The Effect of a Time Dilation Gradient

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The results from previous investigations have lead to updating the total energy model from $E_T = mc^2$ to $E_T = \frac{1}{2}mc^2$, updating the kinetic energy model from $\Delta K = (\gamma - 1)m_0c^2$ to $\Delta K = \frac{1}{2}mv^2$, and inducing their causal relationship to time dilation. Equation (1) shows this newly induced causal model, where dt is the time rate of change for an object traveling in an inertial frame, as measured by some clock in that frame; dt' represents the time rate of change for a stationary object, as measured by an identical clock in its inertial frame; Δe_K is and traveling object's change in specific kinetic energy relative to the stationary frame; and e_T is the traveling object's total specific energy, as measured in the stationary frame. The ratio of time derivatives is termed *inertial time differential* (ITD), which remains constant for any object until work is done to it.

$$\frac{dt}{dt'} = \sqrt{1 - \frac{\Delta K}{E_T}} = \sqrt{1 - \frac{\Delta e_K}{e_T}} = \sqrt{1 - \frac{w}{e_T}} \blacksquare \tag{1}$$

I can now take these concepts and turn to the question: what happens to a body that exists in a time dilation gradient, or what is termed here a *time derivative gradient* (TDG)? Observation reveals that a TDG exists around physical objects, and are defined by Equation (2).

$$\nabla dt \triangleq \frac{dt' - dt}{dr'} \tag{2}$$

$$\begin{aligned}
&\text{Where :} \\
&\quad \nabla dt \text{ is time time derivative gradient} \\
&\quad dt' \text{ is time derivative of an object further away from the gravitational source} \\
&\quad dt \text{ is time derivative of an object closer to the gravitational source} \\
&\quad dr' \text{ is distance between time derivatives}
\end{aligned}$$

An example instrument that can measure a single TDG dimension is shown in in Figure 1.

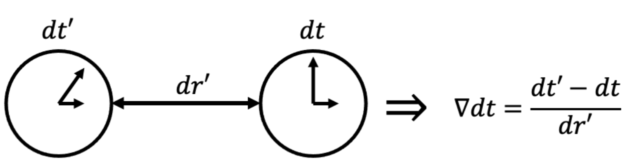

Figure 1. **Single dimension TDG measuring instrument.**

Armed with the cause of ITDs, the existence of TDGs implies that the equivalency principle is falsifiable. As in, free falling is not equivalent to floating in empty space, and being on earth is not equivalent to accelerating in empty space.

The difference is that TDGs do not exist in empty space. This breach of equivalence is well known, yet this principle is accepted as *approximately* true. For example, within a TDG $dt - dt'$ is almost zero for really small spaces, just like they are zero in empty space; however, what this approach seems not to realize is that TDGs are also scaled by inverse dr', meaning TDGs converge to a non-zero value as the limit of dr' approaches zero. Therefore, I am rejecting the equivalence principle.

Since the equivalency principle is being rejected, a new accounting of gravity is required apart from general relativity. Given the ITD causal model shown in Equation (1) and the definition of TDGs in Equation (2), I now deduce the TDG's causal relationship to specific force, $g(r)$, where r is the distance from the gravitational source's center of mass:

$$\nabla dt = \frac{dt' - dt}{dr'} = \frac{dt' - dt'\sqrt{1 - \frac{w}{e_T}}}{dr'} \tag{3a}$$

$$\sqrt{1 - \frac{w}{e_T}} = 1 - \nabla dt \frac{dr'}{dt'} \tag{3b}$$

$$w = e_T \left(1 - \left(1 - \nabla dt \frac{dr'}{dt'}\right)^2\right) \tag{3c}$$

$$\text{Let} : \nabla\tau = \left(1 - \left(1 - \nabla dt \frac{dr'}{dt'}\right)^2\right) \tag{3d}$$

$$\int g(r)dr = e_T \nabla\tau \tag{3e}$$

$$\bar{g} = \frac{e_T}{dr'}\nabla\tau \tag{3f}$$

$$\lim_{r_1 \to r_2} \frac{\int_{r_1}^{r_2} g(r)dr}{\int_{r_1}^{r_2} dr} = \frac{e_T}{dr'}\nabla\tau \tag{3g}$$

$$\text{Let} : \text{g(r)} = \frac{GM}{r^2} \tag{3h}$$

$$GM \lim_{r_1 \to r_2} \frac{\int_{r_1}^{r_2} \frac{1}{r^2}dr}{r_2 - r_1} = \frac{e_T}{dr'}\nabla\tau \tag{3i}$$

$$GM \lim_{r_1 \to r_2} \frac{\frac{1}{r_1} - \frac{1}{r_2}}{r_2 - r_1} = \frac{e_T}{dr'}\nabla\tau \tag{3j}$$

