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The Pioneer and Cassini Anomalies - A Possible Explanation

Abstract

Using a recently developed model of gravity that differs from both the Newton and Einstein models, close agreement is achieved between the anomalous accelerations of the Pioneer and Cassini mission vehicles and the predictions of the model. This conjecture supports the notion of a ***temporal-inertial (TI)*** field that is the principle mediator of the gravitational and inertial interactions. The TI field is subject to gravity and, in response to the acceleration of gravity, transmits its own acceleration to massive particles and objects comprising massive particles. No assertion is made relating properties of the TI field to those of the Higgs field. The ***flux model*** posits that in a gravitational field, the velocity of the TI field combines with that of gravitons emitted by the gravitational body to increase the flux of gravitons relative to the TI field. Thus the response of the TI field to gravity adds to the force of gravity. The flux model may offer an explanation for the anomalous accelerations experienced by the Pioneer and Cassini spacecraft.

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^ Properties of The Temporal-Inertial (TI) Field

The relation of the Higgs field or the Higgs mechanism [1] and what I designate as the TI field is undefined. I may attribute properties to the TI field (such as the particles of the field being subject to gravity) that are not attributed to the Higgs field.

The characteristics of the TI field as they affect gravity are developed in reference [2]. Some of the conclusions of the referenced paper are summarized below.

1. When a matter particle or an object composed of matter particles is accelerated by an external force, its motion is resisted by its acceleration relative to the TI field. This reactive force of the TI field of space is the familiar inertial force.
2. Particles of the TI field are accelerated by gravity directly toward the center of each gravitational body just as a test particle would be and reach the escape velocity of such a particle at the distance of that particle from the center of mass of the gravitational body.
3. The ***flux model*** of gravity [3] is part of the TI field model of gravity and posits that in a gravitational field, the velocity of the TI field combines with that of the gravitons emitted by the gravitational body to increase the flux of gravitons relative to the TI field. Thus the response of the TI field to gravity adds to the force of gravity.
4. Inherent in the flux model is the assertion that the TI field supports the propagation of gravitons.
5. The gravitational acceleration of the TI field relative to a matter particle or an object composed of matter particles applies a force to that matter particle or object. This

force is the familiar gravitational force applied indirectly through the intermediary of the acceleration of the TI field of space.

6. The TI field accelerates massive particles at the same rate as its own acceleration.
7. Acceleration of the TI field in its own response to gravity is the sole accelerator of massive particles in response to gravity. Accordingly, massive particles are not directly subject to the gravitational force.
8. The TI field supports the propagation of light.
9. The speed of light and gravitons is their speed relative to the TI field.
10. Acceleration of the TI field is moderated by a second field termed the static field which, itself, is not subject to gravity.

^ The Pioneer and Cassini Spacecraft Trajectory Anomalies

Unexpected accelerations toward the Sun have been observed in the trajectories of Pioneer 10, Pioneer 11 and the Cassini spacecraft [4]. Asymmetric heat radiation from on-board power sources has been advanced as the putative cause of these anomalous accelerations. This paper proposes that the flux model of gravity offers a different explanation for these anomalous accelerations.

^ *The Pioneer Anomaly*

The Pioneer 10 and Pioneer 11 spacecraft experienced unexpected accelerations toward the Sun that were measured after the spacecraft passed beyond about 20 astronomical units from the Sun [4]. The Pioneer spacecraft experienced unexpected accelerations of about $(8.74 \pm 1.33) \times 10^{-10}$ m/sec^2. This excess was first noticed at 20 AU, then stayed constant beyond 20 AU. Asymmetric heat radiation is the putative cause.

^ *The Cassini Anomaly*

The Cassini spacecraft experienced an unexpected acceleration of $(26.7 \pm 1.1) \times 10^{-10}$ m/sec^2 at the distance of Saturn [4]. The flux model offers a possible explanation for this anomalous acceleration. As in the Pioneer anomalies, asymmetric heat radiation has been suggested as the putative cause.

