5. Equivalence of Lorentz's transformation and the Doppler effect for the light : longitudinal case

5.1 Introduction

The current chapter deals with Lorentz's transformation and the Doppler effect in the longitudinal case that is to say when the movement of the source is parallel to the light ray that it emits. The Lorentz's transformation is established in the particular case of the light and it's shown that the obtained formulas are exactly the ones that describe the longitudinal relativistic Doppler effect. Afterwards, it is assumed that there is a medium for the propagation of light. It will be explained at the end of the next chapter why the Morley-Michelson experiment with an interferometer has a negative result and therefore doesn't make it possible to highlight the existence of this medium of propagation.

From this medium of propagation, it is possible to deduce a Preferred Frame of Reference.
It is also introduced a model of the photon made of N entities called "vortex" regularly spaced, that concentrate the energy of the photon and have for medium of propagation the one of the light.
By using the proposed model of the photon, the rest of the chapter deals successively with the case of a light source in motion with regard to the Preferred Frame of Reference, the case of a receiver in motion with regard to the Preferred Frame of Reference and finally the case where the source and the receiver are both in motion with different speeds with regard to the Preferred Frame of Reference.

The study of these different cases using the proposed model of the photon shows that **the Doppler effect is the visible physical result, measurable of the composition of speeds for the light by change of referential.**
It also shows that **the constancy of the speed of light is apparent.**
It shows that the role of the source and the receiver are not symmetrical or identical with regard to the Preferred Frame of Reference :

- the movement of the source modifies really, physically the line of vortices constituting the photon in the Preferred Frame of Reference ;
- the receiver, moving with regard to the Preferred Frame of Reference, doesn't modify at all the line of vortices constituting the photon in the Preferred Frame of Reference. Only at the moment of the reception of the photon, of the absorption of the line of vortices, the receiver will deduce an apparent wavelength and an apparent speed of the photon in conformity with the formulas issued by the Lorentz's transformation.

Thus, this study shows that the direct and inverse Lorentz's transformations are not equivalent :

- the movement of the source with regard to the Preferred Frame of Reference gives place to real effects in accordance with Lorentz's vision ;
- the movement of the receiver with regard to the Preferred Frame of Reference gives place to observational or apparent effects in accordance with Einstein's vision.

Finally, when we want to go directly from the referential of the source to the referential of the receiver, this is possible thanks to the **TRANSITIVITY** of Lorentz's transformation even if we want to know the complete physical reality, it is necessary to go through the Preferred Frame of Reference.

5.2 Lorentz's transformation for the light

The equations of the Lorentz's transformation between two frames of reference R and R' can be written :

$$\begin{cases} x = \gamma\left(x' + V.t'\right) \\ t = \gamma\left(t' + \dfrac{V}{c^2}x'\right) \end{cases} \quad \text{or} \quad \begin{cases} x' = \gamma\left(x - V.t\right) \\ t' = \gamma\left(t - \dfrac{V}{c^2}x\right) \end{cases} \quad \text{where } V = V_{R'/R} \text{ and } \gamma = \left(1 - \frac{V_{R'/R}^2}{c^2}\right)^{-1/2}.$$

In the following, I would rather use $\begin{cases}\Delta x = x_2 - x_1 \\ \Delta t = t_2 - t_1\end{cases}$ and $\begin{cases}\Delta x' = x'_2 - x'_1 \\ \Delta t' = t'_2 - t'_1\end{cases}$ because I consider that the reasoning is actually carried out over lengths (spatial difference) and durations (time difference).
Lorentz's equations are therefore written :

$$\begin{cases}\Delta x = \gamma(\Delta x' + V.\Delta t') & (1a) \\ \Delta t = \gamma\left(\Delta t' + \frac{V}{c^2}\Delta x'\right) & (2a)\end{cases} \quad \text{and} \quad \begin{cases}\Delta x' = \gamma(\Delta x - V.\Delta t) & (1'a) \\ \Delta t' = \gamma\left(\Delta t - \frac{V}{c^2}\Delta x\right) & (2'a)\end{cases}$$

By setting $v_x = \frac{\Delta x}{\Delta t}$ and $v'_x = \frac{\Delta x'}{\Delta t'}$ (for $\Delta t \neq 0$ and $\Delta t' \neq 0$), we can write :

$$\boxed{\begin{cases}\Delta x = \gamma\left(1 + \frac{V}{v'_x}\right)\Delta x' \\ \Delta t = \gamma\left(1 + \frac{V.v'_x}{c^2}\right)\Delta t'\end{cases}} \begin{matrix}(1b) \\ (2b)\end{matrix} \quad \text{and} \quad \boxed{\begin{cases}\Delta x' = \gamma\left(1 - \frac{V}{v_x}\right)\Delta x \\ \Delta t' = \gamma\left(1 - \frac{V.v_x}{c^2}\right)\Delta t\end{cases}} \begin{matrix}(1'b) \\ (2'b)\end{matrix}$$

This presentation is interesting because it is closer to a formulation $\Delta x' = K_x.\Delta x$ and $\Delta t' = K_t.\Delta t$ and it allows to find very quickly the relativistic composition of speeds :

$$v_x = \frac{\Delta x}{\Delta t} = \frac{\gamma\left(1 + \frac{V}{v'_x}\right)}{\gamma\left(1 + \frac{V.v'_x}{c^2}\right)} \frac{\Delta x'}{\Delta t'} = \frac{v'_x + V}{1 + \frac{V.v'_x}{c^2}}.$$

Likewise, we have : $v'_x = \frac{\Delta x'}{\Delta t'} = \frac{\gamma\left(1 - \frac{V}{v_x}\right)}{\gamma\left(1 - \frac{V.v_x}{c^2}\right)} \frac{\Delta x}{\Delta t} = \frac{v_x - V}{1 - \frac{V.v_x}{c^2}}$.

Note : by setting $\beta_V = V/c$ and $\beta' = v'_x/c$, we have :
$\boxed{\Delta x = \gamma(1 + \beta_V / \beta')\Delta x'}$ and $\boxed{\Delta t = \gamma(1 + \beta_V \beta')\Delta t'}$.

This presentation makes it possible to deduce easily the relations concerning the light itself.
Indeed, for a light ray of speed $v'_x = c$ with regard to R', we have :

$$\begin{cases}\Delta x = \gamma\left(1 + \frac{V}{c}\right)\Delta x' \\ \Delta t = \gamma\left(1 + \frac{V.c}{c^2}\right)\Delta t'\end{cases} \quad \text{that is to say} \quad \begin{cases}\Delta x = \sqrt{\frac{1 + \frac{V}{c}}{1 - \frac{V}{c}}}\Delta x' \\ \Delta t = \sqrt{\frac{1 + \frac{V}{c}}{1 - \frac{V}{c}}}\Delta t'\end{cases} \quad \text{or} \quad \boxed{\begin{cases}\Delta x = \sqrt{\frac{c + V}{c - V}}\Delta x' \\ \Delta t = \sqrt{\frac{c + V}{c - V}}\Delta t'\end{cases}}.$$

Likewise, we have: $\begin{cases} \Delta x' = \gamma\left(1-\frac{V}{c}\right)\Delta x \\ \Delta t' = \gamma\left(1-\frac{V.c}{c^2}\right)\Delta t \end{cases}$ that is to say $\begin{cases} \Delta x' = \sqrt{\frac{1-\frac{V}{c}}{1+\frac{V}{c}}}\Delta x \\ \Delta t' = \sqrt{\frac{1-\frac{V}{c}}{1+\frac{V}{c}}}\Delta t \end{cases}$ or $\boxed{\begin{cases} \Delta x' = \sqrt{\frac{c-V}{c+V}}\Delta x \\ \Delta t' = \sqrt{\frac{c-V}{c+V}}\Delta t \end{cases}}$.

