DOES THE LAITHWAITE GYROSCOPIC WEIGHT LOSS HAVE PROPULSION POTENTIAL?

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ABSTRACT
Prof. Laithwaite had stated that gyroscopic weight loss is observable, and that his fellow professors specializing in rotational mechanics had not been able to discover the theoretical mechanisms for the weight loss of the 50 lb motorcycle wheel demonstration.

NASA's work on gyroscopic weight loss, however, did not produce any measurable results. A comparison of Prof. Laithwaite's experiment with NASA's revealed substantial differences, thus reopening this issue. If a gyroscope can lose weight, under what conditions is this observable, and what are the possible theoretical explanations for such an effect?

This paper uses a structured approach to compare a gravitational field with a centripetal force field to determine the key experimental parameters. These parameters account for the differences between Prof. Laithwaite's experiments and NASA's.

The purpose of this paper is to make available publicly, a through and reasoned, deconstruction and analysis of what Prof. Eric Laithwaite had observed. Primarily because, both sides, the yea and the nay sayers have not made their analysis available to public or peer scrutiny. It is hoped that the material presented will encourage others to develop further theoretical analyses and experimental designs, until we are sure that weight loss is or is not possible.

The paper presents sufficient experimental evidence to confirm that the Laithwaite gyroscopic weight loss is genuine, and not due to gyroscopic forces. It then presents a possible theoretical approach to explaining this weight loss, a critical requirement for the development of future propulsion technologies. Two approaches are examined, the curvature approach and the gradient approach. Both approaches are derived within the context of Special Relativity, a body of knowledge that is very well documented and understood.

Does the Laithwaite Gyroscopic Weight Loss have Propulsion Potential? My current conclusion is that further experiments are required to calibrate this behavior. At this juncture, it is difficult to differentiate between gravitational buoyancy and thrust.

Further research will shed light on whether these results will impact theoretical and (Ning Li) experimental work (Podkletnov & Nieminen, and Hayasaka & Takeuchi).

1. INTRODUCTION

1.1 A Brief History
In 1973, Prof. Eric Laithwaite (1921 - 1997)[1], the inventor of the linear motor and Emeritus Professor of Heavy Electrical Engineering at Imperial College, London, UK, presented some anomalous gyroscopic behavior for the Faraday lectures at the Royal Institution. Included in this lecture-demonstration was a big motorcycle wheel weighing 50lb that he spun up and raised effortlessly above his head with one hand, claiming it had lost weight and so contravened Newton's third law.

1.2 Laithwaite's Findings
Laithwaite demonstrated[2] four rules[3]. A precessing gyroscope,

1. Will not exhibit lateral forces in the plane of precession.
2. Will not exhibit centrifugal forces in the plane of precession.
3. Will not exhibit angular momentum in the plane of precession.
4. Will lose weight.

1.3 Scope of Paper
In this paper I will examine only the fourth rule, as this is the most pertinent to future space propulsion technologies. I take a scientific approach to examining Laithwaite's fourth rule, duplicating wheels, and fabricating an experimental set-up to prove or disprove this last claim.

1.4 Other Similar Reported Behavior
In researching this subject I found that others (Podkletnov & Nieminen, 1992, and Hayasaka & Takeuchi, 1989) had observed similar anomalous weight change behavior with, or in the presence of, spinning disc. Could there be some commonality with the Laithwaite gyroscopic weight loss?

1.5 The Window of Opportunity
In deconstructing and structuring this research, I present, first, a possible theoretical explanation. I distinguish between two types of spinning disc behavior. I assume one type of spinning disc behavior losses weight (Laithwaite) while the other (Jones) does not. After all, not all gyroscopes lose weight. Examples of those that do not lose weight are those used for navigation. The hunt, is then for the window of opportunity for when a gyroscope will lose weight, if they do.

1.6 The Purpose of this Paper
The purpose of this paper is to make available publicly, a through and reasoned, deconstruction and analyses of what Prof. Eric Laithwaite had observed. Primarily because, both sides, the yea and the nay sayers have not made their analyses available to public or peer scrutiny. It is hoped that the material presented will encourage others to develop further theoretical analyses and experimental designs.

2. A REVIEW OF THE PRINCIPLE OF EQUIVALENCE & ITS CONSEQUENCES

2.1 Introduction

There has been much work on relativistic rotating masses, Browne (1977) for example. However, the problems addressed are about near velocity of light behavior of rotating masses. In order to understand how the Laithwaite gyroscopic weight loss occurs, a different approach to gravitational fields is required.

2.2 Principle of Equivalence

The Principle of Equivalence (Schutz 2003) states that if gravity were everywhere uniform we could not distinguish it from acceleration. That is a point observer within a gravitational field would not be able to distinguish between a gravitational field and acceleration.

2.3 Time Dilation is the Key Parameter

Taking this a step further, Solomon (2001) had shown that the escape or free-fall-from-infinity velocities are dictated by the time dilation of the gravitational field at that point in space, one can now interpret velocity and acceleration as representation of time dilation or vice versa. Such that, using the Lorentz transformation (Gibilisco 1983) equations,

$$v = c \,.\, \sqrt{(1 - t_\infty^2 / t_v^2)} \tag{2.1}$$

$$= c \,.\, \sqrt{(1 - 1 / t_v^2)} \tag{2.2}$$

where

v	=	velocity of interest at a specific radial distance from the center of the gravitational source
c	=	velocity of light
t_∞	=	time dilation at infinity, 1
t_v	=	time dilation at a specific radial distance from the center of the gravitational source

The results of these formulae are tabulated in Table 2.1 below, using planets in our Solar System. The empirical evidence concurs with the hypothesis that radial velocities are governed by time dilation. This is not in disagreement with Relativity's Principle of Equivalence.

The hypothesis (Solomon, 2001) is that time dilation causes a shift in the center of mass. For a hemisphere it is given by,

$$S_{CM} = (3/8)\, s_{xo}\, (d_{xd}/d_{xo} - 1) \quad (2.3)$$

where d_{xd} = duration required to detect particle under time dilation
d_{xo} = duration required to detect particle without time dilation
s_{xo} = space required to detect particle along axis of motion, without time dilation
S_{CM} = shift in the center of mass.

This is essentially reduced to,

$$S_{CM} = (3/8)\, s_{xo}\, (t_d - 1) \quad (2.4)$$

where t_d = time dilation at that point, where the particle is.
= d_{xd}/d_{xo}

Since $(t_d - 1) > 0$ (2.5)

$S_{CM} > 0$ a shift towards greater time dilation.

Equation (2.5) presents a mechanism, based solely on Special Relativity, on how time dilation causes the center of mass of a particle to shift in the direction of increasing time dilation, thereby providing the effect of gravity.

3. ANALYSIS OF TIME DILATION IN A GRAVITATIONAL FIELD

3.1 Tangential & Radial Parameters

Solomon (2001) had shown that the escape or free-fall-from-infinity velocities are dictated by the time dilation of the gravitational field at that point in space. One infers that there are two time dilation parameters in a gravitational field, and that time dilation is a vector. Radial time dilation, t_r and tangential time dilation, t_t. These correspond to the free fall or escape (radial), v_r, and orbital (tangential), v_t, velocities in a gravitational field respectively. The relationship between the velocities and time dilation is governed by Lorentz-FitzGerald transformation (Gibilisco 1983), such that,

$$v = c \,.\, \sqrt{(1 - t_\infty^2 / t_v^2)} \quad (3.1)$$

where	v	=	velocity of interest at a specific radial distance from the center of the gravitational source
	c	=	velocity of light
	t_∞	=	time dilation at infinity, 1
	t_v	=	time dilation at a specific radial distance from the center of the gravitational source

Therefore, the respective velocities are,

$$v_r = c \cdot \sqrt{(1 - t_\infty^2 / t_r^2)} \qquad (3.2)$$

$$v_t = c \cdot \sqrt{(1 - t_\infty^2 / t_t^2)} \qquad (3.3)$$

Given that the escape velocity, v_e, and the orbital velocity, v_o, of a gravitational field (Schutz 2003) is governed by the relationships,

$$v_e = \sqrt{(2GM/R)} \qquad (3.4)$$

$$v_o = \sqrt{(GM/R)} \qquad (3.5)$$

Where	G	=	gravitational constant.
	M	=	mass of gravitational source, e.g. Earth.
	R	=	distance from the center of the gravitational source.

One can substitute the radial velocity, v_r, for the escape velocity, v_e, and tangential velocity, v_t, for the orbital velocity, v_o, to get, the radial and tangential time dilation, as follows,

$$t_r = 1 / \sqrt{(1 - 2GM/(R.c^2))} \qquad (3.6)$$

$$t_t = 1 / \sqrt{(1 - GM/(R.c^2))} \qquad (3.7)$$

or

$$t_r = 1 / \sqrt{(1 - K_r/R)} \qquad (3.8)$$

$$t_t = 1 / \sqrt{(1 - K_t/R)} \qquad (3.9)$$

where $K_r = 2GM/c^2$
$K_t = GM/c^2$

3.2 Gradient & Curvature

We can now determine the gradient and curvature of the respective time dilations. The gradient of the time dilations with respect to radial distance, R, is given by,

$$\text{Gradient} = dt/dR \qquad (3.10)$$

And solving, gives,

$$dt_r/dR = (-K_r/2R^2).(1/(1 - K_r/R)^{3/2}) \qquad (3.11)$$

$$dt_t/dR = (-K_t/2R^2).(1/(1 - K_t/R)^{3/2}) \qquad (3.12)$$

It turns out that the second term, in both equations, (3.11) & (3.12), is equal to 1, therefore, the two equations reduce to,

$$dt_r/dR = (-K_r/2R^2) = - (GM/c^2)/R^2 \qquad (3.13)$$

$$dt_t/dR = (-K_t/2R^2) = - (GM/2c^2)/R^2 \qquad (3.14)$$

and the second differential is given by

$$d^2t_r/dR^2 = (K_r/R^3).((1- K_r/R)^{-3/2}) + (3K_r^2/4R^4).((1- K_r/R)^{-5/2}) \qquad (3.15)$$

$$d^2t_t/dR^2 = (K_t/R^3).((1- K_t/R)^{-3/2}) + (3K_t^2/4R^4).((1- K_t/R)^{-5/2}) \qquad (3.16)$$