^ The Flux Model of Gravity

The acceleration ‘a’ of gravity by a central mass M at a distance r is given by Newtonian mechanics as

$$a = GM / r^2 \qquad (1)$$

The flux model posits that in the gravitational field of a massive body, the velocity of the TI field combines with that of the gravitons emitted by the body to increase the flux of gravitons relative to the TI field. Thus the response of the TI field to gravity adds to the force of gravity.

If gravity is mediated by gravitons, then the acceleration in Eq (1) is proportional to the flux of gravitons at a distance r from a gravitational body of active gravitational mass M. The graviton flux seen by particles of the TI field is augmented by the velocity of particles of the TI field at a given radius from the gravitational body. The augmentation in graviton flux relative to the value given implicitly in Eq (1) is proportional to v / c, where v is the velocity of particles of the TI field toward the gravitational body and c is the velocity of light and of gravitons relative to the TI field. Particles of the TI field are thus accelerated as shown in Eq (2).

$$a = (GM / r^2) * (1 + v / c) \qquad (2)$$

The escape velocity at a distance r from a gravitational body of mass M is given [5] by

$$v_{Escape} = (2\ GM / r)^{1/2} \qquad (3)$$

The ***magnitude*** of the infall velocity of particles of the TI field at a distance r is the same as the escape velocity of a particle falling from infinity radially toward the gravitational mass at that radius from the center of mass of the gravitational body as expressed in the conventional Newtonian model. The infall velocity of the TI field is the negative of the escape velocity of a particle; the magnitudes of the velocities are the same.

$$v_{Infall} = v_{Escape} = (2\ GM / r)^{1/2} \qquad (4)$$

The value of v in Eq (2) is the value given for v_{Infall} in Eq (4). The expression for the acceleration of particles of the TI field in Eq (2) becomes Eq (5).

$$a_{Total} = (GM / r^2) * (v + c) / c$$

$$a_{Total} = (GM / r^2) * ((\ 2\ GM / r\ )^{1/2} + c\ ) / c$$

$$a_{Total} = (GM / r^2) * (\ 1 + (2\ GM / r\ c^2\ )^{1/2}\ ) \qquad (5)$$

An object in free fall at a distance r from the gravitational mass would experience this same acceleration [3].

The incremental acceleration is given by

$$a_{incremental} = (GM / r^2) * (2GM / r\ c^2)^{1/2} \qquad (6)$$

Rewrite Eq (7) as

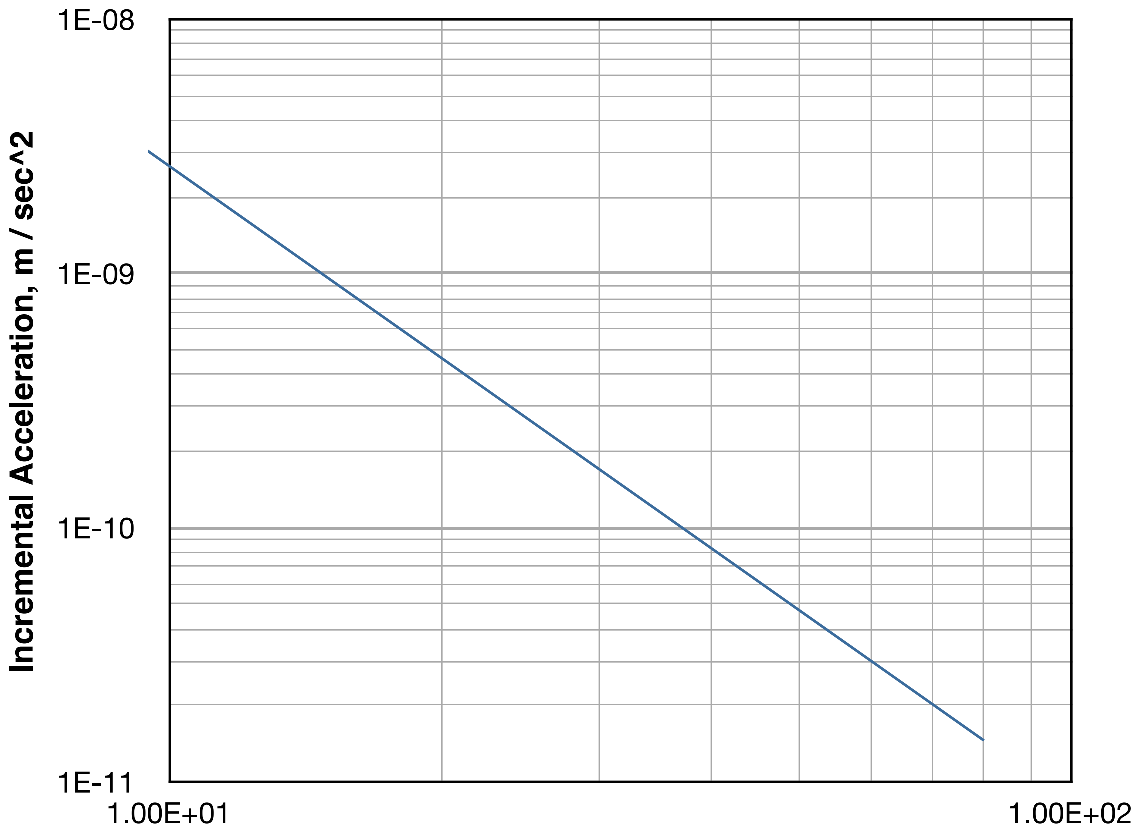
$$a_{incremental} = 2^{1/2} * (GM)^{3/2} / (r^{5/2}\ c) \qquad (7)$$