By setting $K = \sqrt{\frac{c+V}{c-V}}$ we have : $\begin{cases} \Delta x = K.\Delta x' \\ \Delta t = K.\Delta t' \end{cases}$ and $\begin{cases} \Delta x' = K^{-1}.\Delta x \\ \Delta t' = K^{-1}.\Delta t \end{cases}$.

The benefit of these formulas is that we understand and verify directly that the speed of light is the same in the referential R and R' :

$$c = \frac{\Delta x}{\Delta t} = \frac{K.\Delta x'}{K.\Delta t'} = \frac{\Delta x'}{\Delta t'} = c.$$

5.3 Doppler effect for the light

Let's assume that a photon is made of N "entities" regularly spaced with the wavelength λ_0 associated with the frequency ν_0 of the photon and that the energy of the photon is concentrated in these N entities and not uniformly distributed in the volume occupied by the photon. I will call these entities "vortices" further.

Let's assume that there is a medium in which these entities propagate. This medium allows to define a Preferred Frame of Reference (PFR).

5.3.1 1st case : the source and the receiver are fixed with regard to the Preferred Frame of Reference

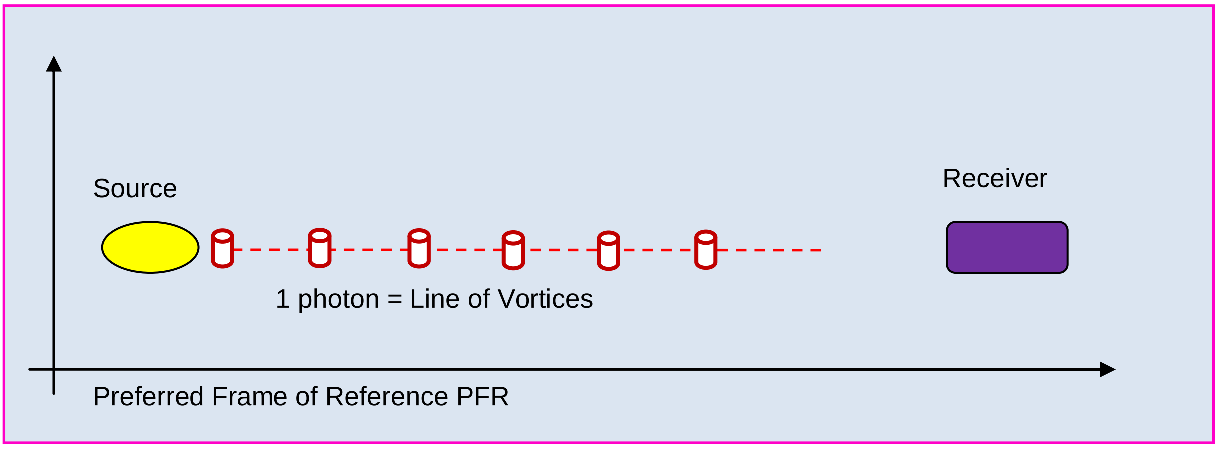

Figure 1 : Source emitting a line of vortices

The source emits vortices every T_0 (in the Preferred Frame of Reference or the referential linked to the source since the source is stationary with regard to PFR).
At this period corresponds the frequency $\nu_0 = 1 / T_0$ and the wavelength $\lambda_0 = c.T_0$.

The receiver absorbs the photon, that is to say the vortices with also a duration T_0 between the absorption of each vortex.
The absorption frequency of the photon is therefore also well $\nu_0 = 1 / T_0 = c / \lambda_0$.

5.3.2 2nd case : Ia the source is moving with regard to the Preferred Frame of Reference

We are assuming in this case that the source is moving with regard to the Preferred Frame of Reference with a constant speed V (the attributed sign to this speed depends on the direction of the source with regard to the light. If the source goes in the same direction of the light, the sign is positive; if the source goes in the reverse direction of the light the sign is negative).

The **speed** of the vortices with regard to the Preferred Frame of Reference doesn't rely on the speed of the source with regard to the Preferred Frame of Reference. Once an atom has emitted a vortex, the latter behaves like a wave with a propagation speed equals to the speed of light with regard to the Preferred Frame of Reference.
On the other hand, the distance between two vortices measured in the Preferred Frame of Reference depends on the speed of the source with regard to the Preferred Frame of Reference : if the source goes in the same direction as the light, this will “tighten” the vortices of the line (the distance between two consecutive vortices will be smaller) and if the source goes in the reverse direction of the light, this will “enlarge” the line of vortices (the distance between two consecutive vortices will be bigger).

All the reasoning below are made in the Preferred Frame of Reference.
Let's assume that the source emits the first vortex at the instant t_0 when it is located at the position x_0.
The source emits the second vortex at the instant $t_0 + T_{source/PFR}$ where $T_{source/PFR}$ represents the period T_0 measured in the Preferred Frame of Reference (the period T_0 representing the duration between the transmission of two consecutive vortices in the referential of the source).
The source behaves like a fixed clock in the referential linked to source of period T_0. The period of the source MEASURED in the Preferred Frame of Reference is given by the relation :

$T_{source/PFR} = \gamma . T_0$ with $\gamma = \left(1 - \frac{V^2}{c^2}\right)^{-1/2}$.

At the instant $t_0 + T_{source/PFR}$, the first vortex is located at the position $x_1 = x_0 + c.T_{source/PFR}$ and the second vortex is located at the position $x_2 = x_{source}(t_0 + T_{source}/_{PFR}) = x_0 + V.T_{source/PFR}$.
The wavelength measured in PFR that is to say the distance between two consecutive vortices measured in the PFR is therefore :

$$\lambda_{PFR} = \Delta x = x_1 - x_2 = (c - V).T_{source/PFR} = (c - V).\gamma.T_0 = \sqrt{\frac{c-V}{c+V}}.c.T_0 = \sqrt{\frac{c-V}{c+V}}.\lambda_0 < \lambda_0$$ where

λ_0 represents the distance separating two vortices when the source is stationary with regard to the Preferred Frame of Reference PFR (and not the wavelength in the referential of the source in the present case where the source is in motion with regard to the Preferred Frame of Reference).

