Universal Specificity Investigation 6: Inducing the Cause of Total Time Dilation and Total Energy's Relation to Potential Energy

Daniel Harris
Northrop Grumman
Morrisville, USA
daniel.harris2@ngc.com

Prior investigations into the theory of universal specificity found a proper conception of time missed in common practice; which led to the realization that a universally stationary frame (USF) must exist; which led to the discovery that the average effective speed of light, c_0, is identical in all directions for any inertial reference frame, and is a function of that frame's velocity, v, relative to the USF, as shown in Equation (1); which led to discovering the cause of kinetic time dilation, shown Equation (2); which led to revisiting the relativistic kinetic energy and total energy model, shown in Equation (3); which finally led to discovering the cause of gravitational time dilation, also shown Equation (2).

$$c_0 = c\sqrt{1 - \frac{v^2}{c^2}} \tag{1}$$

$$\frac{dt'}{dt} = \sqrt{1 - \frac{w}{e_T}} \tag{2a}$$

$$\frac{dt'}{dt} = \sqrt{1 - \frac{\Delta e_K}{e_T}} \tag{2b}$$

$$\frac{dt'}{dt} = \sqrt{1 - \frac{\Delta e_P}{e_T}} \tag{2c}$$

$$\Delta E_K = \frac{1}{2}mv^2 \tag{3a}$$

$$E_T = \frac{1}{2}mc^2 = \frac{1}{2}mc_0^2 + \frac{1}{2}mv^2 \tag{3b}$$

1. Time Dilation Equivalence

I now relate changes in ITDs to changes in specific total external energy—as in ignoring internal energy, $\frac{1}{2}mc_0^2$—and then I will update the total energy model to include potential energy.

Changes in specific kinetic or specific potential energy are related to changes in ITDs, but each are only half of the picture because we tacitly assumed all else remained equal. Now we test what if all else does not remain equal to discover a more precise cause to changes in ITDs.

In reviewing Equation (2), simple analysis reveals that transferring some amount of specific kinetic energy to some amount of specific potential energy (or vice versa) would not cause an overall change in the ITD. As an example, consider an object with some amount of specific potential energy that then enters a state with equal specific kinetic energy, but without the potential. Equation (4) shows that the two ITDs in each state are equivalent.

$$\text{Let } \Delta \mathrm{e_P} > 0.$$

$$\text{Let } \frac{1}{\gamma} = \frac{dt'}{dt} \tag{4a}$$

$$\frac{1}{\gamma_P^2} = 1 - \frac{\Delta e_P}{e_T} \tag{4b}$$

$$1 - \frac{1}{\gamma_P^2} = \frac{\Delta e_P}{e_T} \tag{4c}$$

$$\left(1 - \frac{1}{\gamma_P^2}\right) e_T = \Delta e_P \tag{4d}$$

$$\Delta e_P \Longrightarrow \Delta e_K \tag{4e}$$

$$\left(1 - \frac{1}{\gamma_P^2}\right) e_T = \Delta e_K \tag{4f}$$

$$1 - \frac{1}{\gamma_P^2} = \frac{\Delta e_K}{e_T} \tag{4g}$$

$$\frac{1}{\gamma_P^2} = 1 - \frac{\Delta e_K}{e_T} \tag{4h}$$

$$\frac{1}{\gamma_P^2} = \frac{1}{\gamma_K^2} \ \blacksquare \tag{4i}$$

Invoking the method of agreement: observing that changes in specific potential energy and changes in specific kinetic energy occurred, while no changes in ITD occurred, proves inductively that they are not the fundamental causes to changes in ITDs—they each play half a role.

The same change in specific total external energy, Δe_t, in each state caused the same change in ITDs. This proves inductively, via method of agreement, that changes in ITD are caused by, Δe_t, and vice versa.

2. The Cause of Total Time Dilation

I begin this causal derivation by trying to solve the ITD for an object stationary within a gravitational field. Then I proceed to determine how a change in kinetic energy, as measured from the stationary position within the gravitational field, affects the overall ITD. This situation is depicted in Figure 1.

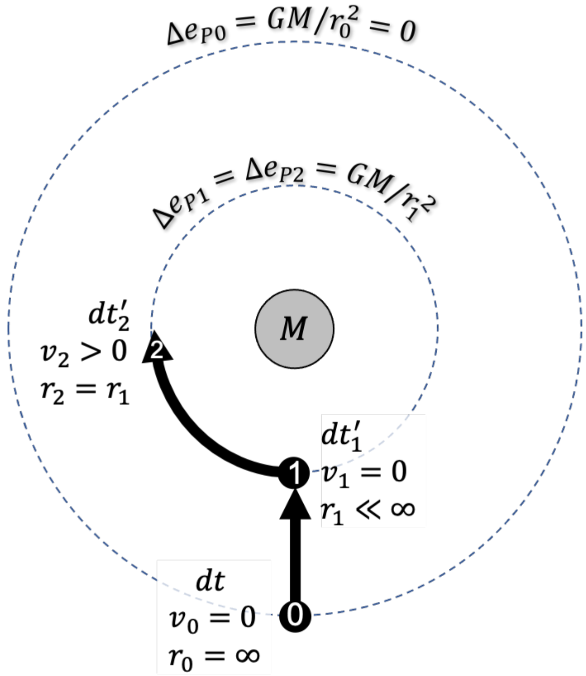

Figure 1. **Total effective time differential example.**

Ultimately, we want to calculate the overall ITD, $\frac{dt_2'}{dt}$, for the moving object within the gravitational field. $\frac{dt_1'}{dt}$ and $\frac{dt_2'}{dt_1'}$ can be measured, and both of these ITDs are relatable to the total effective ITD via the chain rule, as shown in Equation (5).