The incremental acceleration profile about a gravitational body is given by Eq (7). This is the incremental acceleration predicted by the flux model, over and above the Newtonian value. These equations are summarized in Table 1.

^ Table 1. Acceleration Equations of the Flux Model of Gravity

Total Acceleration	Incremental Acceleration
$(GM / r^2) * (1 + (2GM / r c^2)^{1/2})$	$(GM / r^2) * (2 GM / r c^2)^{1/2}$
$(GM / r^2) * (1 + (2GM / r c^2)^{1/2})$	$2^{1/2} * (GM)^{3/2} / (r^{5/2} c)$

^ Application of the Flux Model to the Pioneer and Cassini Anomalies



Distance r from the Sun, Astronomical Units

^ Figure 1. Incremental Acceleration Toward the Sun Predicted by the Flux Model, m/sec^2 (log-log scales)

Governing equation: $a_{Incremental} = 2^{1/2} (GM)^{3/2} / (r^{5/2} c)$

The incremental acceleration toward the Sun is graphed in Figure 1. At 20 AU from the Sun, the graph shows an incremental acceleration of 4.6 x 10^{-10} m/sec^2 toward the Sun. Compare this value with (8.74 ± 1.33) x 10^{-10} m/sec^2 measured for the Pioneer spacecraft. Data shows that the anomalous acceleration of the Pioneer spacecraft remained at this value as the craft moved beyond 20 AU from the Sun, whereas the incremental acceleration predicted by the flux model decreases with the factor 1 / $r^{5/2}$.

The incremental acceleration at Saturn's distance from the Sun (10.05 AU) [6] at the first encounter of Cassini with Saturn compares more closely: The incremental acceleration toward the Sun predicted by the flux model is 26.0 x 10^{-10} m/sec^2. The measured value for the Cassini spacecraft was (26.7 ± 1.1) x 10^{-10} m/sec^2 [4]. Table 2 compares the measured anomalous accelerations of the Pioneer and Cassini spacecraft and the incremental accelerations predicted by the flux model.

^ Table 2. Comparison of Anomalous Accelerations of Pioneer and Cassini Spacecraft with Predictions of the Flux Model of the Incremental Acceleration Toward the Sun

Spacecraft	Distance from the Sun in Astronomical Units	Anomalous Acceleration of Spacecraft [4]	Incremental Acceleration Predicted by the Flux Model
Pioneer 10 Pioneer 11	20	$(8.74 \pm 1.33) \times 10^{-10}$ m/sec^2.	4.6×10^{-10} m/sec^2
Cassini [Note 1]	10.05	$(26.7 \pm 1.1) \times 10^{-10}$ m/sec^2	26.0×10^{-10} m/sec^2

Note 1

1. Calculation is based on Saturn's distance of 10.05 AU from the Sun on 30 June 2004 at the arrival of the Cassini spacecraft [6].