The duration for a vortex at the speed c in the Preferred Frame of Reference to cover the distance λ_{PFR} is $T_{PFR} = \frac{\lambda_{PFR}}{c} = \sqrt{\frac{c-V}{c+V}}.T_0 < T_0$ and the frequency of arrival of the vortices seen by a receiver fixed with regard to the Preferred Frame of Reference is $\nu_{PFR} = \frac{c}{\lambda_{PFR}} = \frac{1}{T_{PFR}} = \sqrt{\frac{c+V}{c-V}}.\nu_0 > \nu_0$.

The receiver that is fixed with regard to the Preferred Frame of Reference will absorb the photon with characteristics λ_{PFR} and T_{PFR} which are written : $\begin{cases} \lambda_{PFR} = \sqrt{\dfrac{c-V}{c+V}}\lambda_0 \\ T_{PFR} = \sqrt{\dfrac{c-V}{c+V}}T_0 \end{cases}$.

We exactly recognise the equations established in the paragraph about the Lorentz's transformation for the light : $\begin{cases} \Delta x = \sqrt{\dfrac{c-V}{c+V}}\Delta x' \\ \Delta t = \sqrt{\dfrac{c-V}{c+V}}\Delta t' \end{cases}$.

Important note :
– When the source is stationary with regard to the Preferred Frame of Reference, the period T_0 of emission of vortices (comparable to the fixed clock of period T_0) equals the duration that a vortex takes to cover the distance λ_0.
– When the source has a speed **V = $\mathbf{V_{R'/R}}$ = $\mathbf{V_{source/PFR}}$** with regard to the Preferred Frame of Reference, the duration between the emission of two consecutive vortices by the source is $T_{source/PFR} = \gamma . T_0$ with $\gamma = \left(1 - \dfrac{V^2}{c^2}\right)^{-1/2}$ whereas the duration taken by a vortex to cover the distance λ_{PFR} is $T_{PFR} = \dfrac{\lambda_{PFR}}{c} = \sqrt{\dfrac{c-V}{c+V}}.T_0$.

In the case where the source has a speed –V with regard to the Preferred Frame of Reference (the source goes in the reverse direction of the light), the wavelength λ_{PFR} and the duration T_{PFR} measured in the Preferred Frame of Reference has for expression :

$\begin{cases} \lambda_{PFR} = \sqrt{\dfrac{c+V}{c-V}}\lambda_0 \\ T_{PFR} = \sqrt{\dfrac{c+V}{c-V}}T_0 \end{cases}$ which is comparable to the Lorentz's transformation : $\begin{cases} \Delta x = \sqrt{\dfrac{c+V}{c-V}}\Delta x' \\ \Delta t = \sqrt{\dfrac{c+V}{c-V}}\Delta t' \end{cases}$.

Conclusion : the Lorentz's transformation applied to the light is equivalent to the relativistic Doppler effect.

5.3.3 3rd case : the receiver is moving with regard to the Preferred Frame of Reference

In this case, let's assume that the receiver is moving with regard to the Preferred Frame of Reference with a constant speed +V, the source being stationary with regard to the Preferred Frame of Reference.

The **distance** between two consecutive vortices measured in the Preferred Frame of Reference is equal to λ_{PFR} and doesn't rely at all on the speed of the **receiver**.
On the other hand, the **duration** between the reception of two consecutive vortices actually rely on the speed of the receiver.

All the reasoning below are carried out in the Preferred Frame of Reference :

- reception of the 1st vortex by the **receiver** at the instant t_0 the receiver occupying the position x_0 ;

- reception of the 2nd vortex by the **receiver** at the instant t_1. In the Preferred Frame of Reference, the 2nd vortex moves at the speed of light c and the distance covered by this 2nd vortex between the instants t_0 and t_1 is :
  $\lambda_{receiver/PFR} = (t_1 - t_0).c = \lambda_{PFR} + (t_1 - t_0).V$ which results in :
  $t_1 - t_0 = \frac{\lambda_{PFR}}{c-V} = T_{PFR}\frac{c}{c-V}$.

In the Preferred Frame of Reference, the period or duration between the reception of two consecutive vortices by the receiver (or the observer) is :

$$T_{receiver/PFR} = t_1 - t_0 = \frac{\lambda_{receiver/PFR}}{c} = \frac{\lambda_{PFR}}{c-V} = T_{PFR}\frac{c}{c-V}$$

therefore the frequency of reception of the vortices :

$$\nu_{receiver/PFR} = \frac{c-V}{\lambda_{PFR}} = \frac{c}{\lambda_{PFR}} - \frac{V}{\lambda_{PFR}} = \nu_{PFR} - \nu_{Doppler}.$$

The distance covered by the n+1th vortex between the reception of the nth vortex and the reception of the n+1th vortex, is in the Preferred Frame of Reference :

$$\lambda_{receiver/PFR} = c.(t_{n+1} - t_n) = c.T_{receiver/PFR} = \frac{c}{c-V}\lambda_{PFR}.$$

A receiver (or observer) is sensitive to the arrival times of the vortices. It has no way to measure the distance that separates the vortices arriving on it, not even to measure the speed of these vortices with regard to it.
In contrast, thanks to its internal clock, the receiver can measure the arrival times of the vortices and therefore deduce a frequency for the photon which represents all the received vortices. For the receiver, it is therefore equivalent to receive :

- N vortices separated by λ_{PFR} and arriving on it with the speed c-V ;
- N vortices separated by $\lambda_{receiver/PFR} = \frac{c}{c-V}\lambda_{PFR}$ and arriving on it with the speed c.

In both cases, the duration between the **reception** of two consecutive vortices is, in the Preferred Frame of Reference : $\boxed{T_{receiver/PFR} = \frac{\lambda_{PFR}}{c-V} = \frac{\lambda_{receiver/PFR}}{c}}$.

Important note :
– the real wavelength is the distance separating two consecutive vortices **at the same moment**. In the Preferred Frame of Reference, it's worth λ_{PFR} in the present case.
– the wavelength $\lambda_{receiver/PFR}$ is an **apparent** wavelength. We deduce it in an erroneous way from the real value of $T_{receiver/PFR}$ (given here in the PFR but we will express it in the referential of the receiver in the following) by assuming in an erroneous way that the light (the line of vortices) arrives on the receiver with the speed c with regard to it. We have already mentioned it, this apparent wavelength corresponds to the distance covered by the n+1th vortex between the reception of the nth vortex and the reception of the n+1th vortex by the receiver.

Finally we need to take in consideration that the clock of the receiver has a different rhythm from a fixed clock with regard to the PFR because of its speed with regard to the PFR (Preferred Frame of Reference).
If we consider that the Preferred Frame of Reference is the referential R and the referential linked to the receiver is the referential R', then we have $V = V_{receiver/PFR} = V_{R'/R}$ and Lorentz's transformation is written : $\begin{cases} x = \gamma(x' + V.t') \\ t = \gamma\left(t' + \frac{V}{c^2}x'\right) \end{cases}$.

