Universal Specificity Investigation 6: Objectively Measuring the Universal Inertial Frame

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Prior investigations found a proper conception of time missed in common practice, which lead to discovering the cause of kinetic time dilation, which lead to revisiting the relativistic kinetic energy, mass and total energy model, which allowed for the integration between potential and kinetic time dilation and an updated total energy model comprised of internal potential, external potential and kinetic energy. The most important takeaway from this investigation thus far is this: the difference in power between properly formed and ill-formed concepts is the difference between scientific progress and stagnation. Using what has been discovered, this investigation now turns to a means to objectively measure a universal inertial frame, or what all other frames objectively agree is stationary, to settle the dispute between relativity of simultaneity and the theory of universal specificity.

1. Universal Inertial Frame

A *universal inertial frame* (UIF) is a reference frame in which all others objectively agree is stationary. There is such a frame for rotation, where a simple water in a buck experiment can tell you if the frame is rotating or not. If the bucket is rotating the surface of the water will create a bowl shape, and if it is not rotating, then the surface will be flat, as shown in Figure 1.

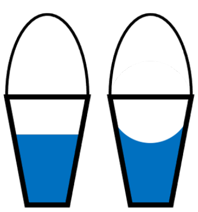

Figure 1. a) Non-rotating bucket of water. b) Rotating bucket of water.

A similar experiment cannot determine a difference in reference frame for any translational velocity, as shown in Figure 2.

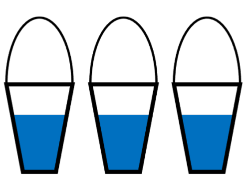

Figure 2. a) Universally stationary. b) Velocity is $0.5c$. c) Velocity is $0.\overline{9}c$.

Michelson and Morely tried (and failed) to determine the relative motion of earth from some universally stationary reference frame by measuring the difference in velocity of light from the same source at different points in earths orbit, but instead demonstrated the interesting fact that the speed of light measured in any inertial frame is constant [1]. Something is special about translational velocity, as from rotational velocity, where any inertial frame at any velocity appears to be stationary; no experiment has yet been devised that could measure motion relative to an objectively provable UIF.

One thing you might have noticed about kinetic time dilation is that despite the unit changes caused by work done, as was discovered in previous investigations in this series, all pair-wise reference frames seem to agree on the relative velocity between their reference frames. This is our first clue as to why all inertial frames seemed stationary up to this point, and doing a quick survey of the unit changes reveals why velocity is special.

2. A Survey of Unit Changes

We know that the units of measurement change for space and time when work is done, but why not velocity? Velocity, being a ratio of a change in distance to a change in time, means the change in units of velocity involves a change in units of the parts to this ratio, as shown in Equation (1).

$$v = \frac{dx}{dt} \tag{1a}$$

$$v' = \frac{dx'}{dt'} \tag{1b}$$

$$\frac{dx}{dx'} = \frac{dt}{dt'} = \sqrt{1 - \frac{\Delta e_K}{e_T}} = \sqrt{1 - \frac{v^2}{c^2}} \tag{1c}$$

$$\therefore v = \frac{dx'\sqrt{1 - \frac{v^2}{c^2}}}{dt'\sqrt{1 - \frac{v^2}{c^2}}} = \frac{dx'}{dt'} = v' \ \blacksquare \tag{1d}$$

This ratio of distance to velocity cancels the effect of change in units. This is what makes velocity special. All attempts to date to measure motion relative to a UIF has relied on measuring velocity, which have thus far proved incapable of detecting the UIF. It is not difficult to see why such attempts have failed to detect the UIF, since the only effect of being in an inertial reference frame different from the UIF is a change of units caused by work done, so of course we ought to expect a failed detection if we use a measurement where the effect is nullified.

What is required to objectively measure the UIF is to use a measurement that does not nullify the effect of being in a reference frame different from the UIF. What is required is a means for the unit change caused by work done to point us in the direction of a UIF.

3. How to Objectively Measuring the Universal Inertial Frame

Experimenting with acceleration appears to be a valid measure to detect the UIF, since acceleration involves a ratio that does not nullify the effect of a unit change. Two forms of acceleration are known, kinetic acceleration and gravitational acceleration. Only gravitational acceleration ends up being useful.