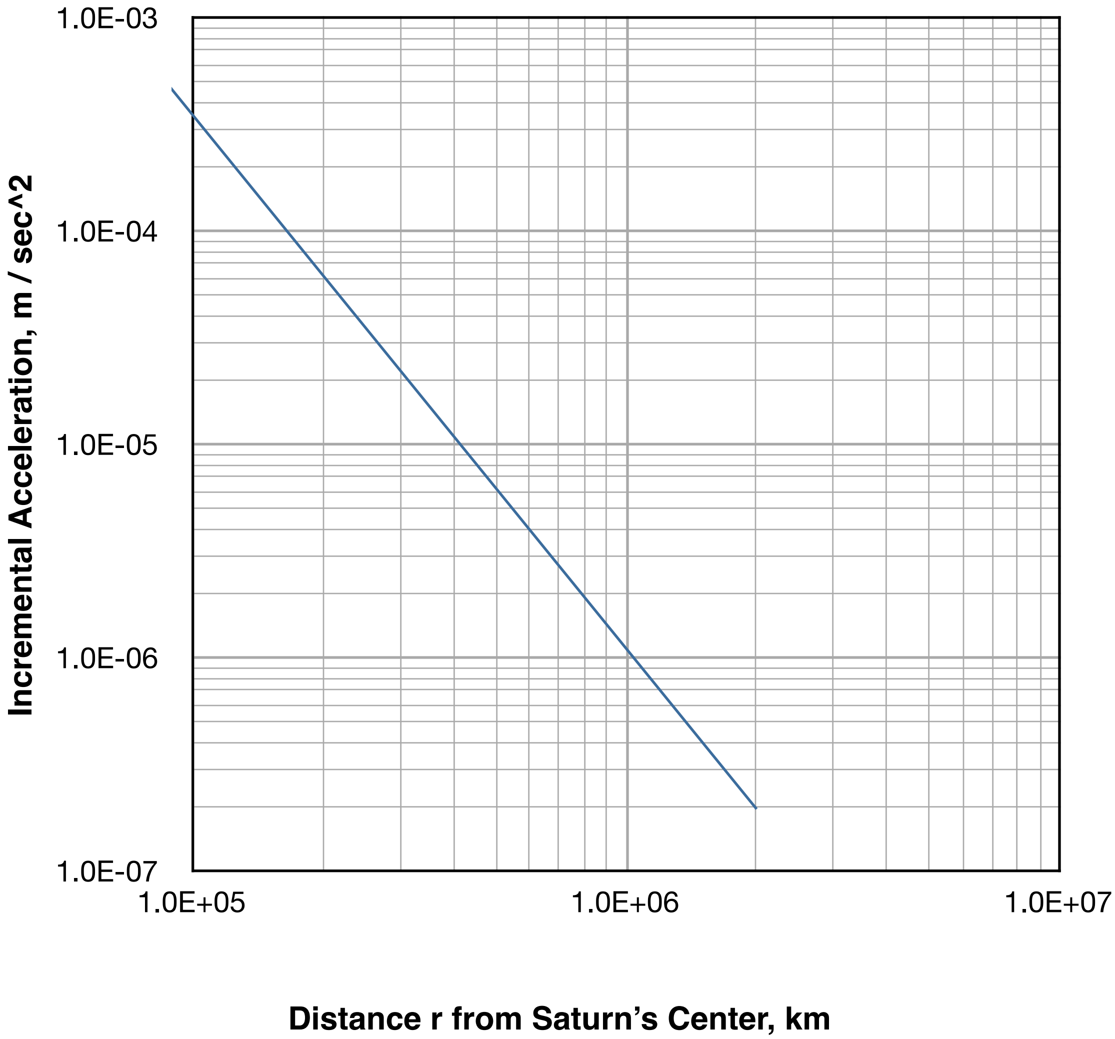
Table 3 lists the incremental acceleration predicted by the flux model at the distance of each planet from the Sun for the Earth and beyond.