The important element is that we have to count the arrival times of vortices with regard to the receiver. So, the receiver is behaving like an internal clock in its referential. Between the reception of two vortices, we have x'$_1$ = x'$_2$ and so $\Delta t = t_2 - t_1 = \gamma.(t'_2 - t'_1) = \gamma.\Delta t'$ that is to say $T_{receiver/PFR} = \gamma.T_{receiver}$ ($T_{receiver}$ is measured in the referential R' linked to the receiver).

We finally get the formula : $T_{receiver} = \frac{T_{receiver/PFR}}{\gamma} = \frac{T_{PFR}}{\gamma}\frac{c}{c-V} = \sqrt{\frac{c+V}{c-V}}T_{PFR}$.

The receiver deduced that the frequency of the photon (group of vortices) is :

$\nu_{receiver} = \frac{1}{T_{receiver}} = \sqrt{\frac{c-V}{c+V}}\nu_{PFR}$ with $\nu_{PFR} = 1/T_{PFR}$ and that the wavelength is :

$\lambda_{receiver} = \frac{c}{\nu_{receiver}} = c.T_{receiver} = \sqrt{\frac{c+V}{c-V}}\lambda_{PFR}$ with $\lambda_{RP} = c / \nu_{RP}$.

The receiver in motion with regard to the Preferred Frame of Reference (in the same direction as the light) will absorb the photon with characteristics $\lambda_{receiver}$ and $T_{receiver}$ which is written :

$$\begin{cases} \lambda_{receiver} = \sqrt{\frac{c+V}{c-V}}\lambda_{PFR} \\ T_{receiver} = \sqrt{\frac{c+V}{c-V}}T_{PFR} \end{cases}.$$

We find back exactly the equations established in the paragraph on Lorentz's transformation for the light :

$$\begin{cases} \Delta x = \sqrt{\frac{c+V}{c-V}}\Delta x' \\ \Delta t = \sqrt{\frac{c+V}{c-V}}\Delta t' \end{cases}.$$

The light covers the distance $\Delta x = \lambda_{PFR}$ during $\Delta t = T_{PFR}$ in the Preferred Frame of Reference and it covers the distance $\Delta x' = \lambda_{receiver}$ during $\Delta t' = T_{receiver}$ in the referential linked to the receiver.
The attentive lector will have written that in this case the sign of the speed V has been reverse with regard to the equations found in the paragraph about Lorentz's transformation for the light.
This is absolutely normal. If we assume that in all the cases, the light is propagating in the direction of x growing, when the source is moving at the speed +V with regard to the Preferred Frame of Reference it goes in the same direction as the light and therefore “contracts” the line of vortices, that is to say the wavelength is physically smaller and the duration (period) necessary to the light to cover this wavelength is shorter (the frequency of the photon is really, physically bigger). On the other hand when the receiver is moving at the speed +V with regard to the Preferred Frame of Reference, it “runs away” from the line of vortices which arrives on him and the measure of the duration between the arrival of two consecutive vortices is bigger than if the receiver was stationary with regard to PFR. The receiver deduces an apparent wavelength bigger than if it were stationary with regard to the PFR.
Actually, the measured period and frequency, observed by the receiver are true, but the wavelength that we deduce is apparent because we assume in an erroneous way that the speed of light with regard to the receiver is c. The vortices constituting the photon have their speed equal to c only in the Preferred Frame of Reference. In any other referential, in particular the one of the receiver, their speed is different from c. For the photon itself, it is the APPARENT speed which is the same and equal to c in all the frames of reference. Only the instants of reception of the vortices acquired with the internal clock of the receiver that allow the deduction of the frequency of the photon count.

5.3.4 4th case : the source and the receiver are in motion with regard to the Preferred Frame of Reference

I refer here to the case where the source and the receiver are in motion with regard to the Preferred Frame of Reference.

As we already established, in the case where the source is in motion with regard to the Preferred Frame of Reference or in the one where only the receiver is in motion with regard to the Preferred Frame of Reference, that the equations giving the wavelength, the period and the frequency of the light are equivalent to the equations of Lorentz's transformation in the case of the light, we simply need to show that Lorentz's transformation in the case of the light is TRANSITIVE.

5.3.4.1 Demonstration of the TRANSITIVITY of Lorentz's transformation in the case of the light

Let's assume that we have three frames of reference R1, R2 and R3 in uniform translation along the same axis with respect to each other with the relative speeds : $V_{R2/R1}$, $V_{R3/R1}$ and $V_{R3/R2}$.
The law of relativistic composition of speeds gives us the following relation :

$$V_{R3/R2} = \frac{V_{R3/R1} - V_{R2/R1}}{1 - \frac{V_{R3/R1}.V_{R2/R1}}{c^2}}$$

We're able to write :

$$c - V_{R3/R2} = c - c^2 \frac{V_{R3/R1} - V_{R2/R1}}{c^2 - V_{R3/R1}.V_{R2/R1}} = c\frac{c^2 - V_{R3/R1}.V_{R2/R1} - c.V_{R3/R1} + c.V_{R2/R1}}{c^2 - V_{R3/R1}.V_{R2/R1}}$$

$$c + V_{R3/R2} = c + c^2 \frac{V_{R3/R1} - V_{R2/R1}}{c^2 - V_{R3/R1}.V_{R2/R1}} = c\frac{c^2 - V_{R3/R1}.V_{R2/R1} + c.V_{R3/R1} - c.V_{R2/R1}}{c^2 - V_{R3/R1}.V_{R2/R1}}$$

Therefore we have : $\frac{c - V_{R3/R2}}{c + V_{R3/R2}} = \frac{c^2 - V_{R3/R1}.V_{R2/R1} - cV_{R3/R1} + cV_{R2/R1}}{c^2 - V_{R3/R1}.V_{R2/R1} + cV_{R3/R1} - cV_{R2/R1}}$

We're able to write this expression in the following way : $\frac{c - V_{R3/R2}}{c + V_{R3/R2}} = \frac{c + V_{R2/R1}}{c - V_{R2/R1}} \frac{c - V_{R3/R1}}{c + V_{R3/R1}}$.

In a range of speed restricted to]-c, +c[for all the speeds, we can therefore write :

$$\boxed{\sqrt{\frac{c - V_{R3/R2}}{c + V_{R3/R2}}} = \sqrt{\frac{c + V_{R2/R1}}{c - V_{R2/R1}}} \sqrt{\frac{c - V_{R3/R1}}{c + V_{R3/R1}}}}.$$

In the case where the three frames of reference are :
- the referential associated to the source of light ;
- the Preferred Frame of Reference ;
- the referential linked to the receiver of light ;

we have :
- $\lambda_{PFR} = \sqrt{\frac{c - V_{source/PFR}}{c + V_{source/PFR}}}\lambda_0$ and $T_{PFR} = \sqrt{\frac{c - V_{source/PFR}}{c + V_{source/PFR}}}T_0$
- $\lambda_{receiver} = \sqrt{\frac{c + V_{receiver/PFR}}{c - V_{receiver/PFR}}}\lambda_{PFR}$ and $T_{receiver} = \sqrt{\frac{c + V_{receiver/PFR}}{c - V_{receiver/PFR}}}T_{PFR}$