A kinetic acceleration experiment might involve studying unit changes caused by accelerating a rocket to Alpha Centauri and back, like in the twins paradox setup. The problem with this experiment is that it would rely on remote measurements, which takes time and distance to make these kinds of measurements. The best form of remote measurement involves using photons, like LADAR, to make estimates of speed (via Doppler frequency shifts) and estimates of distance (via lap time of returns). Therefore, this experiment reliance on the speed of light traveling for some time and distance, which nullifies the effects we are attempting to measure, causes this form of experimentation with acceleration to fail in detecting the UIF.

A gravitational acceleration experiment might involve using a gravimeter—like the one derived in an earlier investigation, shown in Figure 3—to measure the gravitational acceleration of a massed object, but at different velocities, as shown in Figure 4, could show the effects required to detect the UIF.

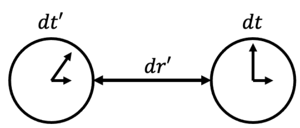

Figure 3. **Gravimeter.**

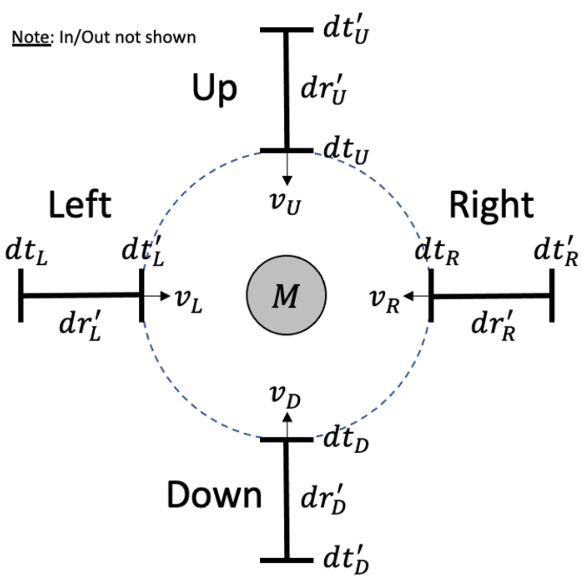

Figure 4. **UIF detection experiment.**

Recall from a prior investigation into universal specificity that the gravimeter is measuring two rates of change in time, dt and dt', via identical clocks some distance, dr', away from each other. Additionally, dr' is normal to the time dilation gradient, and dt' is farther from the center of mass than dt. Lastly, these measurements translates to gravitational acceleration as shown in Equation (2).

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

$$g(r') = \lim_{dr'\to 0} -e_T \nabla\tau^2 \tag{2b}$$

$$\text{Where}: \ e_T = \frac{1}{2}c^2 \tag{2c}$$

How this experiment works is that each clock takes a measure of dt and dt' once the forward part of the clock reaches some marked threshold equidistant to the center of mass, as measured from the center of mass' inertial reference frame. Each clock, being identical and calibrated to the same initial inertial reference frame, assumes dr' is the same under any condition; however, the radial location where dt' is measured changes since the units subsumed under dr' changes in different frames—i.e., dr' is a physically different length in different reference frames. Any changes to the ratio $\frac{dt}{dt'}$ due to kinematic time dilation is nullified, in the same way it is nullified for velocity; therefore, the only change in the ratio $\frac{dt}{dt'}$ will be due to changes in the location where dt' is measured.

Once gravitational acceleration is measured, backing out the relative velocity of the massed object with respect to the UIF might not be solvable directly because of the set of non-linear equation; however, simulation can run the set of possible velocities and experimental results can be compared to simulated results. That way the velocity associated with the simulated results that line up with experimental results will be the estimated velocity we seek.

In order to gain the necessary precision, the orbital acceleration and the velocity towards the center of mass had to be quite large. A simulation for a single spatial dimension was ran (see code in Appendix), and the parameters for the executed simulation was:

- Mass of object: 1000 $[Solar\ Masses]$
- Original distance clocks were apart: 1 $[km]$
- Measurement distance from center of mass: 0.5 $[AU]$
- Speed of gravimeters in massed object's frame: 0.1 $[fraction\ of\ c]$

The results of this simulation can be seen in Figure 5. From the results we can see how the massed object's velocity in the UIF (x-axis) affects the gravimeter readings (y-axis) for an orbital gravimeter, for a gravimeter traveling faster than the massed object in the UIF (gravimeter1), and for another gravimeter traveling slower (gravimeter2).

4. Conclusion

In conclusion, it was shown that it is possible to detect the UIF if measurements are taken that do not nullify the effects of changes of units caused by work done. The designed experiment involving sending gravimeters hurtling towards the center of mass of a massive object is capable of such a detection.