^ Table 3. Incremental Acceleration of the Flux Model vs Distance from the Sun

Planet	Distance r from the Sun AU [7]	Incremental acceleration, m / sec^2
Earth	1.0	8.42E-07
Mars	1.52	2.95E-07
Jupiter	5.20	1.36E-08
Saturn [Note 1]	10.05	2.60E-09
Uranus	19.18	5.22E-10
Neptune	30	1.71E-10
Beyond1	40	8.32E-11
Beyond2	50	4.76E-11
Beyond3	60	3.02E-11
Beyond4	80	1.47E-11
Beyond5	100	8.42E-12

Note 1. Calculation is based on Saturn's distance of 10.05 AU from the Sun on 30 June 2004 at the arrival of the Cassini spacecraft.

The Cassini spacecraft was placed in orbit about Saturn on arrival at the planet. The flux model predicts incremental accelerations relative to Newtonian mechanics for an object (the Cassini spacecraft) in free fall (orbit) about a gravitational body (Saturn). Figure 2 shows the incremental acceleration toward Saturn predicted by the flux model.



^ Figure 2. Incremental Acceleration Toward Saturn Predicted by the Flux Model, m/sec^2 (log-log scales)

Governing equation: $a_{Incremental} = 2^{1/2} (GM)^{3/2} / (r^{5/2} c)$

^ Conclusions

1. The flux model of gravity gives good agreement of the anomalous acceleration of the Pioneer spacecraft measured at 15-20 AU, but is much higher than the satellite data closer to the Sun and gives much lower acceleration farther than 20 AU.
2. The flux model does not fit the Pioneer data.
3. The flux model gives good agreement with the anomalous acceleration of the Cassini spacecraft at the distance of Saturn.
4. The flux model predicts periodic anomalies in the orbital speed of the Cassini spacecraft in its elliptical orbits about Saturn.

^ Appendix A

^ Basic Parameters Used to Generate the Tables and Figures

The basic parameters used to generate the tables and figures are listed in Table A-1.

^ Table A-1. Basic Parameters [4] [6] [8] [9]

Reference	Parameter	Value	Units
Earth	GM	398,600.4418	km^3 / sec^2
Earth	Radius r	6,371	km
Earth	Distance from Sun	149,598,262	km
Earth	Distance from Sun	1.0	AU
Sun	GM	1.32712E+11	km^3 / sec^2
Sun	Radius r	695,500	km
Universal	Velocity of light c	299,792.458	km / sec
Jupiter	GM	126,686,534	km^3 / sec^2
Jupiter	Radius r	69,911	km
Jupiter	Distance from Sun	778,340,821	km
Jupiter	Distance from Sun	5.203	AU
Saturn	GM	37,931,187	km^3 / sec^2
Saturn	Radius r	58,232	km
Saturn	Distance from Sun	1.50E+09	km
Saturn	Distance from Sun	10.05	AU

^ References

1. ^ *Higgs Mechanism,* http://en.wikipedia.org/wiki/Higgs_mechanism, February 2015.
2. ^ Peters, Richard A., *Conjecture on Time Dilation, Gravity and Inertia*, http://viXra.org/abs/1205.0112.
3. ^ a b Peters, Richard A., *Escape Velocities of the Flux Model of Gravity,* http://viXra.org/abs/1410.0019.
4. ^ *a b c d e f Pioneer anomaly,* http://en.wikipedia.org/wiki/Pioneer_anomaly.
5. ^ *Escape velocity,* http://en.wikipedia.org/wiki/Escape_velocity.
6. ^ *a b* c *Ephemeris for Saturn,* 6-30-2004 to 7-20-2004, http://ssd.jpl.nasa.gov/horizons.cgi#results.
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