And finally we have :

$$\lambda_{receiver} = \sqrt{\frac{c + V_{receiver/PFR}}{c - V_{receiver/PFR}}}\lambda_{PFR} = \sqrt{\frac{c + V_{receiver/PFR}}{c - V_{receiver/PFR}}}\sqrt{\frac{c - V_{source/PFR}}{c + V_{source/PFR}}}\lambda_0$$

that is to say : $$\lambda_{receiver} = \sqrt{\frac{c - V_{source/receiver}}{c + V_{source/receiver}}}\lambda_0 = \sqrt{\frac{c + V_{receiver/source}}{c - V_{receiver/source}}}\lambda_0.$$

Also we have : $$T_{receiver} = \sqrt{\frac{c - V_{source/receiver}}{c + V_{source/receiver}}}T_0 = \sqrt{\frac{c + V_{receiver/source}}{c - V_{receiver/source}}}T_0.$$

Thus, the passage from a referential R1 to another referential R2 seems direct to us and the effects between the two frames of reference seem apparent while taking only in consideration the relative speed of one referential with regard to the other.
In fact, the physical reality cannot be totally known without going through the intermediary of the Preferred Frame of Reference. The physical phenomenon linked to the referential R1 (like the beating of a fixed clock with regard to R1) observed by the Preferred Frame of Reference are REAL just like Lorentz was thinking and like the study of a **source** in motion with regard to the Preferred Frame of Reference shows it. The physical phenomenon linked to the Preferred Frame of Reference observed by any referential R2 are apparent (or only observational) like Einstein was thinking and just like the study of a **receiver** in motion with regard to the Preferred Frame of Reference shows it.
However, thanks to the **transitivity** of Lorentz's transformation, it is possible to go directly from the referential R1 (source) to the referential R2 (receiver) even if to know the detail of what's happening physically, it is necessary to consider two steps :

- a first step to go from the referential R1 (source) to the Preferred Frame of Reference ;
- a second step to go from the Preferred Frame of Reference to the referential R2 (receiver).

The following figure illustrates the words above :

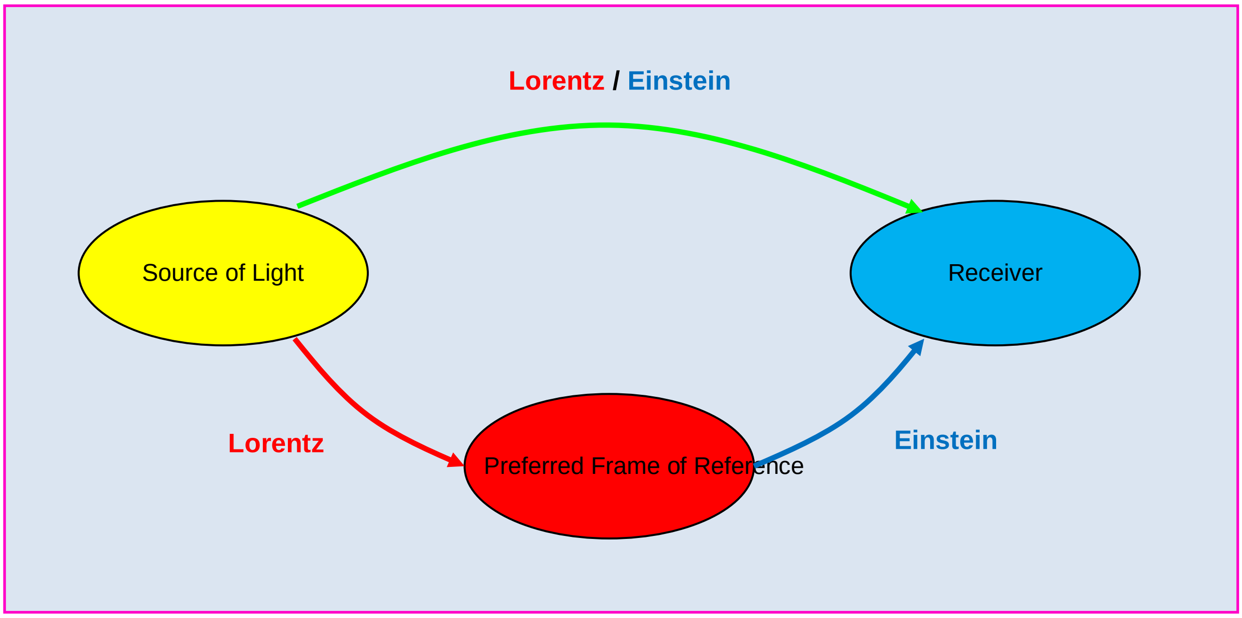

Figure 2 : Real effect (Lorentz) or observational effect (Einstein) of Lorentz's transformation for the light

It is possible to provide details about the scheme above with the two following schemes :

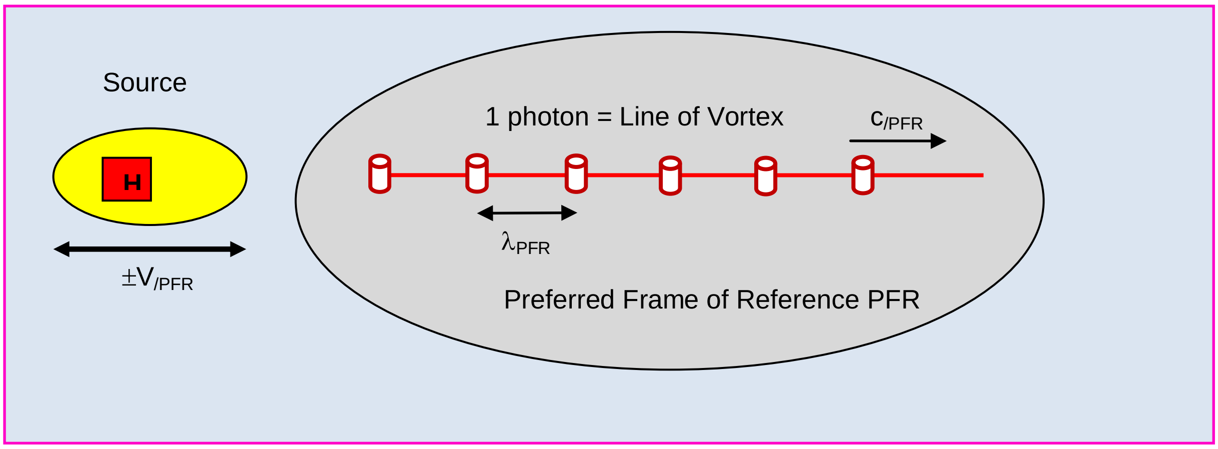

Figure 3 : Real effect due to the movement of the source with regard to the Preferred Frame of Reference PFR

The internal clock of the source has a period T_0 physically different from the period of an identical construction clock fixed with regard to the Preferred Frame of Reference.