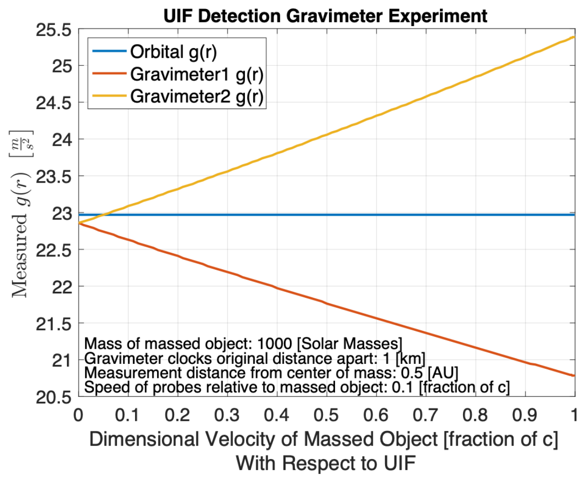

Figure 5. **Simulated Results.**

The last question to be investigated by this universal specificity series is: if the bending of spacetime does not cause gravity, and it is not responsible for kinetic time dilation as an environmental affect on objects, what then causes everything in the same reference frame to be effected by time dilation in the same way? Addressing that question is the focus of the next and last investigation.

References

[1] A. Michelson & E. Morley, *On the relative motion of the Earth and the luminiferous ether*,American Journal of Science, vol. s3-34, no. 203, pp. 333–345, 1887.