Curvature (Kline 1977) of the time dilations is given by

$$\text{Curvature, } C = \pm (d^2y/dx^2) / (1 + (dy/dx)^2)^{3/2} \quad (3.17)$$

And solving, gives, the radial, C_r, and tangential, C_t, curvatures as follows

$$C_r = [(K_r/R^3).((1- K_r/R)^{-3/2}) + (3K_r^2/4R^4).((1- K_r/R)^{-5/2})]/[1 + (K_r^2/4R^4)/(1- K_r/R)^3]^{3/2} \quad (3.18)$$

$$C_t = [(K_t/R^3).((1- K_t/R)^{-3/2}) + (3K_t^2/4R^4).((1- K_t/R)^{-5/2})]/[1 + (K_t^2/4R^4)/(1- K_t/R)^3]^{3/2} \quad (3.19)$$

It turns out that the denominator is equal to 1, thus the two equations reduce to,

$$C_r = (K_r/R^3).((1- K_r/R)^{-3/2}) + (3K_r^2/4R^4).((1- K_r/R)^{-5/2}) \quad (3.20)$$

$$= d^2t_r/dR^2 \quad (3.21)$$

$$C_t = (K_t/R^3).((1- K_t/R)^{-3/2}) + (3K_t^2/4R^4).((1- K_t/R)^{-5/2}) \quad (3.22)$$

$$= d^2t_t/dR^2 \quad (3.23)$$

The important finding here is that the curvature of the time dilation is also the second derivative.

And since the second term (3.5639×10^{-32}) is much smaller than the first (3.4177×10^{-23}), (3.20) & (3.22) reduce to,

$$C_r = (K_r/R^3).((1- K_r/R)^{-3/2}) \quad (3.24)$$

$$C_t = (K_t/R^3).((1- K_t/R)^{-3/2}) \quad (3.25)$$

As, the second term is 0.99999999791447 or approximately 1, (3.22) & (3.23) can be further simplified to,

$$C_r = (K_r/R^3) = (2GM/c^2)/ R^3 \quad (3.26)$$

$$C_t = (K_t/R^3) = (GM/c^2)/ R^3 \quad (3.27)$$

Figure 3.1, 3.2 and 3.3 present the results of these calculations.

4. ANALYSIS OF TIME DILATION IN A CENTRIPETAL FIELD

4.1 Tangential Parameters

In this section we review the centripetal force field from the perspective of time dilation. As with gravitational fields, centripetal force fields have two time dilation parameters. Radial time dilation, t_r and tangential time dilation, t_t. However, radial velocity, v_r, is zero, and tangential velocity, v_t, is determined by the radius, r, and angular rotation ω. We will review tangential parameters, before we look at radial parameters. Using Lorentz transformation,

$$t_t = t_o / \sqrt{(1 - v_t^{\ 2} / c^2)} \quad (4.1)$$

where
- v_t = velocity is the tangential velocity of a rotating plane, a radial distance r from the center.
- c = velocity of light
- t_o = time dilation when rotating plane is stationary, 1
- t_v = time dilation at a specific radial distance, r, from the center of the rotating plane

Given that, the tangential velocity is governed by the speed of rotation, ω, then

$$v_t = \omega . r \quad (4.2)$$

$$t_t = 1 / \sqrt{(1 - \omega^2 .r^2 / c^2)} \quad (4.3)$$

or

$$t_t = 1 / \sqrt{(1 - k_t r^2)} \quad (4.4)$$

where $k_t = \omega^2 / c^2$

4.2 Gradient & Curvature

We can now determine the gradient and curvature of the tangential time dilation. The gradient of time dilation with respect to radial distance, R, is given by,

$$\text{Gradient} = dt_t/dr \qquad (4.5)$$

And solving, gives,

$$dt_t/dr = (k_t\, r).(1 - k_t\, r^2)^{-3/2} \qquad (4.6)$$

It turns out that the second term, in equations (4.6), is equal to 1, therefore, the (4.6) reduces to,

$$dt_t/dr = (k_t\, r\,) \qquad (4.7)$$

and the second differential is given by

$$d^2t_t/dr^2 = k_t.(1- k_t r^2)^{-3/2} + (3.k_t^2 . r^2).(1- k_t r^2)^{-5/2} \qquad (4.8)$$

as both denominators reduce to 1, equation (4.8) reduces to

$$d^2t_t/dr^2 = k_t. + 3.k_t^2 . r^2 \qquad (4.9)$$

Curvature (Kline 1977) of the tangential time dilation is given by

$$\text{Curvature, C} = \pm (d^2y/dx^2) / (1 + (dy/dx)^2\,)^{3/2} \qquad (4.10)$$

And solving, gives, tangential time dilation curvature, C_t, as follows

$$C_t = [k_t.(1- k_t r^2)^{-3/2} + (3.k_t^2 . r^2).(1- k_t r^2)^{-5/2}] / [1 + \{(k_t r).(1 - k_t r^2)^{-3/2})\}^2]^{3/2} \quad (4.11)$$

Since the denominators is equal to 1, equation (4.11) reduces to,

$$C_t = k_t. + 3.k_t^2 . r^2 \quad (4.12)$$

$$= d^2t_t/dr^2 \quad (4.13)$$

4.4 Gradient of Time Dilation is the Key Parameter

One can summarize the numerical analysis presented in figures 3.1, 3.2, 3.3, 4.1, and 4.2, in Table 4.1, below.

If gyroscopic spin is to produce gravity modifications, of the type that results in some amount of weightlessness, the gyroscopic spin has to have a parameter value that is opposite to gravity's. This is achieved with the gradient of time dilation. The centripetal force field gradient of time dilation is of the opposite sign to that of gravity's. The magnitude of the time dilation behaves in the correct manner to increasing or decreasing tangential velocities and therefore, force.

Note that curvature is positive for both fields, and is therefore, unable to distinguish attraction from repulsion. However, change in curvature has opposite behaviors. Curvature, therefore, is not a useful property for propulsion technology theory development, as it cannot distinguish the direction of the increasing time dilation. It has no vector properties.

5.0 HUNT FOR THE WINDOW

"You have to find the window where physics behaves 'differently' "[4]. This window of opportunity, if it exists, will not be found in the known theoretical models, as Laithwaite and his colleagues have investigated existing bodies of knowledge thoroughly. Sections 2, 3 & 4 present a new avenue for research.

Section 3 presents equations for the shape of both radial and tangential time dilation behavior in a gravitational field. One can view the gravitational field graphically, Fig 5.1 & 5.2, as a function of time dilation. The graph has been presented in a manner so that one can visualize how time dilation forms a funnel like structure in 3-dimensional space.

Section 4, however, does not discuss radial time dilation for a centripetal force. There isn't one, because there is no radial velocity. Therefore, a conic like structure in 3-dimensional space does not exist for a non-rotating gyroscopic disc, like that of gravity.

However, if one were to rotate (not precess) the spinning gyroscopic disc, one produces a centripetal force overlaid on the tangential time dilation field of the spinning disc, as discussed in Section 4. The calculated centripetal acceleration, A_r, at any point along the radius of the spinning disc is given by,

$$A_r = \omega_l \,.\, l / \cos(\theta) \qquad (5.1)$$

where ω_l = rotational frequency of the spinning disc.
θ = angle between the level arm, from pivot, and the hypotenuse, to a point on the radius of the spinning disc.
l = the lever arm length.

A quick and dirty formula for radial time dilation can be derived from equation (3.8), and substituting centripetal acceleration for gravity's, g, one gets,

$$t_r = 1 / \sqrt{(\, 1 - 2.(\omega_l^{\,2} / c^{\,2}).r^2 \,)} \qquad (5.2)$$

Plotting this graphically, Fig 5.3 and 5.4, we see that the time dilation behavior is a conic (and the opposite of gravity's funnel) in the presence of a centripetal force that causes radial time dilation field to "pop" into existence. This is a key attribute, if rotating spinning wheels are to evidence some form of gravity modification.

Since this is a quick and dirty approach to estimating the radial time dilation, at this juncture we face three problems,

1. Do not know how to combine the two time dilations, radial and tangential, into a single unified field for centripetal force fields.
2. To proceed with this theoretical analysis, we require empirical data, to provide suggestions on how radial and tangential time dilations are to be combined into a single unified field that can negate or neutralize the surrounding gravitational field.
3. What is the range of this field effect?
4. What properties does this field have? Is a thrust or is it just gravitational buoyancy?

6. DECONSTRUCTING THE LAITHWAITE AND NASA EXPERIMENTS

6.1 The Laithwaite Experiment

Laithwaite[2] presented two types of demonstrations of weight change. The first, the Laithwaite Effect[5], was the Big Wheel experiment, which visibly demonstrates weight loss. See Fig. 6.1 & 6.2. The Big Wheel was a 50 lb (≈ 22.7 kg) motorcycle wheel, spinning at 5,000 rpm, attached to a 3 ft rod (≈ 1 m), which Laithwaite held by one wrist, and slowly swung it over and around his head, at about 7 rpm. Experiments show that the wrist is not capable of holding more than 3 lb

(≈ 1.4 kg) at the end of a 3 ft (≈ 1 m) rod weighing 2.5 lb (≈ 1.2 kg). Therefore, the Big Wheel had to have lost about 45 lb (≈ 20.5 kg)

The second, the Jones Effect, was the Small Wheel experiment, Fig 6.3. This experiment consisted of two 2-inch (≈ 5 cm) radius gyroscopes, using gyroscopic motions to create a directed force. Laithwaite and Dawson were granted a US patent (5,860,317[6]) on January 19, 1999, for a device based on the principles of the Small Wheel experiments.

In this paper I consider the Big Wheel experiment only. This experiment is much simpler, and therefore, easier to reproduce, test, and draw out the governing principles.

6.2 The NASA Experiment

In 2002, NASA[7] investigated this Laithwaite gyroscopic weight loss behavior (Thomas 2002). NASA's experiment comprised of manually spinning 4 in (≈ 10 cm) radius bicycle wheel. The experiment and results are presented here as a comparison to Laithwaite's original demonstration.

