Universal Specificity Investigation 6: Inducing the Cause of Total Time Dilation & Its Relation to Total Specific Energy

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Prior investigations into universal specificity found a proper conception of time missed in common practice. In addition, it was found that a universally stationary frame (USF) must exist; which led to discovering the cause of kinetic time dilation, shown Equation (1); which led to deriving a relativistic specific energy model, shown in Equation (2); which led to discovering the cause of gravitational time dilation, shown in Equation (3); which finally led to gravity being caused by a specific internal energy gradient, shown in Equation (4).

$$\frac{dt'}{dt} = \frac{c_0}{c} = \sqrt{1 - \frac{\Delta e_K}{e_T}} = \sqrt{1 - \frac{w_K}{e_T}} = \frac{1}{\gamma_K} \tag{1}$$

$$e_T = \frac{1}{2}c^2 = e_I + \Delta e_K = \frac{1}{2}c_0^2 + \frac{1}{2}v^2 \tag{2}$$

$$\begin{aligned}\frac{dt'}{dt} &= \frac{c_0}{c} = \sqrt{1 - \frac{\Delta e_P}{e_T}} = \sqrt{1 - \frac{w_P}{e_T}} = \frac{1}{\gamma_P} \\ &= \sqrt{1 - \frac{\int_\infty^r g(r)dr}{e_T}} = \sqrt{1 - \frac{\int_\infty^r -\nabla e_I dr}{e_T}}\end{aligned} \tag{3}$$

$$g(r) = -\nabla e_I = \frac{d(e_I)}{dr} \tag{4}$$

dt' is the time rate of change measured by a clock undergoing time dilation; dt represents the time rate of change measured by an identical clock in the USF infinitely away from gravitational sources; c_0 is the average effective speed of light in the objects reference frame; c is the speed of light in the USF in a vacuum not under any gravity potential; Δe_K is the object's change in specific kinetic energy in the USF; Δe_P is the object's change in specific potential energy; w is the specific work done to the object in the USF; $g(r)$ is specific force of gravity; ∇e_I is the specific internal energy gradient within objects that are within a gravitational field; and e_T is total specific energy, $\frac{1}{2}c^2$. The ratio of time derivatives is termed *inertial time differential* (ITD), which remains constant for any object until specific work, w, is done.

This investigation now relates changes in inertial time differentials (ITDs) to changes in specific total external energy—as in ignoring specific internal energy, $\frac{1}{2}c_0^2$, by keeping it constant—and then I will update the total specific energy model to relate to changes in this quantity.

1. Time Dilation Equivalence

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 Equations (1) and (3), simple analysis reveals that transferring some amount of specific kinetic energy to the same 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 (5) shows that the two ITDs in each state are equivalent.

$$\begin{aligned}\text{Let } \Delta \mathrm{e_P} &> 0. \\ \text{Let } \frac{1}{\gamma} &= \frac{dt'}{dt} \\ \frac{1}{\gamma_P^2} &= 1 - \frac{\Delta e_P}{e_T} \\ 1 - \frac{1}{\gamma_P^2} &= \frac{\Delta e_P}{e_T} \\ \left(1 - \frac{1}{\gamma_P^2}\right) e_T &= \Delta e_P \\ \Delta e_P &\implies \Delta e_K \\ \left(1 - \frac{1}{\gamma_P^2}\right) e_T &= \Delta e_K \\ 1 - \frac{1}{\gamma_P^2} &= \frac{\Delta e_K}{e_T} \\ \frac{1}{\gamma_P^2} &= 1 - \frac{\Delta e_K}{e_T} \\ \frac{1}{\gamma_P^2} &= \frac{1}{\gamma_K^2} \blacksquare\end{aligned} \tag{5}$$

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. Deriving the Causal Math Model