Appendix

Matlab Code

```matlab
% Code designed to demonstrate detection of universal inertial frame (UIF)
function UIF_via_gravity()
%% initializations, constants and simple functions
% initialization
clear all
clc
close all

% constants
c  = 299792458;  % [m/s] speed of light
G  = 6.6744e-11; % [m^3/(kg s)] gravitational constant
Me = 5.97219e24; % [kg] earth's mass
Ms = 333000*Me;  % [kg] sun's mass
et = 0.5*c^2;    % [m^2/s^2] specific total energy
AU = 152.03e9;   % [m] distance from sun to earth

% simple functions
gamma        = @(v) 1./sqrt(1-v.^2);
add_vel      = @(v1_in,v2_in) (v1_in+v2_in)/(1 + v1_in*v2_in);
grav_2_dt    = @(g,r) sqrt(1-g*r/et);
r_2_gravObj  = @(M,r) G*M/r^2;
gravimeter   = @(dtnear_dtfar,dr) (c^2/(2*dr))*(1-(dtnear_dtfar)^2);

%% experiement: travel two gravimeters (probes) towards center of massed object (MO)
% set conditions (in MO's frame)
M_MO      = 1e3*Ms; % [kg] mass of object at center of experiment
r_measure = AU/2;   % [m] nearest clock distance from center of MO
probe_dv  = 0.1;    % [frac of c] speed of probes relative to MO
gmtr_dr   = 1000;   % [m] clocks distance apart when stationary

% initialize
gr_orbit_all  = [];
gr_probe1_all = [];
gr_probe2_all = [];

% loop through range of MO velocities
v_obj_all = [0:0.01:0.99 0.99:0.001:0.999]; % [frac of c] speed of MO (in UIF)
for ivo = 1 : length(v_obj_all)
    % (in UIF)
    v_obj          = v_obj_all(ivo);            % [frac of c] velocity of MO
    v_p1           = add_vel(v_obj,probe_dv);   % [frac of c] velocity of probe1
    v_p2           = add_vel(v_obj,-probe_dv);  % [frac of c] velocity of probe2
    drUIF_drp_obj  = gamma(v_obj);              % [-] kinetic differential for MO
    drUIF_drp_p1   = gamma(v_p1);               % [-] kinetic differential for probe1
    drUIF_drp_p2   = gamma(v_p2);               % [-] kinetic differential for probe2

    % determine kinetic time/space dilation effects on grivimeters (in UIF)
    gmtr_dr_UIF_obj = gmtr_dr/drUIF_drp_obj; % [m] clocks distance apart
    gmtr_dr_UIF_p1  = gmtr_dr/drUIF_drp_p1;  % [m] clocks distance apart
    gmtr_dr_UIF_p2  = gmtr_dr/drUIF_drp_p2;  % [m] clocks distance apart

    % determine effects on gravimeter from orbit of MO (in MO frame)
    dr_obit       = drUIF_drp_obj*gmtr_dr_UIF_obj;       % [m] clocks distance apart
    r_f_orbit     = r_measure+dr_obit;                   % [m] farthest clock distance to MO
    r_n_orbit     = r_measure;                           % [m] nearest clock distance to MO
    dtn_dtf_orbit = frames_dtn_dtf(r_f_orbit,r_n_orbit); % [-] clock differential
    g_m_orbit     = gravimeter(dtn_dtf_orbit,gmtr_dr);   % [m/s^2] measured g

    % determine effects on gravimeter from probe 1 (in MO frame)
    dr_p1          = drUIF_drp_obj*gmtr_dr_UIF_p1;          % [m] clocks distance apart
    r_f_probe1     = r_measure+dr_p1;                       % [m] farthest clock distance to MO
```

```matlab
    r_n_probe1     = r_measure;                           % [m] nearest clock distance to MO
    dtn_dtf_probe1 = frames_dtn_dtf(r_f_probe1,r_n_probe1); % [-] clock differential
    g_m_probe1     = gravimeter(dtn_dtf_probe1,gmtr_dr);    % [m/s^2] measured g

    % determine effects on gravimeter from probe 2 (in  MO frame)
    dr_probe2      = drUIF_drp_obj*gmtr_dr_UIF_p2;          % [m] clocks distance apart
    r_f_probe2     = r_measure+dr_probe2;                 % [m] farthest clock distance to MO
    r_n_probe2     = r_measure;                           % [m] nearest clock distance to MO
    dtn_dtf_probe2 = frames_dtn_dtf(r_f_probe2,r_n_probe2); % [-] clock differential
    g_m_probe2     = gravimeter(dtn_dtf_probe2,gmtr_dr);    % [m/s^2] measured g

    % store results
    gr_orbit_all  = [gr_orbit_all g_m_orbit];
    gr_probe1_all = [gr_probe1_all g_m_probe1];
    gr_probe2_all = [gr_probe2_all g_m_probe2];
end

% plot results
fig = figure(1);
hold off
plot(v_obj_all, gr_orbit_all,'LineWidth',2);
hold on
plot(v_obj_all, gr_probe1_all,'LineWidth',2);
plot(v_obj_all, gr_probe2_all,'LineWidth',2);

% clean up plot
legend('Orbital g(r)','Gravimeter1 g(r)','Gravimeter2 g(r)','FontSize',16,'location','NW');
xlabel({'Dimensional Velocity of Massed Object [fraction of c]','With Respect to UIF'},'FontSize',16);
ylabel('Measured $g(r)~\left[\frac{m}{s^2}\right]$','FontSize',16,'Interpreter','latex');
grid on
a = get(gca,'XTickLabel');
set(gca,'XTickLabel',a,'fontsize',16)
xticks([0:.1:1]);
title({'UIF Detection Gravimeter Experiment'},'fontsize',16);
annotation(fig, 'textbox', [.13 .10 .8 .2], 'String'...
    ,sprintf('Mass of massed object: %d [Solar Masses]',M_MO/Ms)...
    ,'EdgeColor','none','FontSize',14);
annotation(fig, 'textbox', [.13 .07 .8 .2], 'String'...
    ,sprintf('Gravimeter clocks original distance apart: %d [km]',gmtr_dr/1e3)...
    ,'EdgeColor','none','FontSize',14);
annotation(fig, 'textbox', [.13 .04 .8 .2], 'String'...
    ,sprintf('Measurement distance from center of mass: %0.1f [AU]',r_measure/AU)...
    ,'EdgeColor','none','FontSize',14);
annotation(fig, 'textbox', [.13 .01 .8 .2], 'String'...
    ,sprintf('Speed of probes relative to massed object: %0.1f [fraction of c]',probe_dv)...
    ,'EdgeColor','none','FontSize',14);

%% supporting function
    function dtn_dtf = frames_dtn_dtf(r_f,r_n)
        % (in MO frame)
         g_f     = r_2_gravObj(M_MO,r_f); % gravitational specific force at clock farthest from MO
         g_n     = r_2_gravObj(M_MO,r_n); % gravitational specific force at clock nearest to MO
         dt_f    = grav_2_dt(g_f,r_f);    % time dilation of clock farthest from MO
         dt_n    = grav_2_dt(g_n,r_n);    % time dilation of clock nearest to MO
         dtn_dtf = dt_n/dt_f;             % relative time differential between closest and farthest clock
    end
end
```