6.3 Laithwaite-NASA comparisons

Having reviewed the videos of Laithwaite's demonstration, and reconstructed NASA's experiments, a table of differences in the experiments, Table 6.1, is documented. It is rather obvious that the experiment that NASA conducted was not the same as Laithwaite's. The good news is that the comparisons suggest boundary conditions, a window of opportunity, exists.

Further, it is possible to test whether precession or centrifugal rotation can explain some of the observable results. In particular, the most suitable observable results would be the rotation, of the Big Wheel about Laithwaite. There are two approaches, gravity induced precession, and centrifugal based rotation.

6.4 Gravity Induced Precession

Using, the equation[8], for gravity induced precession,

$$\omega_{precession} = M.g.R / L \quad (6.4.1)$$

where M = mass of spinning wheel or gyroscope, 22.7 kg.
L = angular momentum
R = length of the torque arm, 1m or 2m, depending whether Laithwaite's arm was outstretched.
g = acceleration due to gravity, 9.81 m/s^2.

Since[9],

$$L = I \cdot \omega \qquad (6.4.2)$$

$$I = \tfrac{1}{2} \cdot M r^2 \qquad (6.4.3)$$

Where I = moment of inertia
ω = spin of the gyroscope, 5,000 rpm or 83.3Hz.
r = radius of the gyroscope or wheel, 0.3m

Substituting, (6.4.2) & (6.4.3) into (6.4.1), one gets,

$$\omega_{precession} = 2 \quad (g.R) \quad / \quad (\omega.r^2) \qquad (6.4.4)$$

$= 314$ rpm (5.2 Hz) when $R = 2$m

$= 157$ rpm (2.6 Hz) when $R = 1$m

Gravity induced precession frequency suggest that the rotation of the Big Wheel about Laithwaite should be somewhere between 157 and 314 rpm, but eh observed value is about 7rpm. This suggest that gravity induced precession cannot explain the Big Wheel experiment.

Inverting the question to figure out the observed gravitational acceleration, g', equation (6.4.4) becomes,

$$g' = (\omega_{precession} \cdot \omega.r^2) / (2\ R) \qquad (6.4.5)$$

$= 0.22\ m/s^2$ when $R = 2$m

$= 0.44\ m/s^2$ when $R = 1$m

Therefore, the observed weight of this 50lb (22.7kg) Big Wheel is between 1.1 and 2.2 lb (0.5 to 1 kg).

6.5 Centrifugal Based Rotation

Using, the conical pendulum equation[10], for centrifugal based rotation,

$\omega_{centrifugal} = \sqrt{[g / (l \cos(\theta))]}$ (6.5.1)

$= 450$ rpm (7.5 Hz) when $l = 2$m

$= 637$ rpm (10.6 Hz) when $l = 1$m

where $\omega_{centrifugal}$ = centrifugal based rotation.

g = acceleration due to gravity, 9.81 m/s^2.

l = length of string, or in this case the rod + Laithwaite's arm, 1m or 2m, depending whether Laithwaite's arm was outstretched.

θ = angle of rod + arm to the vertical, approximately 85^o.

We observe that the conical pendulum solution cannot account for the Big Wheel rotation, as the rotation required to support the Big Wheel at almost horizontal is between 450 and 637 rpm, but the observed rotation is 7 rpm. This suggests that centrifugal force cannot explain the Big Wheel experiment.

On can turn this problem around and ask the question what is the observed gravitational acceleration, g'. Equation 2.5.1, can be rewritten as,

$$g' = \omega_{centrifugal}^2 . l \cos(\theta) \quad (6.5.2)$$

$= 0.002$ m/s^2 when $l = 2$m

$= 0.001$ m/s^2 when $l = 1$m

Therefore, the observed weight of this 50lb (22.7kg) Big Wheel is between 0.1 and 0.2 oz (2 to 6 grams).

6.6 Error Sensitivity Analysis

Since this first phase of experimental analysis consists of reviewing video documentation (Laithwaite), and
verbal commentary (NASA) of experimental designs and results, I asked the question, could errors in the estimation of the experimental parameters lead to different results? Or, how sensitive are the observed effects to error in the estimation of the experimental design?

Equation (6.4.4) shows that for a spinning disc, the frequency of the precession is independent of the mass of the disc. Equation (6.4.4) was used to generate different $\omega_{precession}$ values for each change in the three parameters. The length of the torque arm, R was varied between 1.5m to

2.5m. The radius of the spinning wheel was varied between 26cm to 34 cm. The spin of the wheel was varied between 4,500 rpm to 5,500 rpm.

The results are presented in Fig. 6.4. The theoretical frequency of precession, $\omega_{precession}$, ranges between 167 rpm and 580 rpm. This is well outside the observed Big Wheel rotation of about 7 rpm.

Further, the analysis of a bicycle wheel precession (How-Stuff-Work[11] video) is presented in Table 6.2. This analysis shows that the mathematical relationships, when precession is in effect, do work, and are correct.

One concludes that the Big Wheel phenomenon Laithwaite was demonstrating was not gyroscopic precession, though it appeared to be, because the practical results do not match theoretical results by two orders of magnitude.

7. WHAT DID LAITHWAITE DEMONSTRATE?

7.1 Brief background

The analyses in this section are based on a through review of the Laithwaite videos[12]. It is my hypothesis that Laithwaite demonstrated two different phenomena.

1. **The Laithwaite Effect** or the Big Wheel Demonstration: Under one set of conditions a spinning disc will lose weight, independently of its orientation with the Earth's gravitational field.

2. **The Jones Effect**[13] or the Small Wheel Demonstration: Under another set of conditions, spinning discs will provide directional motion that is dependent upon the gyroscopic orientation of the device.

7.2 Precession or Rotation?

The How-Stuff-Works demonstration, Table 6.2, shows that precession is a proven mathematical fact. Sensitivity analysis, Fig 6.4, shows that on basis theoretical precession analysis, the frequency of precession should be between 167 rpm and 580 rpm. Table 6.1 shows that the theoretical precession, if all parameters are correct, should be 314 rpm. Actual observed is 7 rpm. These observations suggest that the Laithwaite demonstrations did not involve precession as a mechanism.

Table 6.1 shows that on the basis of centrifugal forces the rotational frequency should be 157 rpm. Actual observed is 7 rpm. This suggests that the spinning wheel is significantly lighter than it should be. Laithwaite believed that mass transfer (US Patent 5,860,317) was the reason for this effect.

The Laithwaite Big Wheel Demonstration is two orders of magnitude different from that required of precession or centrifugal force theories. Something is definitely amiss.

Graphical deconstruction of the two demonstrations, are presented in Figures 7.1, 7.2 & 7.3. Fig. 7.1 demonstrates how the three orthogonal forces in gyroscopic motion interact. Fig 7.2 shows the mathematically proven precessing behavior of a spinning disc. The graphical analysis shown in Fig 7.3 suggests that if the pivot is placed at some distance beyond the radius of the spinning disc, the net forces should mimic centripetal behavior. The position of the pivot point determines whether the spinning disc is precessing or rotating. In Laithwaite's experiments, the pivot's distance is about 3x radius or more.

If the pivot point is at a distance less than a particular value, P, (to be determined as part of future research) from the center of the disc, the gyroscopic action is precession. Fig 7.2 illustrates the net forces, on the disc. The precessing forces change direction across the disc.

If the pivot point is at a distance greater than, P, from the center of the disc, the gyroscopic action is rotation. Fig 7.3 illustrates the net forces, on the disc. The centripetal forces of rotation are always pointing towards the pivot point.

It is seen that, all Laithwaite's demonstrations were based on a rotating gyroscopic action as the distance between the spinning disc and the pivot was about three times the radius of the spinning disc. Therefore, if correct, the 4 Laithwaite rules can be reformulated as follows: A rotating gyroscope,

1. Will not exhibit lateral forces in the plane of rotation.
2. Will not exhibit centrifugal forces in the plane of rotation.
3. Will not exhibit angular momentum in the plane of rotation.
4. Will lose weight.

8. THE SOLOMON-LAITHWAITE EXPERIMENTS

8.1 Experimental Set-up

The experimental set-up is as shown in Fig. 8.1. One of the criticisms[14] of Laithwaite rotating the Big Wheel over his head was that he had pushed the wheel into flight, and therefore, the resulting weight loss was due to inertia. This set-up was designed to allow only horizontal rotational motion, thereby ensuring that neither vertical inertia nor nutation was possible.

The second criticism[15] of the original Laithwaite experiment was that total system weight was not measured. The logic is that the weight of the Big Wheel is carried through the wrist and should be observable as Total System Weight. We know that the wrist is not capable of such weight. However, to satisfy the needs of the critics, the weight scale arrangement was such as to measure the Total System Weight.

The analysis in section 6 showed that mathematically, precession could not have been the source of the weight loss. To further negate the precession hypothesis, the effected rotation was in the opposite sense of precession.

8.2 Experimental Procedure

A first step was to note the total system weight without spin or rotation. A second step was to observe any variations in weight if the disc was slowly rotated about the vertical support. The rate of rotation was similar to that during the spinning wheel experiment.

The experimental procedure involved spinning the big disc up to 3,000 rpm, and then rotating this spinning disc. Observe the total system weight, while spinning and rotating. We noticed that the slow down in the spin was quite fast, so our records are taken from examination of video records.

8.3 Experimental Results

The individual component weights are documented in Table 8.1. Two experiments were conducted. See Table 8.2. Video documentation of the experiments is available at http://www.iSETI.us/. The rotation of the spinning disc varied between 0 rpm and 10 rpm, which is significantly less than allowed by precession. Rotation was in the opposite sense of that required of precession.

We observed that a non-rotating but spinning wheel did not lose weight, but a rotating-spinning wheel did. Weight loss was as high as 54 lbs. Note that the weight of the wheel was about 50 lbs. The observed weight was not steady and was bouncing around.

A review of video suggests that weight decreased as rotation increased. Weight increased as spin decreased. We noticed that when the spin and rotation was too slow, the wheel would "crash" back to earth. It would suddenly regain all it weight, and the effect would be equivalent to falling. See Fig 8.2. In other words, there are boundary conditions or threshold values before weight loss would come into effect.