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

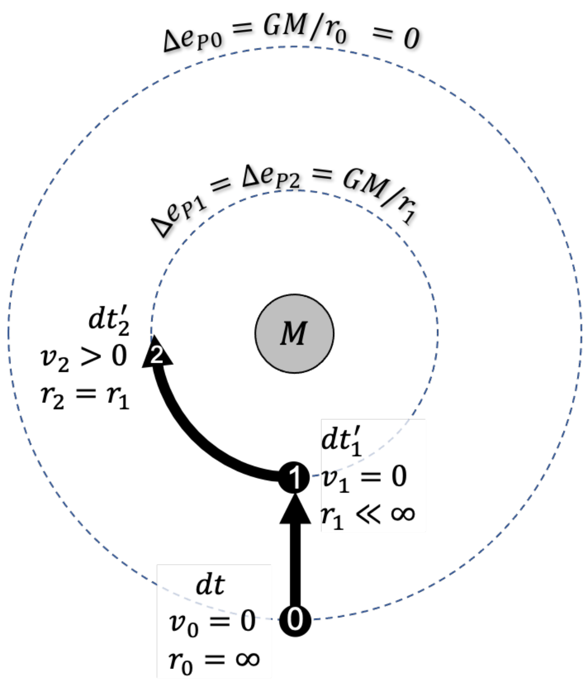

Figure 1. **Total effective time differential example.**

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 (6).

$$\frac{dt'_1}{dt} = \sqrt{1 - \frac{\Delta e_{P1}}{e_T}}$$
$$\frac{dt'_2}{dt'_1} = \sqrt{1 - \frac{\Delta e_{K2|P1}}{e_T}}$$
$$\frac{dt'_2}{dt} = \frac{dt'_2}{dt'_1}\frac{dt'_1}{dt} = \sqrt{1 - \frac{\Delta e_{K2|P1}}{e_T}}\sqrt{1 - \frac{\Delta e_{P1}}{e_T}} \tag{6}$$

Applying a change in specific kinetic energy after a change in specific potential energy can be generalized to any condition where an object with kinetic energy is within a stationary gravitational field, as shown in Equation (8).

$$\text{Let}: \frac{1}{\gamma_{\mathrm{P}}} = \frac{dt'_P}{dt} = \sqrt{1 - \frac{\Delta e_P}{e_T}}$$
$$\text{Let}: \frac{1}{\gamma_{\mathrm{K|P}}} = \frac{dt'_K}{dt'_P} = \sqrt{1 - \frac{\Delta e_{K|P}}{e_T}}$$

$$\frac{1}{\gamma_T} = \frac{1}{\gamma_{K|P}}\frac{1}{\gamma_P} = \sqrt{1 - \frac{\Delta e_{K|P}}{e_T}}\sqrt{1 - \frac{\Delta e_P}{e_T}} \tag{8a}$$
$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\gamma_P^{-2}\Delta e_{K|P} + \Delta e_P}{e_T}} \tag{8b}$$
$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_K + \Delta e_P}{e_T}} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \blacksquare \tag{8c}$$

Of note, what the term, $\gamma_P^{-2}\Delta e_{K|P}$, in Equation (8b) tells us is that an object's speed slows down (even light), by a factor of γ_P^{-1}.

Just for completeness one can consider another situation, akin to this last situation, but where the gravitational potential is moving rather than stationary, as shown in Equation (9).

$$\text{Let}: \frac{1}{\gamma_{P|K}} = \frac{dt'_P}{dt'_K} = \sqrt{1 - \frac{\Delta e_{P|K}}{e_T}}$$
$$\text{Let}: \frac{1}{\gamma_K} = \frac{dt'_K}{dt} = \sqrt{1 - \frac{\Delta e_K}{e_T}}$$
$$\frac{1}{\gamma_T} = \frac{1}{\gamma_K}\frac{1}{\gamma_{P|K}} = \sqrt{1 - \frac{\Delta e_K}{e_T}}\sqrt{1 - \frac{\Delta e_{P|K}}{e_T}} \tag{9a}$$
$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_K + \gamma_K^{-2}\Delta e_{P|K}}{e_T}} \tag{9b}$$
$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_K + \Delta e_P}{e_T}} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \blacksquare \tag{9c}$$

The term, $\gamma_K^{-2}\Delta e_{P/K}$, in Equation (9b) means that the observed gravitational effects in the moving frame are mis-calibrated by a factor of γ_K^2, which matches the results of the thought experiment found in the appendix.