$$GM \lim_{r_1 \to r_2} \frac{\frac{r_2 - r_1}{r_1 r_2}}{r_2 - r_1} = \frac{e_T}{dr'}\nabla\tau \tag{3k}$$

$$\lim_{r_1 \to r_2} \frac{GM}{r_1 r_2} = \frac{e_T}{dr'}\nabla\tau \tag{3l}$$

$$\lim_{r_1 \to r_2} \sqrt{g(r_1)g(r_2)} = \frac{e_T}{dr'}\nabla\tau \tag{3m}$$

$$g(r) = \frac{e_T}{dr'}\nabla\tau \blacksquare \tag{3n}$$

Concrete examples using Equation (3m) for single dimension cases are given in the Appendix. Also, note that $g(r)$ is measuring unit specific force (e.g., Newton per kilogram). A non-zero TDG induces a specific force we call gravity—a force proportional to mass. This is also why everything falls at the same rate, because forces scale with mass—as in, the TDG affects every particle to the same degree—and this is why gravity is indeed a real (specific) force.

A new understanding emerges from the derivation shown in Equation (3): the relationship between changes in specific energy and changes in ITDs are reciprocal causal phenomena—changes in one causes changes in the other. Given that a TDG induces a change in energy (proportional to mass), an object existing in this gradient is said to have specific potential energy. It has the potential to achieve some specific kinetic energy state caused by this gradient.

A change in ITD between the two objects at two different radial distances from a gravitational source is caused by the gravitational field consistent with Equation (1), meaning it is caused by a change in their specific potential energy between the two states. Essentially, however much specific work is required to get from one stationary point in the gradient to another is causally related to their ITD change.

For example, if an object's initial location is at the center of mass of a hollow gravitational source, then the ITD at the center vs some distance away is equal to ITD created by a change in specific kinetic energy necessary for the apex of the trajectory to reach said distance, as show in Figure 2. This is because this is how much specific work is done by the TDG between the two points.

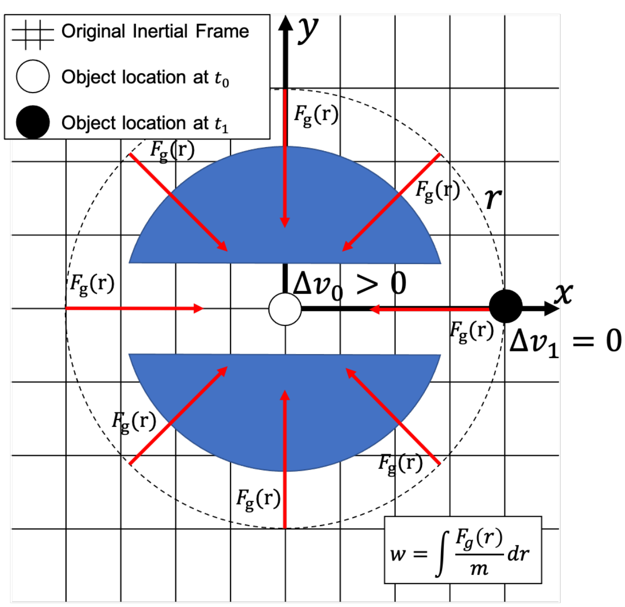

Figure 2. Example of specific work done by TDG.

As another example, if the initial location is at some altitude away from the gravitational source, and the new location is infinitely far away, then the ITD at that altitude is equal to ITD created by a change in specific kinetic energy required to achieve escape velocity, because this is how much specific work is done by the gravitational force by the time the object is infinitely far away as given by Equation (4):

$$\frac{dt}{dt'} = \sqrt{1 - \frac{GM/r}{e_T}} \tag{4}$$

Adjusting Equation (4) to be in its more general form, in terms of specific work done or change in specific potential energy, Δe_P, gives us Equation (5), which concludes my current investigation.

$$\frac{dt}{dt'} = \sqrt{1 - \frac{w}{e_T}} = \sqrt{1 - \frac{\Delta e_P}{e_T}} \tag{5a}$$

APPENDIX

Two examples are provided to show how the TDG relates to gravitational acceleration. The first example involves the earth's TDG and its respective gravitational acceleration at its surface; and the second example involves the Sun's TDG and its respective gravitational acceleration at a distance of one astronomical unit.