$$\frac{dt_1'}{dt} = \sqrt{1 - \frac{\Delta e_{P1}}{e_T}} \tag{5a}$$

$$\frac{dt_2'}{dt_1'} = \sqrt{1 - \frac{\Delta e_{K2/P1}}{e_T}} \tag{5b}$$

$$\frac{dt_2'}{dt} = \frac{dt_2'}{dt_1'}\frac{dt_1'}{dt} = \sqrt{1 - \frac{\Delta e_{K2/P1}}{e_T}}\sqrt{1 - \frac{\Delta e_{P1}}{e_T}} \tag{5c}$$

Applying a change in specific kinetic energy after a change in specific potential energy can be generalized to any condition where an object within a gravity potential also has kinetic energy, as shown in Equation (6).

$$\frac{1}{\gamma_T} = \frac{1}{\gamma_{K/P}}\frac{1}{\gamma_P} = \sqrt{1 - \frac{\Delta e_{K/P}}{e_T}}\sqrt{1 - \frac{\Delta e_P}{e_T}} \tag{6a}$$

$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\gamma_P^{-2}\Delta e_{K/P} + \Delta e_P}{e_T}} \tag{6b}$$

$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_K + \Delta e_P}{e_T}} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \blacksquare \tag{6c}$$

$$\text{Where}: \frac{1}{\gamma_{\text{P}}} = \frac{dt_P'}{dt} = \sqrt{1 - \frac{\Delta e_P}{e_T}}$$

$$\frac{1}{\gamma_{K/P}} = \frac{dt_K'}{dt_P'} = \sqrt{1 - \frac{\Delta e_{K/P}}{e_T}}$$

Of note, what the term, $\gamma_P^{-2}\Delta e_{K/P}$, in Equation (6b) tells us is that an object's speed slows down (even light), by a factor of γ_P^{-1}, due to the gravitational time dilation.

Just for completeness one can consider another situation, akin to the last thought experiment in investigation 4, where gravitational effects can be observed after applying kinetic energy, as shown in Equation (8).

$$\text{Let}: \frac{1}{\gamma_{P/K}} = \frac{dt_P'}{dt_K'} = \sqrt{1 - \frac{\Delta e_{P/K}}{e_T}}$$

$$\text{Let}: \frac{1}{\gamma_K} = \frac{dt_K'}{dt} = \sqrt{1 - \frac{\Delta e_K}{e_T}}$$

$$\frac{1}{\gamma_T} = \frac{1}{\gamma_K}\frac{1}{\gamma_{P/K}} = \sqrt{1 - \frac{\Delta e_K}{e_T}}\sqrt{1 - \frac{\Delta e_{P/K}}{e_T}} \tag{8a}$$

$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_K + \gamma_K^{-2}\Delta e_{P/K}}{e_T}} \tag{8b}$$

$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_K + \Delta e_P}{e_T}} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \blacksquare \tag{8c}$$

The term, $\gamma_K^{-2}\Delta e_{P/K}$, in Equation (8b) means that the observed gravitational effects in the moving frame are mis-calibrated by a factor of γ_K^2, which matches the results found in the last thought experiment in Investigation 4.

Therefore, one is able to apply any number of $i = N$ combinations of changes to specific kinetic energy and specific potential energy using the chain rule, as shown in Equation (9).

$$\frac{1}{\gamma_{T,i}} = \prod_{j=1}^{i}\frac{dt_j'}{dt_{j-1}'} = \prod_{j=1}^{i}\sqrt{1 - \frac{\Delta e_{j/j-1}}{e_T}} \tag{9a}$$

$$= \sqrt{1 - \frac{\sum_{j=1}^{i}\frac{1}{\gamma_{T,j-1}^2}\Delta e_{j/j-1}}{e_T}} \tag{9b}$$

$$= \sqrt{1 - \frac{\Delta e_K + \Delta e_P}{e_T}} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \blacksquare \tag{9c}$$

$$\text{Where}: dt_0' = dt,\ \Delta e_{1/0} = \Delta e_1,\ \&\ \frac{1}{\gamma_{T,0}} = 1$$

3. Updating Total Energy Model

I can now use these tools to update the total energy model in Equation (3) to include the potential energy term, along with the other terms—internal energy and kinetic energy—as shown in Equation (10).

$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \tag{10a}$$

$$\frac{1}{\gamma_T^2} = 1 - \frac{\Delta e_t}{e_T} \tag{10b}$$

$$e_T = \frac{1}{\gamma_T^2} e_T + \Delta e_t = e_I + \Delta e_K + \Delta e_P \tag{10c}$$

$$E_T = E_I + \Delta E_K + \Delta E_P \tag{10d}$$

$$\frac{1}{2}mc^2 = \frac{1}{2}mc_0^2 + \frac{1}{2}mv^2 + m\int g(r)dr \blacksquare \tag{10e}$$

4. Conclusion

In conclusion, total time dilation was found to be ultimately caused by a change in specific total external energy, which led to two grand integrations: (1) kinetic and gravitational time dilation are two aspects of the same phenomenon, namely total time dilation, caused by changes in specific total external energy; and (2), total energy must include a potential energy term to be complete.

This investigative series into the theory of universal specificity has developed enough tools and concepts that we can circle back to one of the original questions: is there a way to objectively determine which inertial reference frame is the USF? That is the focus of the next investigation.