Therefore, one is able to apply any number of N combinations of changes to specific kinetic energy and specific potential energy using the chain rule. Where $N \in \mathbb{Z} > 0$, and for all $i = \{1..N\}$, this yields Equation (10):

$$
\begin{aligned}
&\text{Let}: dt'_0 = dt,\ \Delta e_{1|0} = \Delta e_1,\ \&\ \frac{1}{\gamma_{T,0}} = 1 \\
&\frac{1}{\gamma_{T,i}} = \frac{dt'_i}{dt} = \prod_{j=1}^{i} \frac{dt'_j}{dt'_{j-1}} = \prod_{j=1}^{i} \sqrt{1 - \frac{\Delta e_{j|j-1}}{e_T}} \\
&\quad = \sqrt{1 - \frac{\sum_{j=1}^{i} \frac{1}{\gamma_{T,j-1}^2} \Delta e_{j|j-1}}{e_T}} \\
&\quad = \sqrt{1 - \frac{\Delta e_K + \Delta e_P}{e_T}} = \sqrt{1 - \frac{\Delta e_t}{e_T}}\ \blacksquare
\end{aligned}
\tag{10}
$$

3. Total Specific Energy Model

I can now use these tools to update the total specific energy model in Equation (2) to include the specific potential energy term, along with the other terms—specific internal energy and specific kinetic energy—as shown in Equation (11).

$$
\begin{aligned}
&\frac{dt'}{dt} = \frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \\
&\frac{1}{\gamma_T^2} = 1 - \frac{\Delta e_t}{e_T} \\
&e_T = \frac{1}{\gamma_T^2} e_T + \Delta e_t = e_I + \Delta e_K + \Delta e_P \\
&\frac{1}{2}c^2 = \frac{1}{2}c_0^2 + \frac{1}{2}v^2 + \int_r^{\infty} \nabla e_I dr\ \blacksquare
\end{aligned}
\tag{11}
$$

If one solves for c_0, shown in Equation (12), again one sees a past pattern reemerge, which is the average effective speed of light (normalized by c) is a function of an energy ratio.

$$
\frac{c_0}{c} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \tag{12}
$$

This suggests that total time dilation (like kinetic time dilation) is actually a consequence of a reduction in c_0, as shown in Equation (13). The average effective speed of light remains the metronome of the Universe under this more general condition.

$$
\frac{dt'}{dt} = \frac{c_0}{c} \tag{13}
$$

The causal chain for time dilation, under this more general condition, becomes a reduction in c_0 causes time dilation, whatever the source. The causal connection between specific work done and a reduction in c_0 is bi-directional in the following way: in the kinetic cases, specific work done causes a reduction in c_0; and in the gravitational cases, a reduction in c_0 causes specific work to be done.

4. Conclusion

In conclusion, total time dilation was found to be ultimately caused by a reduction in c_0, which can be determined by a change in specific total external energy of an object, which led to two grand integrations: (1) kinetic and gravitational time dilation are two aspects of the same phenomenon; and (2), total specific energy must include a specific potential energy term to be complete.

The ambiguities that resulted from relating total specific energy with total energy in earlier investigations remain unresolved. Enough tools and concepts have now been developed so that these ambiguities can be properly addressed, which is the focus of the next investigation.

Appendix

Kinetic Effects on Gravity

This appendix section considers the kinetic effects on gravitational forces, specifically kinetic time dilation effects. Suppose we managed to craft four Osnium[2] orbs, each having the same shape and size. Assuming each orb has a radius of $0.1\ [m]$, then the mass of each would be identical and roughly $92\ [kg]$. The first pair of orbs are setup in the USF with an initial distance of $100\ [m]$ between their center of masses. It would take about four months, in the orb's proper time, for their gravitational forces to bring them into contact.

Now, suppose the other pair of orbs were sent away, in the twins paradox fashion, but otherwise the same initial conditions.[3] Supposing they returned at the moment the stationary orbs touched, then the traveling orbs, being "younger" due to kinetic time dilation, would not be touching, as shown in Figure 2.

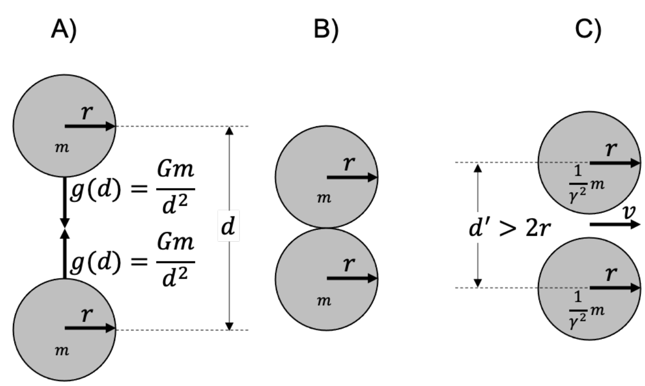

Figure 2. A) Initial Conditions In Stationary Frame; B) State of stationary orbs at the end of four months; C) State of traveling orbs at the end of four months.