According to the value and the sign of the speed of the source with regard to the Preferred Frame of Reference, the wavelength λ_{PFR} and the period T_{PFR} of the line of vortices (photon) will be physically and truly different from the ones corresponding to a line of vortices generated by the same stationary source with regard to the Preferred Frame of Reference (λ_0, T_0).

For example in the case where $V_{source/PFR} = +V$, we have : $\begin{cases} \lambda_{PFR} = \sqrt{\dfrac{c-V}{c+V}}\lambda_0 \\ T_{PFR} = \sqrt{\dfrac{c-V}{c+V}}T_0 \end{cases}$.

Physically we have in the Preferred Frame of Reference : $V_{vortex/PFR} = c = \dfrac{\lambda_0}{T_0} = \dfrac{\lambda_{PFR}}{T_{PFR}}$.

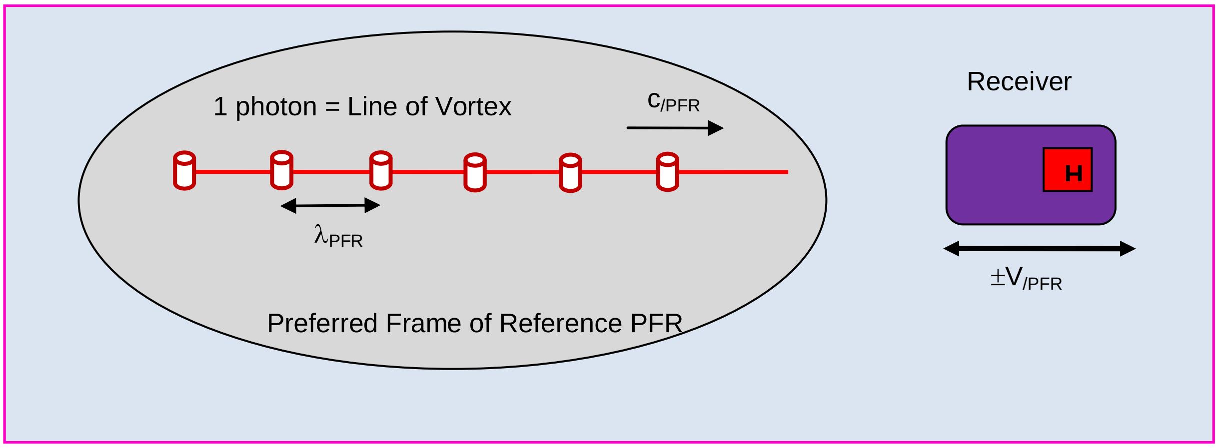

Figure 4 : Observational effect due to the movement of the receiver with regard to the Preferred Frame of Reference PFR

In the Preferred Frame of Reference, the line of vortices (the photon) has the following characteristics : speed $V_{vortex/PFR} = c$, period T_{PFR}, frequency $\nu_{PFR} = 1/T_{PFR}$ and wavelength λ_{PFR}.

As long as the receiver hasn't absorbed the line of vortices, the speed of the receiver doesn't have any influence on the line of vortices which stays physically the same in the Preferred Frame of Reference.

When the receiver absorbs the line of vortices (the photon), the only information that it acquires are the arrival times of the vortices. If its speed is constant with regard to the Preferred Frame of Reference, it deduces a real period $T_{receiver}$ and a real frequency $\nu_{receiver}$ which depend on its internal clock (which period is physically, really different from the one that the clock would have if it was resting with regard to the Preferred Frame of Reference).
On the other hand, from this frequency, we deduce that the wavelength of the photon is $\lambda_{receiver} = c.T_{receiver}$ by assuming that the speed of the photon is c with regard to the receiver.
This wavelength is only apparent, because the real speed of the vortices is c only in the Preferred Frame of Reference.

The following figure helps to understand the difference between the real role of the source on the line of vortices and the apparent role of the receiver. It also helps to understand that in reality :

- we have to apply a first time the Lorentz's transformation between the source and the Preferred Frame of Reference ;
- we need to apply a second time the Lorentz's transformation between the Preferred Frame of Reference and the receiver ;
- finally, these two transformations can be reduced to a single Lorentz's transformation between the source and the receiver by using only the speed of the receiver with regard to the source **thanks to the TRANSITIVITY of the Lorentz's transformation**.

Thus, for a given relative speed of the receiver with regard to the source $V_{receiver/source}$, the final result is always the same whatever the speed of the source with regard to the Preferred Frame of Reference.
However, if we bother to look into detail physically what's happening in the Preferred Frame of Reference, we will realize that, at each different speed of the source with regard to the PFR, there is a different reality for the line of vortices depending of the distance separating the vortices of the line.

The following figure is drawn in the simple case where the speed of the receiver with regard to the source is null. However we need to distinguish three principal cases :

- the source has a null speed with regard to the Preferred Frame of Reference. The distance separating the vortices in the PFR is $\lambda_0 = c.T_0$ where T_0 is the period of the source for the emission of the vortices. The period at which **the receiver receives the vortices is also T_0 ;**
- the source is moving in the same direction than the light with the speed V with regard to the PFR. **This "contracts" the line of vortices observed in the Preferred Frame of Reference**. However, the speed V of the receiver with regard to the PFR makes **the receiver receive the vortices with a period T_0** ;
- the source is moving in the reverse direction of the light with a speed -V with regard to the PFR. **This "expands" the line of vortices observed in the Preferred Frame of Reference.** However, the speed -V of the receiver with regard to the PFR makes that **the receiver receive the vortices with a period T_0**.

