# Special relativistic effects: time distortion and relativity of uniqueness

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**Abstract**

A previous study about the observation of arrays of equivalent clocks shows three results. Time dilation is observed when looking at the same clock. Time contraction is observed when looking at a fixed point. Time invariability is observed when looking at a set of "magic clocks". Time distortion is the effect that is observed when looking at a set of clocks in an array. The set depends on the velocity of observation, which indicates the observed clock in the array and it is independent of the velocity of movement of the array. Time distortion includes time dilation, time contraction, and time invariability. Relativity of uniqueness is an effect that is observed when looking at a single clock in one frame and at a set of clocks in an array in another frame. The observer is only aware of clock readings, that is, without being aware of velocities of observation and other conditions. In this scenario, the observer cannot tell the difference between the single clock in the first frame and the set of clocks in the second frame.

**Keywords:** array of equivalent clocks, relativity of uniqueness, special relativity, time contraction, time dilation, time distortion

**MSC classification:** 83A05

# 1 Introduction

J. H. Field studied the observation of arrays of equivalent clocks (Field, 2000). Time dilation is observed when looking at the same clock. Time contraction is observed when looking at a fixed point. Time invariability is observed when looking at a set of "magic clocks".

These effects can be included in a global effect that depends on the velocity of observation; this global effect is called time distortion. The velocity of observation indicates the observed clock in the array and it is independent of the velocity of movement of the array.

The set of "magic clocks" shows the same time as the single reference clock. This fact leads to the effect that is called relativity of uniqueness because any single clock in one frame shows the same time as a set of clocks in another frame.

In present formulas, $x$ and $t$ are space-time coordinates in the reference frame, $x'$ and $t'$ are coordinates in the moving frame, $v_M$ is the velocity of movement, $v_O$ is the velocity of observation, and $c$ is the speed of light.

# 2 Time distortion

Time distortion is the effect that is observed when looking at a set of clocks in an array of equivalent clocks. The set depends on the velocity of observation.

Starting from the inverse Lorentz boost:

$$t = \gamma \left( t' + \frac{v_M x'}{c^2} \right) \tag{1}$$

$$x = \gamma \left( x' + v_M t' \right) \tag{2}$$

where:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v_M^2}{c^2}}} \tag{3}$$

$$x = v_O t \tag{4}$$

then the time distortion is:

$$t' = \gamma \left( 1 - \frac{v_M v_O}{c^2} \right) t \tag{5}$$

If $v_O = v_M$, then $t' = \frac{t}{\gamma}$; time dilation is observed. If $v_O = 0$, then $t' = \gamma t$; time contraction is observed. If $v_O = \frac{\gamma}{1+\gamma} v_M$, then $t' = t$; time invariability is observed.

# 3 Relativity of uniqueness

Relativity of uniqueness is an effect that is observed when looking at a single clock in one frame and at a set of clocks in an array of equivalent clocks in another frame. The observer is only aware of clock readings.

Two frames are considered; the subscript of variables shows each frame. In the first frame, $v_{O1} = v_{M1}$, thus $t'_1 = \frac{t}{\gamma_1}$; one single clock is observed. In the second frame, general time distortion applies, then $t'_2 = \gamma_2 \left(1 - \frac{v_{M2} v_{O2}}{c^2}\right) t$; a set of clocks is observed. If the observer reads the same time in both frames:

$$\frac{t}{\gamma_1} = \gamma_2 \left(1 - \frac{v_{M2} v_{O2}}{c^2}\right) t \tag{6}$$

therefore:

$$v_{O2} = \left(1 - \frac{1}{\gamma_1 \gamma_2}\right) \frac{c^2}{v_{M2}} \tag{7}$$

If the observer is only aware of clock readings, that is, without being aware of velocities of observation and other conditions, perse cannot tell the difference between the single clock in the first frame and the set of clocks in the second frame. In this scenario, uniqueness of the observed clock is relative.

If $\gamma_1 = 1$, then $v_{O2} = \frac{\gamma_2}{1+\gamma_2} v_{M2}$; the clock in the first frame is equivalent to the reference clock and shows the same time as the set of "magic clocks" in the second frame.

# 4 Conclusion

Regarding the observation of arrays of equivalent clocks, two special relativistic effects are presented:

1. Time distortion is the effect that is observed when looking at a set of clocks in an array; the set depends on the velocity of observation. Time distortion includes time dilation, time contraction, and time invariability.

2. Relativity of uniqueness is an effect that is observed when looking at a single clock in one frame and at a set of clocks in an array in another frame. The observer is only aware of clock readings, that is, without being aware of velocities of observation and other conditions. In this scenario, the observer cannot tell the difference between the single clock in the first frame and the set of clocks in the second frame.

# References

Field JH (2000) Two novel special relativistic effects: Space dilatation and time contraction. American Journal of Physics 68(4):367–374. doi:10.1119/1.19439, arXiv:physics/0004012