The Earth's TDG Example

In this example, I form a TDG estimate between a location, r_1, on the earth's surface and another location, r_2, 1000 meters above r_1. Assuming that our base time derivative is dt_2, then the result is the ITD from Equation (6):

$$\text{Let} : \mathrm{r}_1 = 6371000\ [m]$$
$$\text{Let} : \mathrm{G} = 6.6744 \times 10^{-11}\ [m^3 kg^{-1} s^{-1}]$$
$$\text{Let} : \mathrm{M} = 5.97219 \times 10^{24}\ [kg]$$
$$\frac{dt_1}{dt_2} = \sqrt{1 - \frac{\Delta e_P}{e_{\max}}} = \sqrt{1 - \frac{\int_{r_1}^{r_2} \frac{GM}{r^2} dr}{e_{\max}}} \tag{6a}$$
$$\frac{dt_1}{dt_2} = \sqrt{1 - \frac{9.81 \times 10^3}{e_{\max}}} = 1 - 1.0925 \times 10^{-13} \tag{6b}$$

The resulting TDG is given in Equation (7).

$$\text{Let} : \mathrm{dt}_2 = 1 \implies dt_1 = 1 - 1.0925 \times 10^{-13}$$
$$\nabla dt \triangleq \frac{dt_2 - dt_1}{dr'} \tag{7a}$$
$$\nabla dt \triangleq \frac{1.0925 \times 10^{-13}}{1000} = 1.0925 \times 10^{-16} \tag{7b}$$

Using Equation (3), the resulting acceleration is show in Equation (8):

$$\bar{g} = \frac{e_T}{dr'}\left(1 - \left(1 - \nabla dt\frac{dr'}{dt'}\right)^2\right) \tag{8a}$$

$$\bar{g} = 9.8185[^m/_s] \tag{8b}$$

Comparing results from Equation (8) to the result of using the geometric mean of known gravitational acceleration values, using Newton's Law of Universal Gravitation, is shown in Equation (9). It shows that errors are within limits of precision of the machine used to do the calculation (percent error is 0.0036% or 36 in million):

$$\sqrt{g(r_1)g(r_2)} = 9.8185 \tag{9a}$$

$$\sqrt{(9.8204)(9.8174)} = 9.8185 \tag{9b}$$

$$9.8189 \approx 9.8185 \blacksquare \tag{9c}$$

The Sun's TDG Example

What about when the distances are really far apart when measuring the TDG? In this example, I form a TDG estimate between a location, r_1, a distance from the sun that is earth's mean orbital radius, and another location, r_2, a half light second further away. Assuming that our base time derivative is dt_2, then the result is the ITD shown in Equation (10):

$$\text{Let} : \mathrm{r_1} = 1.5203 \times 10^{11}\ [m]$$

$$\text{Let} : \mathrm{G} = 6.6744 \times 10^{-11}\ [m^3kg^{-1}s^{-1}]$$

$$\text{Let} : \mathrm{M} = 1.9887 \times 10^{30}\ [kg]$$

$$\frac{dt_1}{dt_2} = \sqrt{1 - \frac{\Delta e_P}{e_{\max}}} = \sqrt{1 - \frac{\int_{r_1}^{r_2}\frac{GM}{r^2}dr}{e_{\max}}} \tag{10a}$$

$$\frac{dt_1}{dt_2} = \sqrt{1 - \frac{8.7352 \times 10^8}{e_{\max}}} = 1 - 9.7192 \times 10^{-9} \tag{10b}$$

The resulting TDG is given in Equation (11).

$$\text{Let} : \mathrm{dt_2} = 1 \implies dt_1 = 1 - 9.7192 \times 10^{-9}$$

$$\nabla dt \triangleq \frac{dt_2 - dt_1}{dr'} \tag{11a}$$

$$\nabla dt \triangleq \frac{9.7192 \times 10^{-9}}{\frac{c}{2}} = 2.1628 \times 10^{-25} \tag{11b}$$

Using Equation (3), I solve for the resulting acceleration as show in Equation (12):

$$\bar{g} = \frac{e_T}{dr'}\left(1 - \left(1 - \nabla dt\frac{dr'}{dt'}\right)^2\right) \tag{12a}$$

$$\bar{g} = 1.9438 \times 10^{-8}[^m/_s] \tag{12b}$$

Comparing results from Equation (12) to the result of using the geometric mean of known gravitational acceleration values, using Newton's Law of Universal Gravitation, is shown in Equation (13). It shows that errors are within limits of precision of the machine used to do the calculation (percent error is 0.049% or 490 in million):

$$\sqrt{g(r_1)g(r_2)} = 1.9438 \times 10^{-8} \tag{13a}$$

$$\sqrt{(0.0057)(6.573 \times 10^{-14})} = 1.9438 \times 10^{-8} \tag{13b}$$

$$1.9429 \times 10^{-8} \approx 1.9438 \times 10^{-8} \blacksquare \tag{13c}$$

TDG Examples Takeaway

The key takeaway with these two examples, with both near and far estimates of TDG, is that the causal model relating the TDG to acceleration matches observation.