These results suggest to me that the inertia of the traveling orbs increased (assuming the force of gravity remained the same), but to what? Through testing, it was found that the resulting increase in inertia is $\gamma^2 m_0$. This result makes intuitive sense, because distance traversed during gravitational acceleration is related to time squared, and the proper time recorded for the traveling orbs' clock is smaller than

[2] Atomic number 76.

[3] With the distance between their center of masses being orthogonal to the velocity direction so acceleration will not affect their gravitational movement.

the proper time recorded for the stationary orbs' identical clock by a factor of γ^{-1}. This can be seen analytically by studying displacement perpendicular to velocity of the system, $s_{\perp}$, as a function of gravitational acceleration, as shown in Equation (14).

$$\begin{aligned} s_{\perp} &= s'_{\perp} \\ t &= \gamma_K t' \\ s_{\perp} &= \frac{1}{2} g(r) t^2 \\ s'_{\perp} &= \frac{1}{2} g'(r) t'^2 \\ \therefore\ g(r) &= \gamma_K^{-2} g'(r) \blacksquare \end{aligned} \tag{14}$$

Studying displacement perpendicular to velocity of the system, $s_{||}$, as a function of gravitational acceleration, as shown in Equation (15).

$$\begin{aligned} s_{||} &= \frac{1}{\gamma_K} s'_{||} \\ t &= \gamma_K t' \\ s_{||} &= \frac{1}{2} g(r) t^2 \\ s'_{||} &= \frac{1}{2} g'(r) t'^2 \\ \therefore\ g(r) &= \gamma_K^{-3} g'(r) \blacksquare \end{aligned} \tag{15}$$

If one is just concerned with the time difference in which the two pairs of orbs touch, then one ignores $s_{||} = \gamma_K^{-1} s'_{||}$ in Equation (15), resulting in $g(r) = \gamma_K^{-2} g'(r)$, which is as before with Equation (14).

Suppose we conducted another similar experiment; however, for this experiment two new orbs are crafted just like the others, except their radii are reduced to grantee that their mass, m'_0, equals $\gamma^{-2} m_0$. Let these new smaller orbs take the place of the stationary orbs. Given this new setup, we would find that upon the traveling orbs return, both pairs of orbs would be the same distance closer.

I actually simulated several trials of such an experiment, numerically solving for the dynamics in each reference frame, and the code is provided in the next two pages. Each trial had the same relative velocities, but each trial tested different return times. At the end of each trial, I compared the two pairs of orbs to see if each traveled the same distance. The results are presented in Figure 3.

The two pairs of orbs had the same gravitational behavior. Therefore, invoking the method of agreement, whereby the same gravitational effect occurred in both cases, proves inductively that gravitational effects reduce (when the source of the gravitational potential is not stationary), by a factor of γ_K^{-2}.

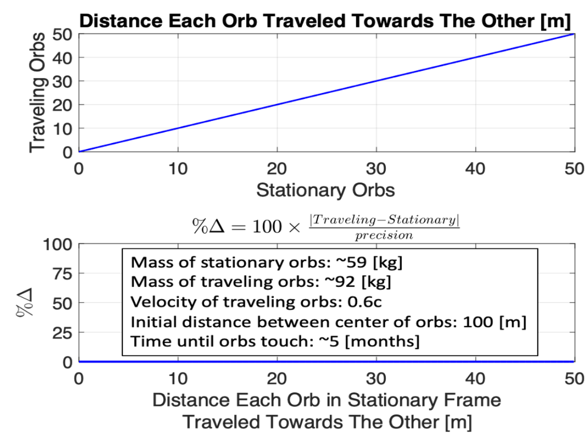

Figure 3. Results for how far the orbs traveled towards each other.