Further experiments are required to refine the observed boundaries. For example, I am sure that 1,000 rpm will not cause weight change, and do believe that the boundary condition is closer to 2,000 rpm.

9. CONCLUSION

We were able to reproduce Laithwaite's results, under stricter conditions. The mathematical and experimental analyses lead us to conclude that weight loss is real, and that it is not caused by gyroscopic precession. There are boundary conditions and threshold values, before weight loss is observed.

10. NEXT STEPS

1. Determine the boundary conditions / threshold values.
2. The theoretical formulation and relationships within the spin-rotate centripetal force field.
3. Determine whether the weight loss effect is a buoyancy or a propulsion effect.

4. Was the work of other researchers dependent upon gyroscopic field effects?
    1. How much of Podkletnov & Nieminen (1992) results (5,000 rpm) are due to gyroscopic spin?
    2. Was Hayasaka & Takeuchi (1989, up to 13,000 rpm) work on one side of boundary conditions while Luo, Nie, Zhang, & Zhou (2002) on the other side of these conditions, thus producing conflicting results?

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Pat & Chad, Colorado Scale Center - weight scales.

Mark, Joy Controls – measurement instruments.

David Solomon – videographer.

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Object	Mass	Radius	Gravity at surface	Gravitational Escape Velocity	Time dilation	Equivalent Lorentz/Time Dilation Velocity	Escape - Equivalent Velocity Error
	M	R	g	v_e	t_v	v_f	$v_e - v_f$
	kg	m	m/s^2	m/s	s	m/s	
Sun	2.00E+30	6.90E+08	274.98	621,946	1.00000215195969	621,946	0.0000000%
Mercury	3.59E+23	2.44E+06	3.70	4,431	1.00000000010922	4,431	0.0000153%
Venus	4.90E+24	6.07E+06	8.87	10,383	1.00000000059976	10,383	0.0000018%
Earth	5.98E+24	6.38E+06	9.80	11,187	1.00000000069626	11,187	-0.0000080%
Mars	6.58E+23	3.39E+06	3.71	5,087	1.00000000014395	5,087	0.0000245%
Jupiter	1.90E+27	7.14E+07	23.12	59,618	1.00000001977343	59,618	0.0000002%
Saturn	5.68E+26	5.99E+07	8.96	35,566	1.00000000703708	35,566	-0.0000002%
Uranus	8.67E+25	2.57E+07	7.77	21,201	1.00000000250060	21,201	-0.0000005%
Neptune	1.03E+26	2.47E+07	11.00	23,552	1.00000000308580	23,552	-0.0000019%
Pluto	1.20E+22	1.15E+06	0.72	1,178	1.00000000000772	1,178	0.0001586%

Table 2.1: Comparison between Escape Velocity and Time Dilation Velocity

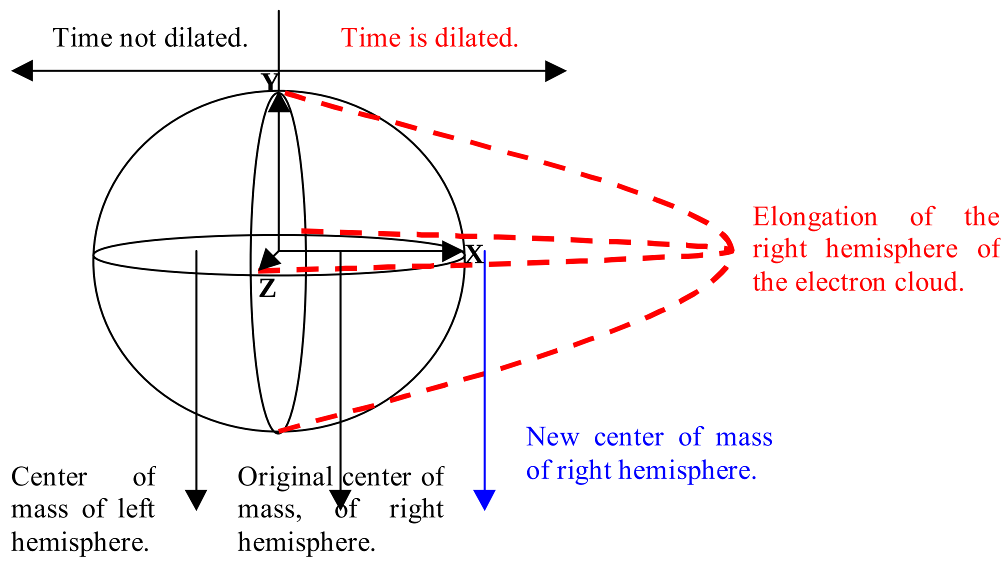


Fig. 2.1: Time dilation distorts a particle's probability cloud with respect to its own frame of reference

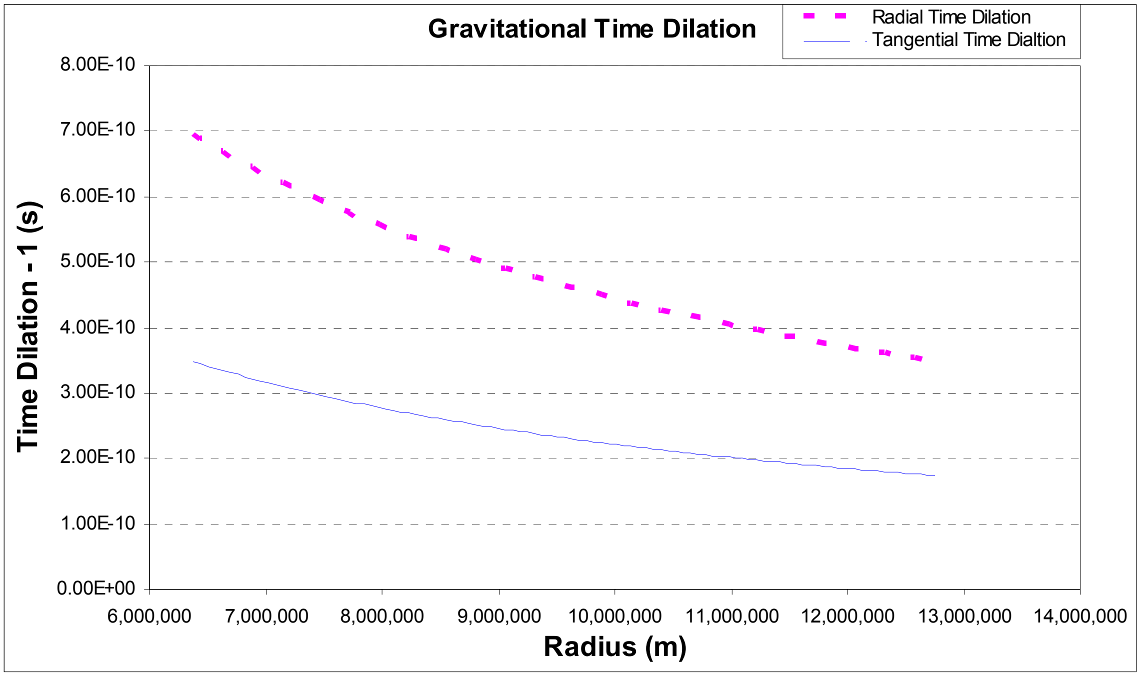


Fig 3.1: Gravitational Time Dilation as a Function of Radius.

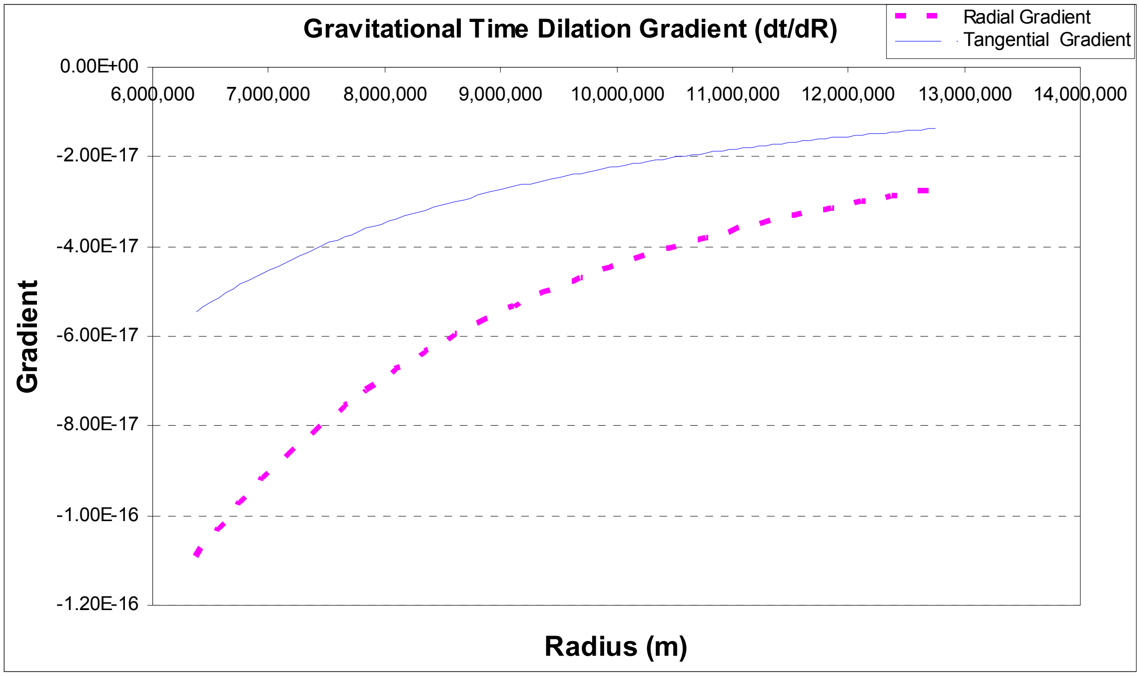


Fig 3.2: Gravitational Time Dilation Gradient as a Function of Radius.