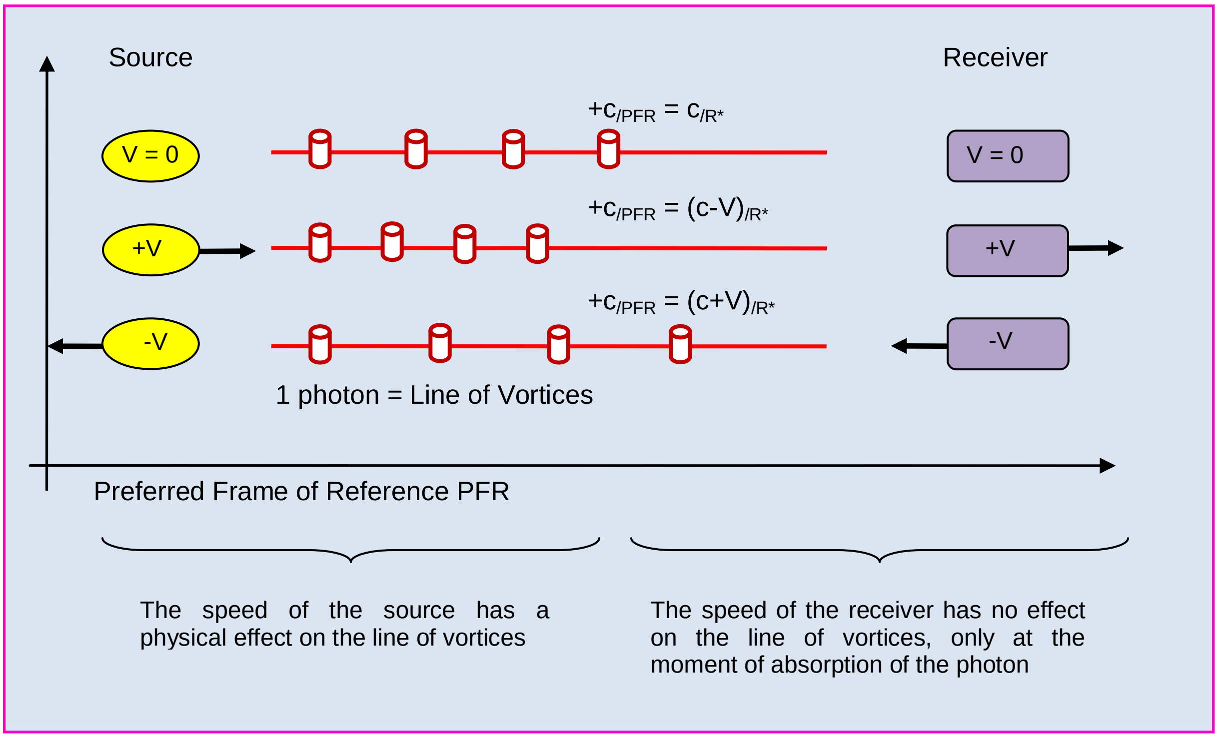

Figure 5 : Three different physical cases while conserving $V_{receiver/source} = 0$

R* refers to the referential linked to the receiver but equipped by thought of clocks which have the same beatings that the ones of the Preferred Frame of Reference and rules with the same length as the ones of the Preferred Frame of Reference.

5.3.4.2 Demonstration of the TRANSITIVITY of Lorentz's transformation in a more general case

The goal of this paragraph is to demonstrate the transitivity of Lorentz's transformation for a body with any speed (therefore we deal with a more general case here than the one of the light with speed c).

Between the frames of reference R and R', we have the relations :

$$\begin{cases} x = \gamma'(x' + V'.t') \\ t = \gamma'\left(t' + \dfrac{V'}{c^2}x'\right) \end{cases} \text{(1) or } \begin{cases} x' = \gamma'(x - V'.t) \\ t' = \gamma'\left(t - \dfrac{V'}{c^2}x\right) \end{cases} \text{(1') where } \mathbf{V' = V_{R'/R}} \text{ and } \gamma' = \left(1 - \frac{V_{R'/R}^2}{c^2}\right)^{-1/2}.$$

Between the frames of reference R et R'', we have the relations :

$$\begin{cases} x = \gamma''(x'' + V''.t'') \\ t = \gamma''\left(t'' + \dfrac{V''}{c^2}x''\right) \end{cases} \text{(2) or } \begin{cases} x'' = \gamma''(x - V''.t) \\ t'' = \gamma''\left(t - \dfrac{V''}{c^2}x\right) \end{cases} \text{(2') where } \mathbf{V'' = V_{R''/R}} \text{ et } \gamma'' = \left(1 - \frac{V_{R''/R}^2}{c^2}\right)^{-1/2}.$$

We need to demonstrate that we have : $\begin{cases} x'' = \Gamma(x' - V_{R''/R'}.t') \\ t'' = \Gamma\left(t' - \dfrac{V_{R''/R'}}{c^2}x'\right) \end{cases}$ with $\Gamma = \left(1 - \dfrac{V_{R''/R'}^2}{c^2}\right)^{-1/2}$.

By using the equations (1) in the equations (2'), we obtain :

$$\begin{cases} x''=\gamma'\gamma''(x'+V'.t')-\gamma'\gamma''\left(t'+\dfrac{V'}{c^2}x'\right) \\ t''=\gamma'\gamma''\left(t'+\dfrac{V'}{c^2}x'\right)-\gamma'\gamma''\dfrac{V''}{c^2}(x'+V't') \end{cases}$$

$$\begin{cases} x''=\gamma'\gamma''\left(1-\dfrac{V'V''}{c^2}\right)x'+\gamma'\gamma''(V'-V'')t' \\ t''=\gamma'\gamma''\left(1-\dfrac{V'V''}{c^2}\right)t'+\gamma'\gamma''(V'-V'')\dfrac{x'}{c^2} \end{cases}$$

The relativistic law of composition of speeds gives us : $V_{R''/R'}=\dfrac{V_{R''/R}-V_{R'/R}}{1-\dfrac{V_{R'/R}.V_{R''/R}}{c^2}}=\dfrac{V''-V'}{1-\dfrac{V'.V''}{c^2}}$.

By setting $\Gamma=\gamma'\gamma''\left(1-\dfrac{V'V''}{c^2}\right)=\gamma'\gamma''\dfrac{V''-V'}{V_{R''/R'}}$, we obtain : $\begin{cases} x''=\Gamma(x'-V_{R''/R}t') \\ t''=\Gamma\left(t'-\dfrac{V_{R''/R'}}{c^2}x'\right) \end{cases}$.

We still need to show that : $\Gamma=\left(1-\dfrac{V^2_{R''/R'}}{c^2}\right)^{-1/2}$.

We have : $\Gamma^{-2}=\left(1-\dfrac{V'^2}{c^2}\right)\left(1-\dfrac{V''^2}{c^2}\right)\dfrac{V^2_{R''/R'}}{(V''-V')^2}$ (for V’ ≠ V’’)

$$\Gamma^{-2}=\left(1-\frac{V'^2+V''^2}{c^2}+\frac{V'^2V''^2}{c^4}\right)\frac{V^2_{R''/R'}}{(V''-V')^2}$$

$$\Gamma^{-2}=\left[1+\frac{V'^2V''^2}{c^4}-\frac{2V'V''}{c^2}-\left(\frac{V'}{c}-\frac{V''}{c}\right)^2\right]\frac{V^2_{R''/R'}}{(V''-V')^2}$$

$$\Gamma^{-2}=\left(1-\frac{V'V''}{c^2}\right)^2\frac{V^2_{R''/R'}}{(V''-V')^2}-\left(\frac{V'}{c}-\frac{V''}{c}\right)^2\frac{V^2_{R''/R'}}{(V''-V')^2}$$

By using the relativistic law of composition of speeds once again, we have :
$\left(1-\dfrac{V'V''}{c^2}\right)^2\dfrac{V^2_{R''/R'}}{(V''-V')^2}=1$ from where we finally obtain : $\Gamma^{-2}=1-\dfrac{V^2_{R''/R'}}{c^2}$.

Therefore for $V_{R''/R'}\in\,]-c\,,\,c[$, we obtain : $\boxed{\Gamma=\left(1-\dfrac{V^2_{R''/R'}}{c^2}\right)^{-1/2}}$.