MATLAB CODE

```matlab
%% constants and functions
G                 = 6.6744e-11; % [m^3/(kg s)] gravitational constant
gamma             = @(v) 1./sqrt(1-v.^2);
seconds2months    = 12/60^2/24/365;

%% Traveling orbs
% initial conditions
rho      = 22000;       % [kg/m^3] density of osmium
r        = 1e-1;        % [m]      radius of each orb
vol      = 4*pi*r^3/3;  % [m^3]    volume of each orb
m        = rho*vol;     % [kg]     mass of each orb
d        = 1e2;         % [m]      initial distance between orbs' surfaces
d_min    = 2*r;         % [m]      minimum distance between center mass of orbs
gd1      = 2*G*m/(d);   % [J/kg]   initial relative xspecific potential energy
v        = 0.6;         % [-]      fraction of the speed of light of orbs
gamma_v = gamma(v);     % [-]      1/sqrt(1-v^2/c^2)

% initialize other variables
dy  = (d-d_min)/1e4;      % increment steps to numerical solution
ds  = d:-dy:d_min;        % all numerical steps
gds = ones(size(ds))*gd1;% specific potential energy
vs  = zeros(size(ds));    % relative velocity of orbs
ts  = zeros(size(ds));    % proper time passed

% incremental solution of orb pairs relative velocity and time passed
for id = 2 : length(ds)
    % this relative specific potential energy for orbs
    gds(id) = 2*G*m/(ds(id));

    % delta relative specific potential energy for orbs
    delta_gd = gds(id)-gd1;

    % relative velocity between them
    vs(id) = sqrt(2*delta_gd);

    % time for distance to close by mean relative velocity
    ts(id) = ts(id-1) + dy/mean([vs(id),vs(id-1)]);
end

% total passage of proper time until orbs contact in years and months
total_time_months = max(ts)*seconds2months;

%% Stationary orbs
my       = m/gamma_v^2; % [kg]    mass of stationary orb is traveling orb's mass
gd1_my   = 2*G*my/(d);  % [J/kg] initial specific potential energy

% time passed, as measured by stationary orbs
ts_gamma = ts*gamma_v;

% total passage of proper time until orbs contact in years and months
total_time_months_my   = max(ts_gamma)*seconds2months;

% initialize stationary orbs with mass my distance steps
dy_my = dy;               % increment steps to numerical solution
ds_my = d:-dy_my:d_min; % all numerical steps

% initialize other variables
vs_my   = zeros(size(ds_my));
gds_my = ones(size(ds_my))*gd1_my;
ts_my   = zeros(size(ds_my));

% incremental solution of orb pairs relative velocity and time passed
for id = 2 : length(ds_my)
    % this relative specific potential energy
    gds_my(id) = 2*G*my/(ds_my(id));

```

```matlab
    % delta relative specific potential energy
    delta_gd_my = gds_my(id)-gd1_my;

    % relative velocity between them
    vs_my(id) = sqrt(2*delta_gd_my);

    % time for distance to close by mean relative velocity
    ts_my(id) = ts_my(id-1) + dy_my/mean([vs_my(id),vs_my(id-1)]);
end

%% Plot Results
figure(1);
% plot the movement of each orb makes towards its pair
subplot(2,1,1)
plot((d-ds)/2,(d-interp1(ts_my,ds_my,ts_gamma))/2,'-b','LineWidth',1.5)
xlim([0 d/2]);
ylim([0 d/2]);
grid on
xlabel('Stationary Orbs','FontSize',20);
ylabel('Traveling Orbs','FontSize',20);
title({'Distance Each Orb Traveled Towards The Other [m]'},'fontsize',16);

% plot the percent difference in movement between pairs of orbs
percent_difference = 100*abs((d-interp1(ts_my,ds_my,ts_gamma))/2 - (d-ds)/2)./(dy);
subplot(2,1,2)
plot((d-ds)/2,percent_difference,'-b','LineWidth',2)
xlim([0 d/2]);
ylim([0 100]);
grid on
xlabel({'Distance Each Orb in Stationary Frame'...
    ,'Traveled Towards The Other [m]'},'FontSize',20);
ylabel({'\%$\Delta$'},'FontSize',20,'Interpreter','latex');
title({'\%$\Delta=100\times\frac{|Traveling-Stationary|}{precision}$'}...
    ,'Interpreter','latex','fontsize',16);

% print ellapsed proper (AAK wall) time for each pair or orbs
fprintf('Elapsed Time for Traveling Orbs: %0.1f [months]\n',total_time_months);
fprintf('Elapsed Time for Stationary Orbs: %0.1f [months]\n',total_time_months_my);
```