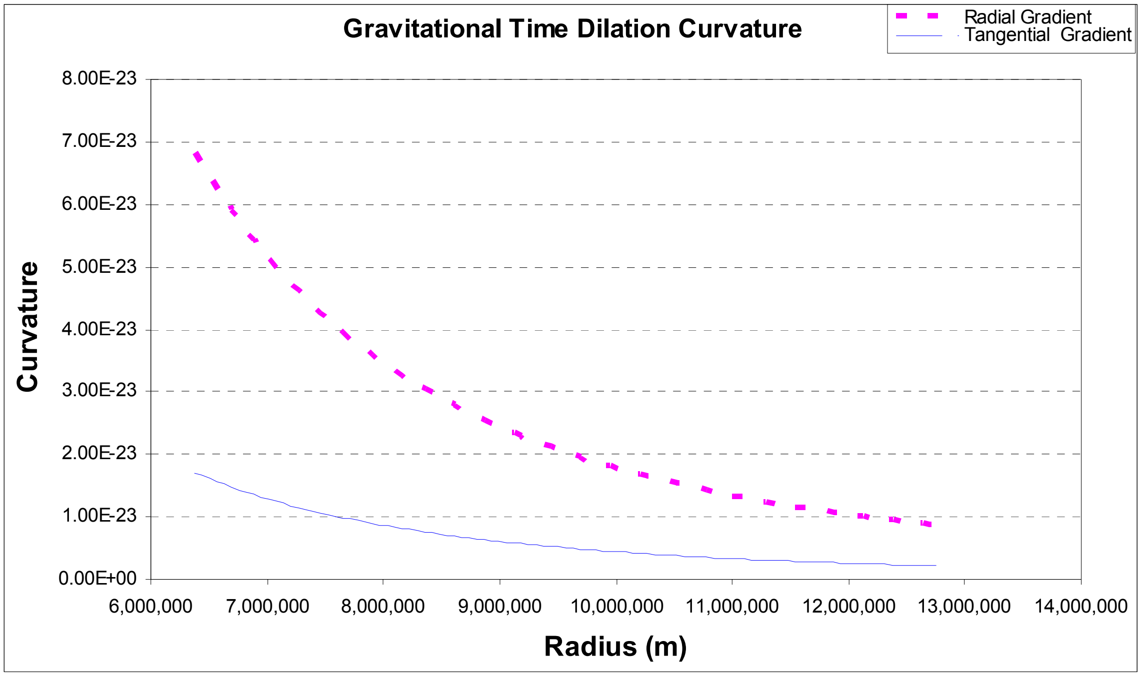


Fig 3.3: Gravitational Time Dilation Curvature as a Function of Radius.

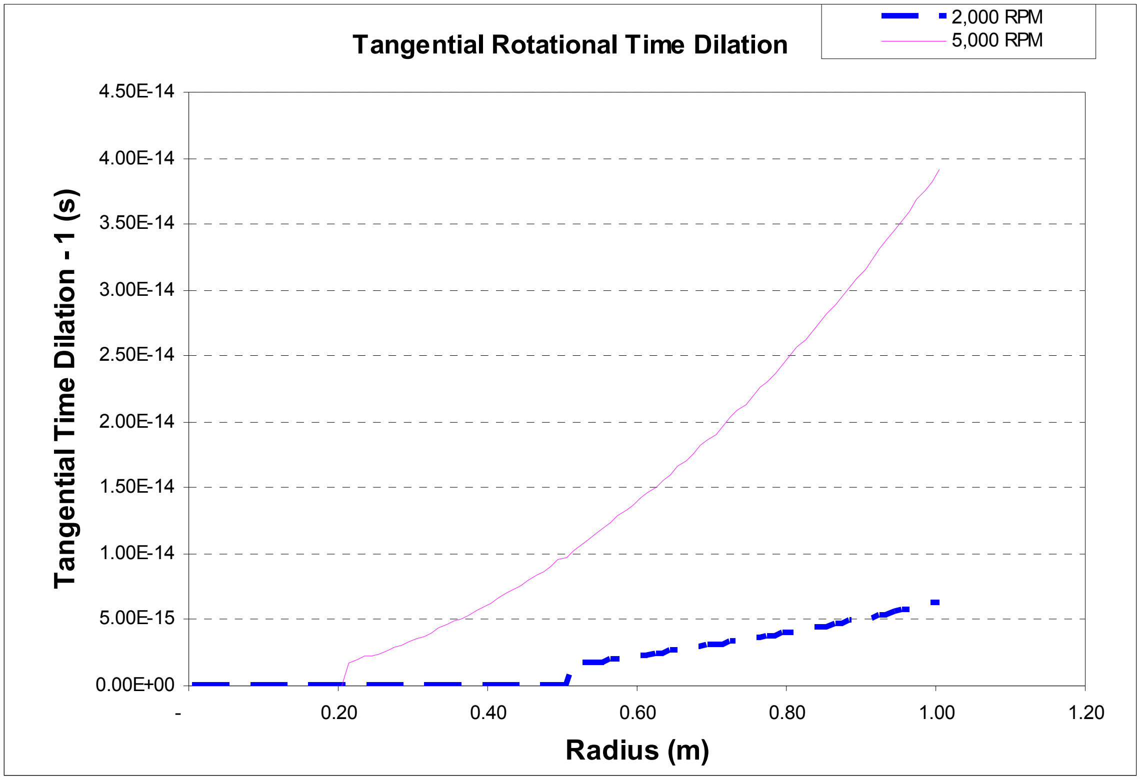


Fig. 4.1: Rotational Time Dilation along the Radius

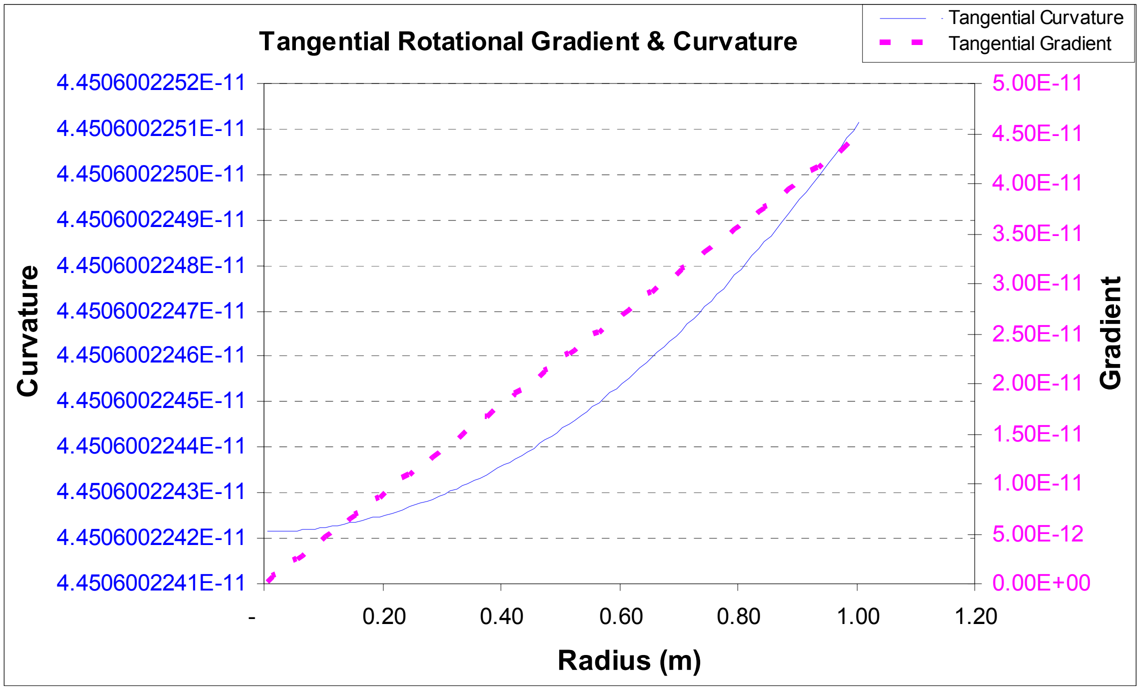


Fig. 4.2: Rotational Time Dilation – Gradient & Curvature

Time Dilation	**Gravitational Field**	**Centripetal Force Field**
Magnitude	Decreases with radius.	Increases with radius.
Gradient	Negative Increases non-linearly with radius.	Positive Increases linearly with radius.
Curvature	Positive Decreases non-linearly with radius.	Positive Increases non-linearly with radius.

Table 4.1: Comparison between Gravitational Field and Centripetal Force Field

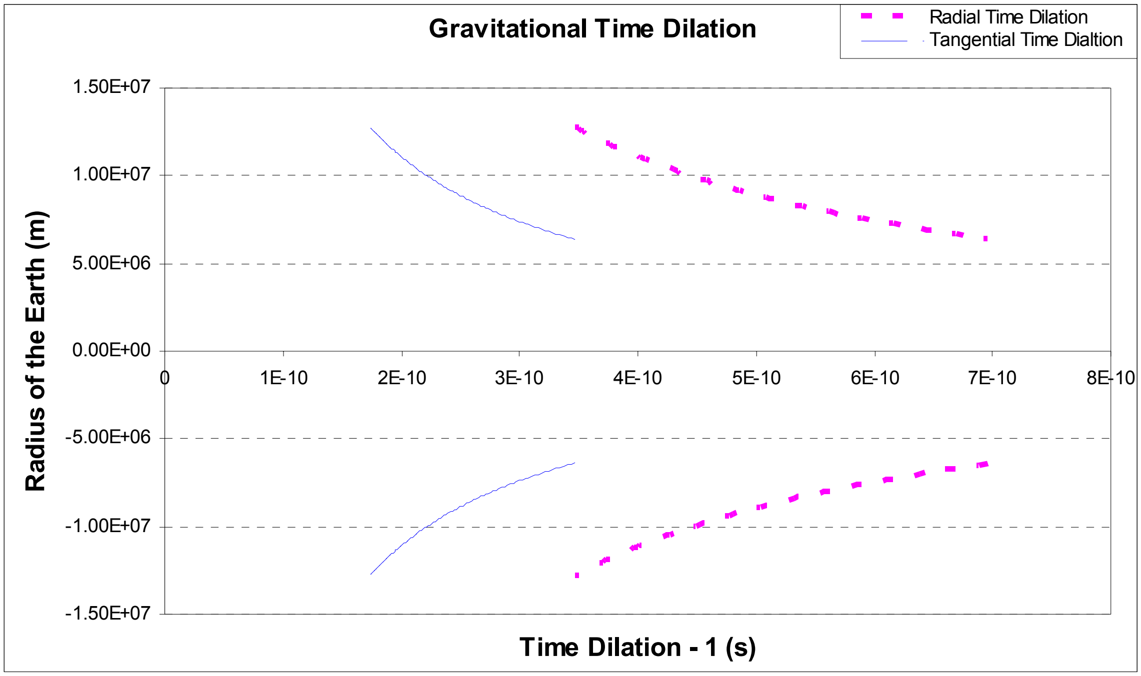


Fig 5.1: Time Dilation as a Function of the Radial Distance from Earth.