This transitivity of Lorentz's transformation is already essential within the framework of the Special Relativity of Einstein.
It is VITAL in Lorentz's vision for who the clocks beat really, physically slower when they're in motion with regard to the Preferred Frame of Reference.
We can, for example, consider the following scenario :

- at a certain point of the surface of the Earth (referential R1), the clocks beat physically slower than in the Preferred Frame of Reference ;

- in a train (referential R2) moving on the surface of the Earth, the clock beat physically slower than in the Preferred Frame of Reference (but with a different frequency than the one of the clocks at the surface of the Earth) ;
- finally, thanks to the transitivity of Lorentz's transformation, the clocks in the train (referential R2) seem to beat slower when measured by clocks at the surface of the Earth (referential R2) and it's possible to only take into consideration the relative speed of the train with regard to the surface of the Earth ;
- likewise, still thanks to the transitivity of the Lorentz's transformation, the clocks at the surface of the Earth (referential R1) seem to beat slower when measured by the clock in the train (referential R2) and it's possible to only take into consideration the relative speed of the surface of the Earth with regard to the train.

The following figure illustrates the words above :

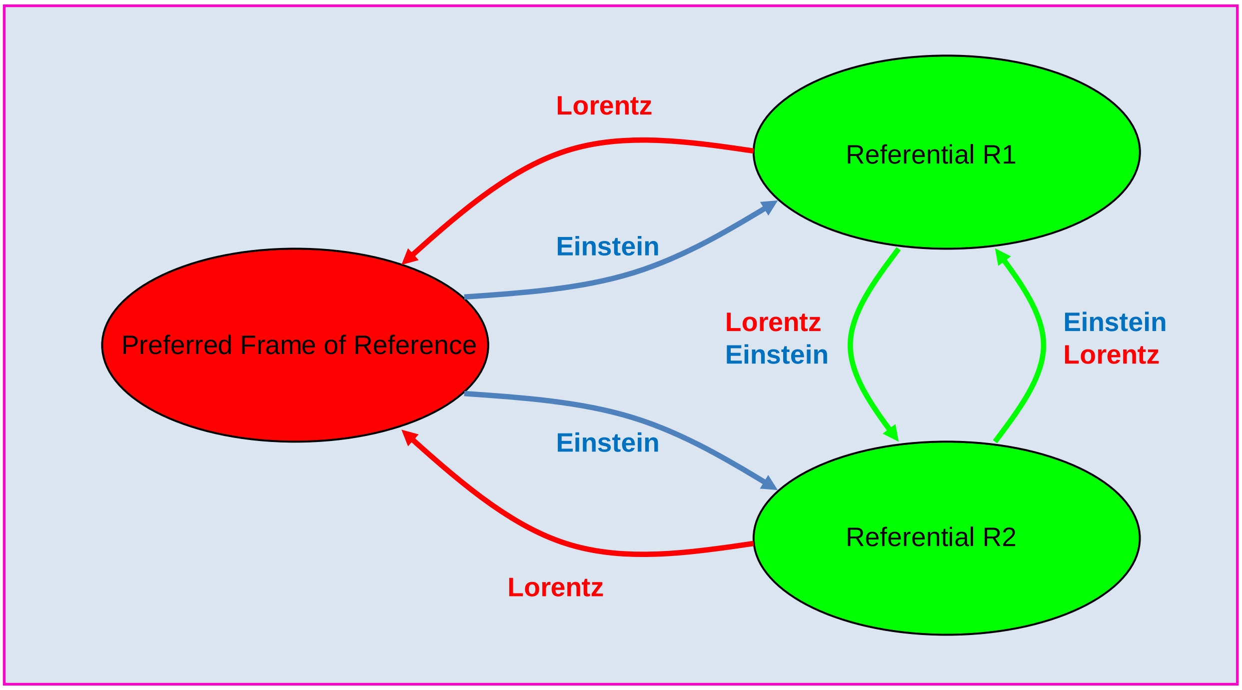

Figure 6 : Real effects (Lorentz) or observational (Einstein) of Lorentz's transformation

Important note : from the transitivity of Lorentz's transformation in the general case and the passage by the Preferred Frame of Reference, we could already deduce that the matter is made of waves (that I call vortices in my theory) to have a behaviour similar to the one of a photon (also made of vortices).

5.4 Conclusion

Lorentz's transformation used in the specific case of the light gives formulas exactly identical to the ones describing the longitudinal relativistic Doppler effect.

The study of different cases using the proposed model of the photon shows that the **Doppler effect is the physical, visible and measurable result of the composition of speeds for the light during a change of referential.**
It also shows that the **constancy of the speed of light is apparent**.

It shows that the role of the source and receiver are not symmetric or identical with regard to the Preferred Frame of Reference :

- the motion of the source modifies really, physically the line of vortices composing the photon in the Preferred Frame of Reference ;
- the receiver, by its movement with regard to the Preferred Frame of Reference doesn't modify in any case the line of vortices constituting the photon in the Preferred Frame of Reference. Only at the moment of the reception of the photon and the absorption of the line of vortices the receiver will deduce an apparent wavelength and an apparent speed of the photon in conformity with the formulas deduced from Lorentz's transformation.

Thus, this study shows that the direct and reverse Lorentz's transformations are not equivalent :
- the movement of the source with regard to the Preferred Frame of Reference gives rise to real effects in accordance with Lorentz's vision ;
- the movement of the receiver with regard to the Preferred Frame of Reference gives rise to observational or apparent effects in accordance to Einstein's vision.

When we want to go directly from the referential of the source to the referential of the receiver, this is possible thanks to the **TRANSITIVITY** of Lorentz's transformation even if to know the complete physical reality, it is necessary to go through the Preferred Frame of Reference.

It's possible to enlarge this concept valid for the light to the matter which rules and clocks are made of. For a rule and a clock in motion with regard to the Preferred Frame of Reference :
- the length of a rule in motion with regard to the Preferred Frame of Reference is physically smaller with regard to the same rule in the Preferred Frame of Reference and the period of a clock in motion with regard to the Preferred Frame of Reference is bigger with regard to the same clock in the Preferred Frame of Reference. The Preferred Frame of Reference is the only referential for which the measure of the contraction of the rule and the measure of the expansion of the period of the clock is **physically true, real**. It's Lorentz's vision ;
- in any referential, the measure of the contraction of the rule and the measure of the expansion of the period of the clock is **apparent**. It's Einstein's vision.

Here again, the **transitivity** of Lorentz's transformation allows to go directly from any referential R1 to any other referential R2.

An observer in the Preferred Frame of Reference sees the real, physical path made by the light (the vortices-light constituting the photons).
An observer in any Galilean referential sees an apparent, observational path made by the light (the vortices-light constituting the photons) due to its movement with regard to the Preferred Frame of Reference.
Furthermore, a receiver can only measure the arrival times of vortices which only inform it about the period (and so the frequency) of the received photons.

Finally, I will finish with a fundamental point of this chapter : to find back the formulas of the relativistic Doppler effect, I've only used two principles :
- the **CLASSIC** composition of speeds applied to the vortices-light ;
- the real expansion of the periods between the Preferred Frame of Reference and the referential of the source ($T_{source/PFR} = \gamma . T_{source}$) and between the Preferred Frame of Reference and the referential of the receiver ($T_{receiver/PFR} = \gamma . T_{receiver}$).