also a back transformation, disregarding the ordinary mathematical rules. Poincaré believed that the Lorentz transformation is a law of nature which prevents to determine the motion relative to the ether. If he had known about Sagnac experiment, he certainly would not have come up with this idea.

Poincaré also described the possibility that two observers moving at the same speed relative to the ether could synchronize their clocks by exchanging light signals [3]. He wrote: *"...Let us suppose that there are some observers placed at various points, and they synchronize their clocks using light signals. They attempt to adjust the measured transmission time of the signals, but they are not aware of their common motion, and consequently believe that the signals travel equally fast in both directions. They perform observations of crossing signals, one traveling from A to B, followed by another traveling from B to A. The local time t is the time indicated by the clocks which are so adjusted..."*

Mathematically this means: An observer A sends a light signal at the time t = 0 and the observer B receives the signal at the time

$$t = \frac{x}{c-v}\,.$$

Observer B believes that the light was traveling with c and he sets his clock to

$$t' = \frac{x}{c}\,.$$

In fact, however, more time has passed, so that a clock set in this way shows a wrong time

$$t' = t\,\frac{c-v}{c} = t - \frac{v\,t}{c} = t - \frac{v\,x}{c^2}\,,$$

where t is replaced in the second term by $\frac{x}{c}$ as an approximation for $\frac{x}{c-v}$.

When the signal is sent back from B to A, the time

$$\tau = \frac{x}{c+v}$$

will elapse. With $\tau' = \frac{x}{c}$ we get

$$\tau' = \tau \frac{c+v}{c} = \tau + \frac{v\,\tau}{c} = \tau + \frac{v\,x}{c^2}\,.$$

The total time for both directions would be

$$T = \frac{x}{c-v} + \frac{x}{c+v} = \frac{2\,x}{c\left(1 - \frac{v^2}{c^2}\right)}$$

but this takes longer than $\frac{2\,x}{c}$, so resynchronization would be necessary immediately. This means that the synchronization of the clocks is not possible in this way.

Later (1904), Poincaré also realized that such synchronization was not possible, and he wrote: *"... The watches adjusted in that way will not mark, therefore, the true time; they will mark what may be called the local time, so that one of them will be slow of the other. It matters little, since we have no means of perceiving it. All the phenomena which happen at A, for example, will be late, but all will be equally so, and the observer will not perceive it, since his watch is slow; so, as the principle of relativity requires, he will have no means of knowing whether he is at rest or in absolute motion.*

Unhappily, that does not suffice, and complementary hypotheses are necessary; it is necessary to admit that bodies in motion undergo a uniform contraction in the sense of the motion..."

But it has been shown, as GPS proves, that synchronization is possible without a contraction hypothesis, if the distances between clocks are known. This is true both for clocks on the surface of the Earth and for clocks located at a certain distance from each other in empty space (satellites). It is only necessary to give up the hypothesis of the constancy of the speed of light.

Poincaré admitted that one could detect the error of synchronization with other signals than light [2]: *"...What would happen if one could communicate by non-luminous signals whose velocity of propagation differed from that of light? If, after having adjusted the watches by the optical procedure, we wished to verify the adjustment by the aid of these new signals, we should observe discrepancies which would render evident the common translation of the two stations. And are such signals inconceivable, if we admit with Laplace that universal gravitation is transmitted a million times more rapidly than light? ..."*

For us is sufficient to state from a philosophical point of view that with infinitely fast signals all clocks would be exactly synchronized. There can be no question of a relativity of time.

After Poincaré analyzed different principles from his point of view, he came to the conclusion (1904): *"Perhaps, too, we shall have to construct an entirely new mechanics that we only succeed in catching a glimpse of, where, inertia increasing with the velocity, the velocity of light would become an impassable limit. The ordinary mechanics, more simple, would remain a first approximation, since it would be true for velocities not too great, so that the old dynamics would still be found under the new."*

Here Poincaré made the mistake of mixing the pure mechanical energy of an uncharged particle, which has nothing to do with electrodynamics, with the energy of the electromagnetic field of a charged particle. The electromagnetic energy of a charged particle does not depend on the mechanical mass of the particle, but on the electrical charge of the particle. The second point is that Poincaré did not realize that the motion of the observer cannot affect the motion of the other (moving) object and that a velocity up to 2c would be possible. This is the case, for example, when 2 electrons are moving towards each other in an accelerator with the velocities close to c. Evidently, Poincaré introduced many unnecessary problems into physics. But all conjectures of Poincaré were taken over by Einstein as "laws of nature".

Lorentz changed his local time variable many times and in 1904 he wrote

$$t' = t\sqrt{1-\frac{v^2}{c^2}} - \frac{\frac{v\,x}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}\ ,\ x' = \frac{x}{\sqrt{1-\frac{v^2}{c^2}}}$$

which Poincaré reformulated in 1905 to give a symmetric system of equations:

$$t' = \frac{t+\epsilon\,x}{\sqrt{1-\epsilon^2}}\ ,\ x' = \frac{x+\epsilon\,t}{\sqrt{1-\epsilon^2}}$$

$$t = \frac{t'-\epsilon\,x'}{\sqrt{1-\epsilon^2}}\ ,\ x = \frac{x'-\epsilon\,t'}{\sqrt{1-\epsilon^2}}\ ,$$

where ϵ is the ratio of v and c and c was set to 1 [4]. Einstein used minus signs and he wrote [5]

$$t' = \frac{t-\frac{v\,x}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}\ ,\ x' = \frac{x-v\,t}{\sqrt{1-\frac{v^2}{c^2}}}\ .$$

The time variable was now the Lorentz old "local time" multiplied by the gamma factor.

By the introduction of the gamma factor either the units of time and length or the quantities time and length themselves were changed in such a way that a synchronization of the clocks seemed possible. Since it is excluded that a mathematical transformation can have an influence on the true physical quantities, a new hypothesis had to be introduced - the motion relative to the ether should influence the clocks and the distances. For material objects such a possibility would be conceivable, but not for empty spaces, if e.g. 2 clocks in a certain distance to each other, in empty space, one moves behind the other with the same speed. The movement relative to the empty space is not definable, i.e. it is impossible to know whether something moves in respect to the empty space or not.

But it came even more blatant, Einstein claimed that coordinate systems and true time change when coordinate systems are considered to be moving. According to Einstein, the clock that is in front, when considered to be moving, is synchronized so that it is always running slow compared to the clock behind. This would be the case for motion through the ether, but in empty space there are no reference points which could adjust the speed of light. Moreover, since motion is relative, the clocks in empty space can consider themselves to be at rest or to be moving. The assertion that an object moves in empty space or is at rest makes no sense.

Synchronization causes clocks to lose their synchronicity when they are considered to be moving, Einstein claims (the desynchronization in the moving system was named by Einstein "relativity of simultaneity"). Relevant is the distance between the clocks and the imaginary speed of movement of the coordinate system. The same time difference would result if one clock were stationary and the other clock were moving away from the first clock at the same speed to the same distance. The "moving" clock would be "slowed down" by the same amount of time as if it were synchronized in the moving system at the same distance.

References

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