For a Gravitational Field the relationship between tangential and radial time dilation is given by,
$$1/t_r^2 - 1/t_t^2 = 1$$

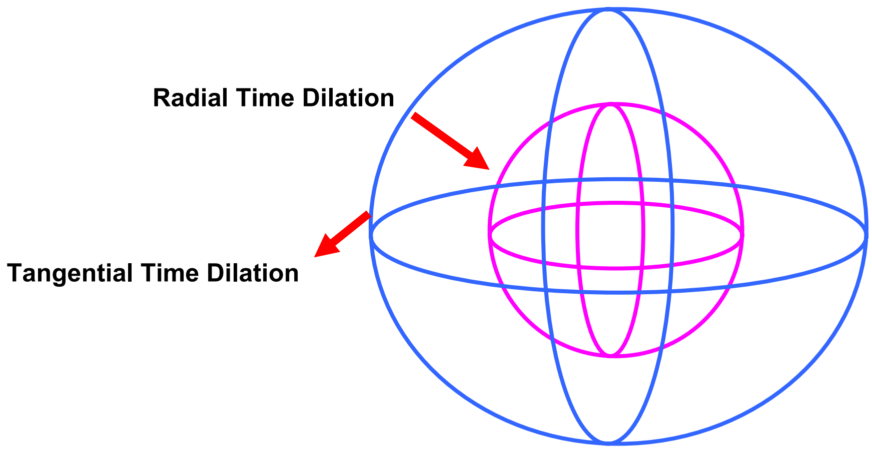


Fig. 5.2: Relationship between Gravitational Field Radial and Tangential Time Dilation

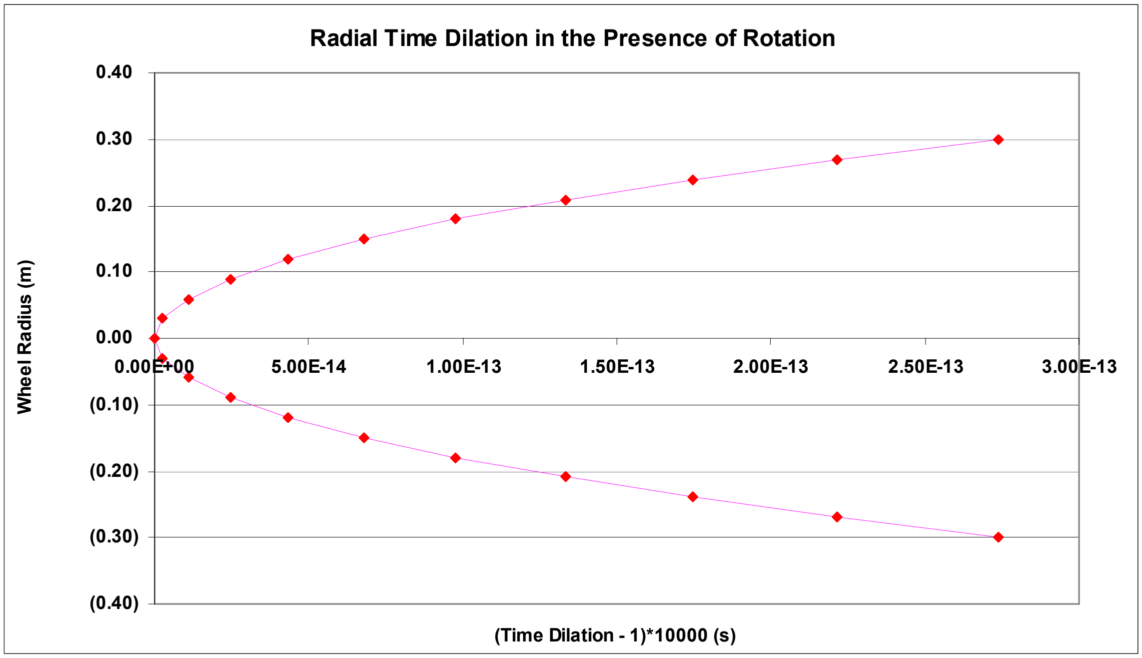
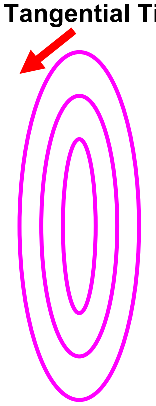


Fig 5.3: Time Dilation as a Function of the Radial Distance across the Spinning Disc.

For a Gyroscopic Centripetal Field the relationship between tangential and radial time dilation has not yet been determined.

Tangential Time Dilation

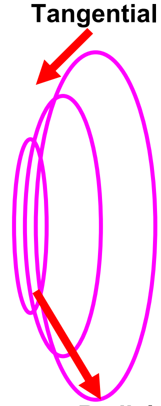


No Rotation

When Rotation exceeds a threshold value, the “flat”, tangential only, time dilation field pops and centripetal forces facilitate a radial time dilation field.

The figures depict field strength values, not physical shape.

Tangential Time Dilation



Radial Time Dilation

With Rotation

Fig. 5.4: Relationship between Centripetal Force Field Radial and Tangential Time Dilation

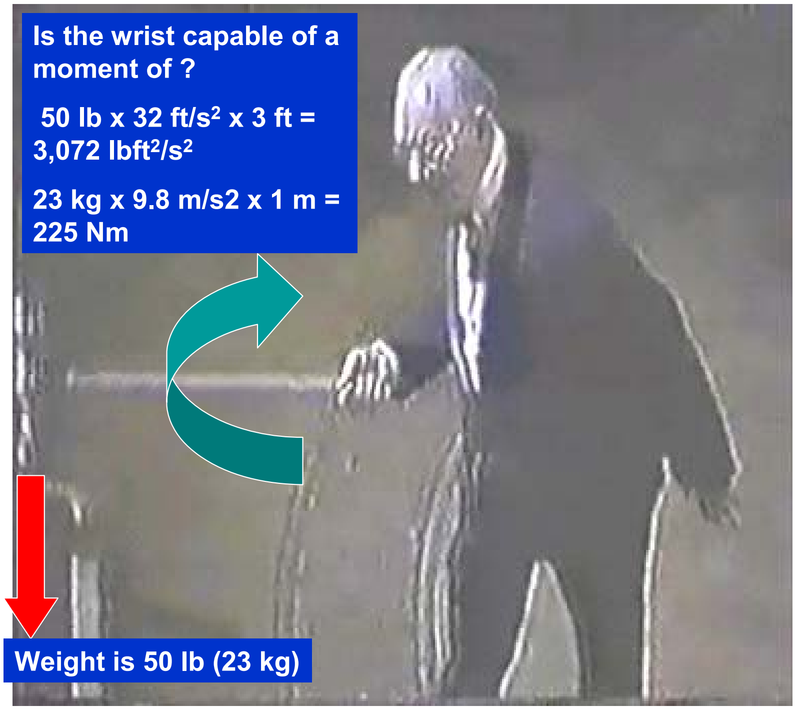


Fig. 6.1: Laithwaite with 50lb Big Wheel: Analysis of Moments Acting on the Wrist

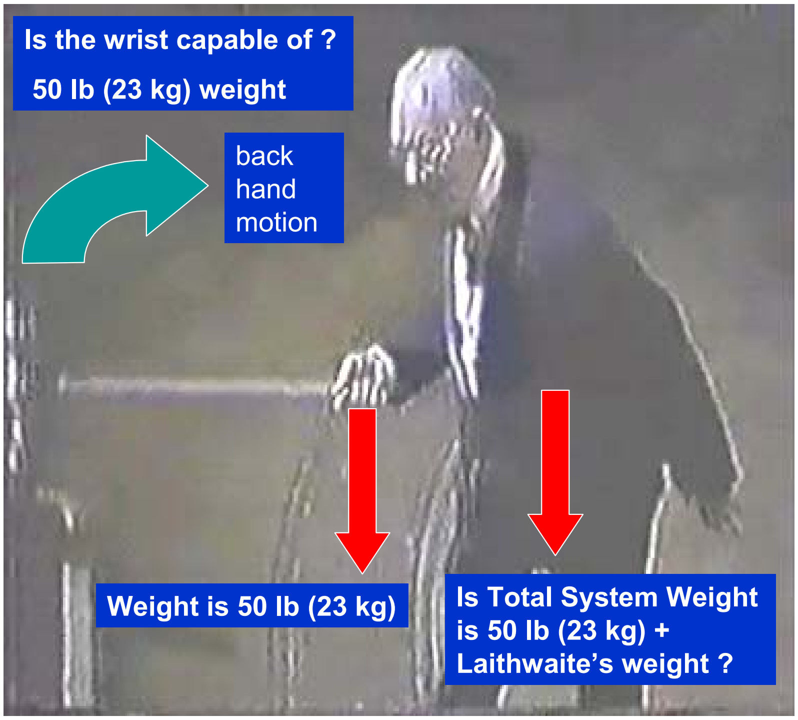


Fig. 6.2: Laithwaite with 50lb Big Wheel: Total Weight Analysis

Fig. 6.3: Laithwaite with Small Wheel Demonstration

Experimental Parameters	Laithwaite	NASA
Wheel Mass	23 kg (≈ 50 lbs)	1 kg (≈ 2 lbs)
Wheel Radius	30 cm (≈ 1 foot)	10 cm (≈ 4 inches)
Non-Rim Rotating Plane Mass	20% - 30%	< 2%
Spin	5,000 rpm	60 to 200 rpm?
Lever Arm Length	2 m (≈ 6 ft)	2 cm (≈ 1 in) ??
Precession/Rotation Rate - Theoretical (centrifugal) - Theoretical (precession) - Actual Observed	 450-637 rpm 157-314 rpm 7 rpm	 - ? - ?
Estimated new g' - Theoretical (centrifugal) - Theoretical (precession) - Actual Observed	 0.002 - 0.001 m/s^2 0.220 – 0.440 m/s^2 9.81 m/s^2	 9.81 m/s^2 9.81 m/s^2
Estimated New Weight - Theoretical (centrifugal) - Theoretical (precession)	 2.0 - 6.0 g (≈ 0.1 – 0.2 oz) 0.5 - 1.0 kg (≈ 1.1 – 2.2 lbs)	 1 kg (≈ 2 lbs)

Table 6.1: Comparisons between Laithwaite & NASA Experiments

Estimated Parameters	How Stuff Works Video Deconstruction			
Lever Arm Length, l	0.020	m		
Wheel Radius, r	0.660	m	26	inches
Wheel Spin, w	5.000	Hz	300	rpm
Gravitational Acceleration, g	9.810	m/s2		
Mass of Wheel, m	2.273	kg	5	lb
Moment of Inertia of Wheel, I	0.991			
Angular Momentum, L	4.956			
Theoretical Results				
Precession Frequency, wp	**0.090**	Hz	**5.40**	rpm
Observed Results				
Duration of 1/2 cycle	7	s		
Precession Frequency, wp	**0.071**	Hz	**4.29**	rpm

Table 6.2: Deconstruction of How-Stuff-Works video.

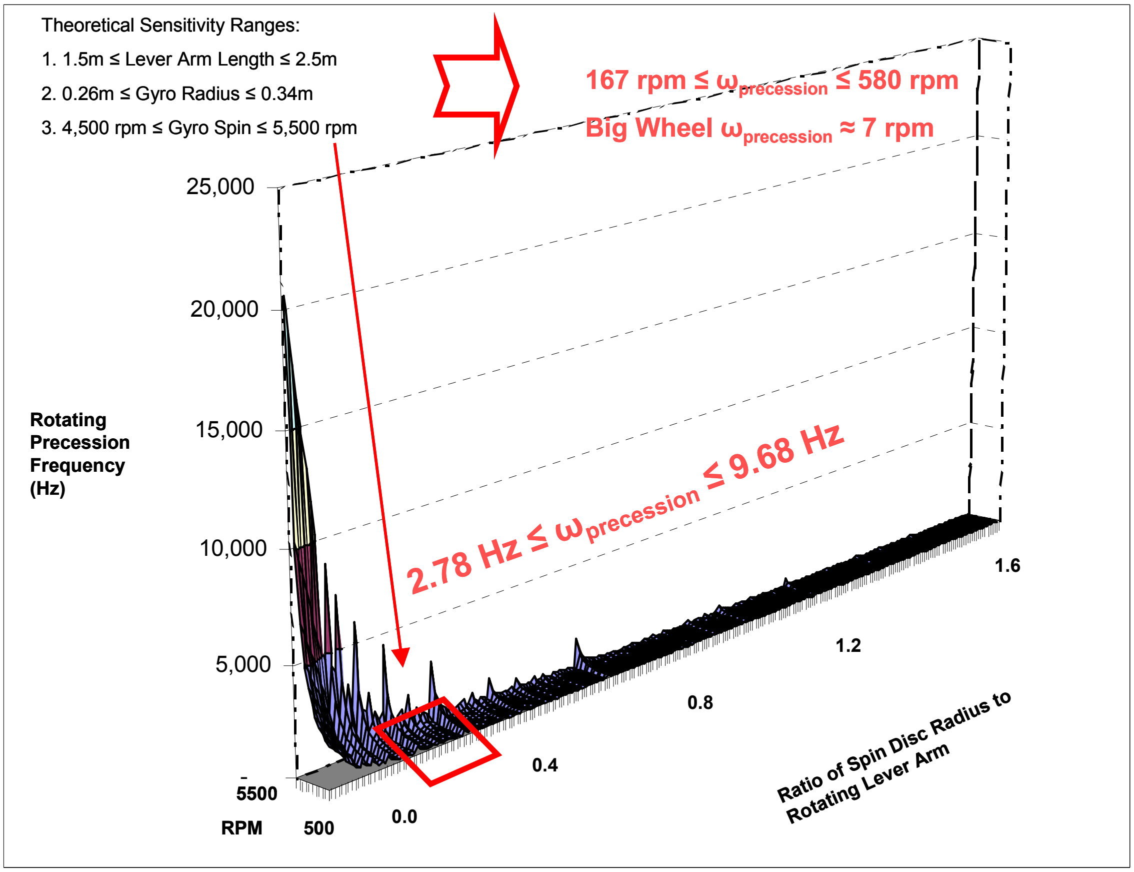


Fig. 6.4:

Sensitivity of Parameter Estimation to Precession Frequency

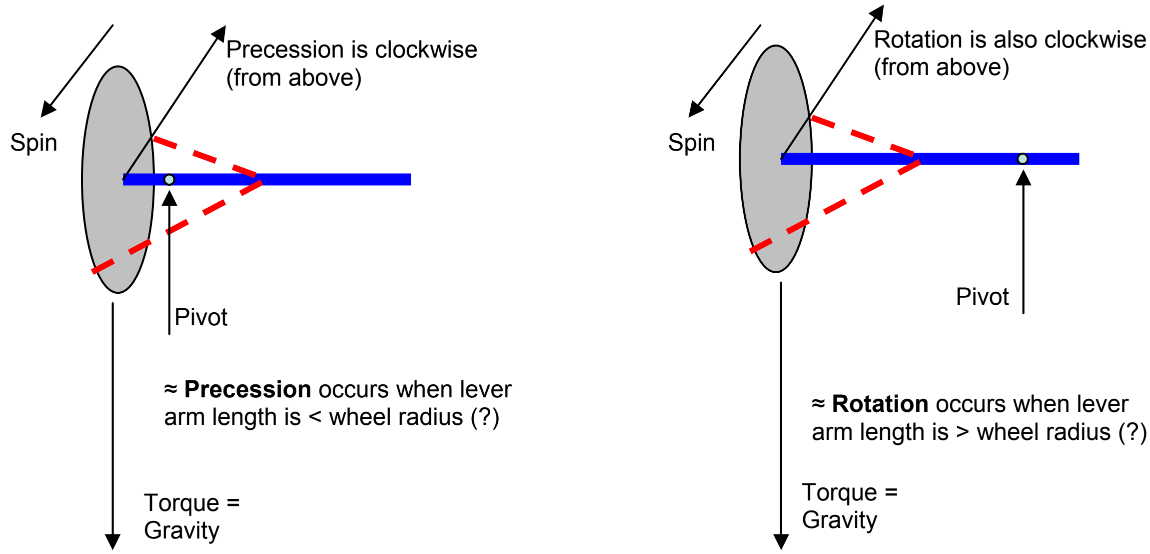


Fig 7.1: Gyroscopic Forces

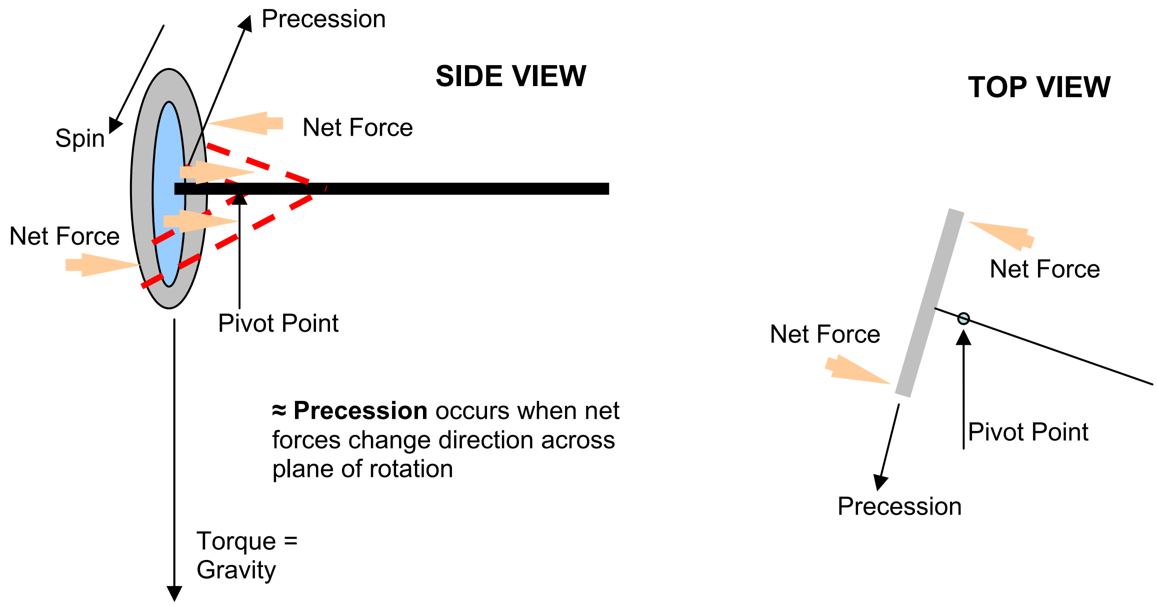


Fig 7.2: Precession Deconstruction

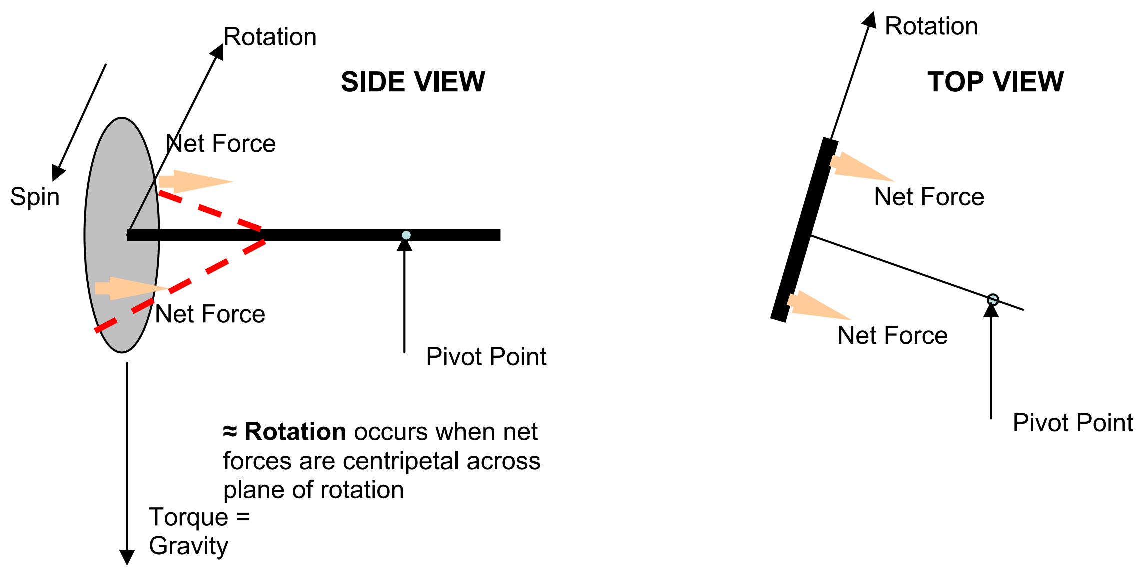


Fig 7.3: Rotation Deconstruction

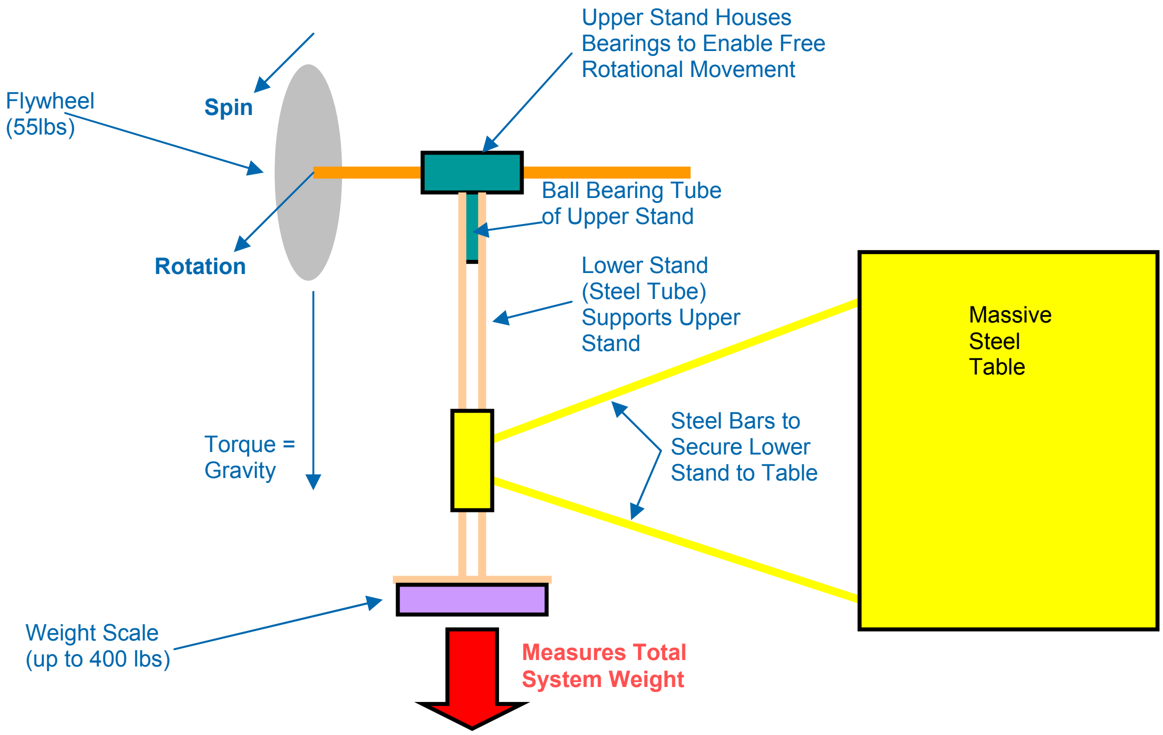


Fig 8.1: Solomon-Laithwaite Experimental Set-Up

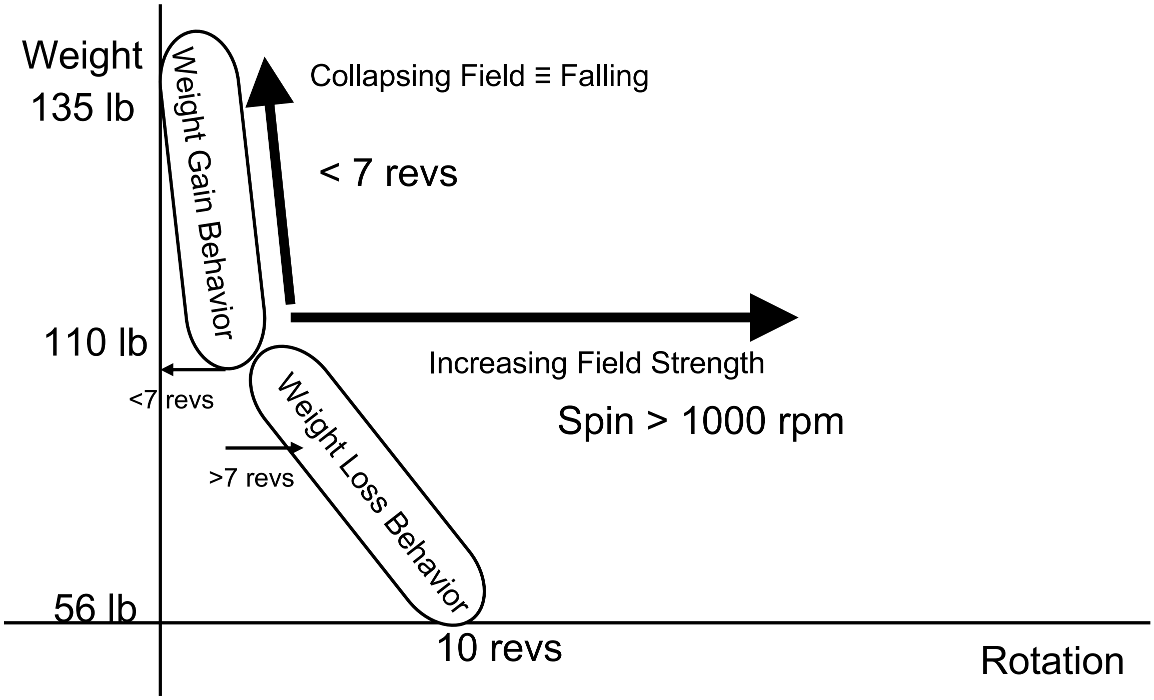


Fig. 8.2: Boundary Conditions for Weight Loss

Static Weights		
Lower Stand	36	Lb
Wheel Upper & Lower Stands	111	Lb
Wheel + Upper Stand	75	Lb
Wheel (+ Bearings)	55	Lb

Table 8.1: Individual Component Static Weights

Dynamic Weight	Lowest	Highest	Average
Not Spinning	105.5 Lb	114.5 lb	110 lb
First Experiment (Spinning)	65 Lb	120.5 lb	92.75 lb
Change	-45 Lb	10.5 lb	
Second Experiment (Spinning)	56 Lb	135 lb	95.5 lb
Change	-54 Lb	25 lb	

Table 8.2: Experimental Results

[1] BBC 1997, http://www.bbc.co.uk/history/historic_figures/laithwaite_eric.shtml

[2] Videos of Laithwaite's, The Royal Society Christmas Lecture 1974-1975, and the BBC documentary 'Heretic' are available from the website http://www.gyroscopes.org/1974lecture.asp and http://www.gyroscopes.org/heretic.asp, respectively.

[3] I've collected his most important observations into these four rules.

[4] Conversations with Bob Schlitters, of Timberline Iron Works.

[5] I have named the effects after the people who first demonstrated or discovered these effects, as best I as could research and determine the original discoverer.

[6] **Abstract:** A propulsion and positioning system for a vehicle comprises a first gyroscope mounted for precession about an axis remote from the center of said gyroscope. A support structure connects the gyroscope to the vehicle. Gyroscopes are used to cause the first gyroscope to follow a path which involves at least one precession-dominated portion and at least one translation-dominated portion, wherein in the precession-dominated portion, the mass of the first gyroscope is transferred and associated movement of the mass of the remainder of the system in a given direction occurs, and, in the translation-dominated portion, the mass of the first gyroscope moves with an associated second movement of the mass of the remainder of the system in substantially the opposite direction, wherein the movement owing to the translation-dominated portion and is larger than the movement owing to the precession-dominated portion of the motion, hence moving the system.

[7] Conservations with Marc G Millis of NASA Glen Research Center on June 22, 2005, regarding the experiment notes for NASA's Laithwaite gyroscopic weight loss investigation

[8] http://scienceworld.wolfram.com/physics/GyroscopicPrecession.html

[9] http://hyperphysics.phy-astr.gsu.edu/hbase/mi.html and
http://hyperphysics.phy-astr.gsu.edu/hbase/amom.html

[10] http://farside.ph.utexas.edu/teaching/301/lectures/node88.html

[11] http://science.howstuffworks.com/gyroscope1.htm

[12] Videos of Laithwaite's, The Royal Society Christmas Lecture 1974-1975, and the BBC documentary 'Heretic' are available from the website http://www.gyroscopes.org/1974lecture.asp and http://www.gyroscopes.org/heretic.asp, respectively.

[13] Alex Jones was the first to demonstrate this effect to Laithwaite. Source: BBC's 'Heretic".

[14] Conversations with Bob Schlitters of Timberline Iron Works

[15] Conversations with Marc Millis of NASA Glen