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Further Experiments Demonstrating the Effect of Light on Gravitation

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Abstract

In *The Effect Of Light On Gravitation Attraction,* published in 2011 (Rancourt, 2011), a purpose built horizontal-torsion pendulum apparatus, based on the Cavendish apparatus, was used to measure the effect of light on freely moving masses. Tests indicated a laser light on one side of a freely movable mass caused the mass to move toward the light. It was hypothesised that light has a screening effect on gravitational force.

In view of these findings the present authors designed a series of experiments using a specially designed light system to further test the effects of light on gravitation.

This paper describes a series of experiments in which layers of light are directed above and below a test mass connected to a sensitive weighing device. The aim being to determine whether light would affect weight readings.

Keywords: field, gravity, graviton, laser, light, Newton, relativity, screening effect, space, weight.

1. Introduction

There are growing references regarding the nature of gravity as researchers in the experimental and theoretical branches of physics continue to wrestle with what has become the *problem of gravity*. One school of thought sees the effect as explainable in terms of General Relativity where gravity emerges as a property of 4-dimensional space-time. This theory asserts that in the vicinity of mass space-time undergoes distortions that effectively lead to the effect we see as gravity. The theory has predicted to a great accuracy both terrestrial and celestial phenomena and is seen as an elegant refinement of the Newtonian theory. (Chihoski, 2011) contends that these theories only quantify forces. It is left to be said — "*Fields made of what?"* Fields are effects, observations. They do not provide the process which underlies their behavior. Field advocates and particle-advocates each have trouble reconciling their own bias with the other.

There are researchers pursuing a line of inquiry that maintains that space is made up of real physical fields and it is these that give rise to mass, inertia, and the force we call gravity. This has grown out of a branch of quantum theory known as quantum electrodynamics. Several of the theoretical proposals are supported by measured phenomena such as the Unruh Effect (Note 1) and the Casimir Effect, both of which can be explained as arising from active fields that fill all of space (Rueda & Haisch, 2005; Tattersall, 2014).

The school with its roots in particle physics, contends that gravity must be like other phenomena in nature where there appears to be action at a distance. This means something is relocated from one place to another place in the course of time. The agent proposed for gravity is a force-carrier or boson. Attempts to discover a boson for gravity is a stumbling block for physics, as all other forces (electromagnetic and nuclear) fit into what is termed the Standard Model of particle physics. If we were to find a boson then all of physics might be comfortably united under one model. Freeman Dyson says we will never find one experimentally because they are too small and too weak. Still we hope their mass effects may point to them as a reality.

There are many types of bosons. Some are considered real and measurable others are theorized as necessary. The particle school maintains that gravity is caused by a force-carrier, a boson - the *graviton*.

Worldwide an ongoing series of experiments not only regularly confirm the central tenet of General Relativity but emphasize the desire to discover some root nature of gravity. Put simply— *What really is the 'pull?'*, the process behind the so-called gravitational '*attraction'*?

The experiments reported in this paper build upon those completed by Rancourt (2011). In his work, conducted over a period of many years, Rancourt used sensitive pendulum balances (based on the Cavendish apparatus) (Alonso & Finn, 1972) to demonstrate how light beams from laser sources appear to affect the movement of selected masses.

Rancourt (2011) tentatively concluded that gravitation was in fact the result of a pushing force (Michelini, 2013) and that light somehow interferes with the force thereby offering an explanation for the observations made during his torsion bar experiments. Chihoski (2011) likewise takes the view that gravity results from a bosonic push, rather than a pulling force as is widely accepted in modern physics.

Faced with what we see as difficult to explain observations in Rancourt's (2011) earlier experiments it was decided to further test the effect of light of varying intensities on the weight (expressed in units of force N) of selected masses.

2. Method

2.1 Measuring Weight Changes of Selected Masses Using a Specially Designed Light Box

The experiments in earlier work (Rancourt, 2011) suggested that light has an effect on gravitation attraction. It was therefore proposed that varying the amount of light and the position of test masses may yield further useful information. An apparatus capable of producing a rectangular block of light was designed and manufactured. Masses connected to a sensitive weighing instrument were placed above and below the light box. Weights were recorded with the light activated and deactivated.

2.2 Principle of Operation and Experimental Set Up

Varying numbers of fluorescent lamps were employed in a purpose built light box. The light sources delivered from 35000 to 63000 lumen (Note 2) depending on the experimental setup. A box fitted with a set of mirror finished aluminum plates was built so that the light was reflected up and down 6 horizontal partitions (see Figures 1 and 2). The dimensions of the box were 1.2 m by 1.2 m by 0.2 m high. The light source was positioned on the bottom partition. Light was directed horizontally to the end where mirrors reflect the light to the next upper partition until arriving at the top partition. There, a mirror reflects the light back to the first partition. Essentially the box reflects light in a zigzag fashion up and down 6 layers creating a block of intense light.

Positioned under the aluminum box a 1.5 cm plywood sheet and two fibre-cement sheets separated by 20 mm of air serve to block any heat effects. During a measurement, the temperature does not change by more than a tenth of a degree Celsius in the container housing the 200 g test mass. The 200 g mass rests in the middle of a light rigid support. The support has one end on the table and the other end rest on the platen of the analytical balance. Thus, only half of the weight rests on the balance pan (Note 3). The whole apparatus rests on a concrete floor resting on 70 cubic meters of rocks, for increased stability.

A web camera (Note 4) recorded the changes from the analytical balance readout from which graphs were created using Microsoft® Excel spread sheet program. During the recording, the apparatus was isolated to ensure minimum disturbance (Note 5).

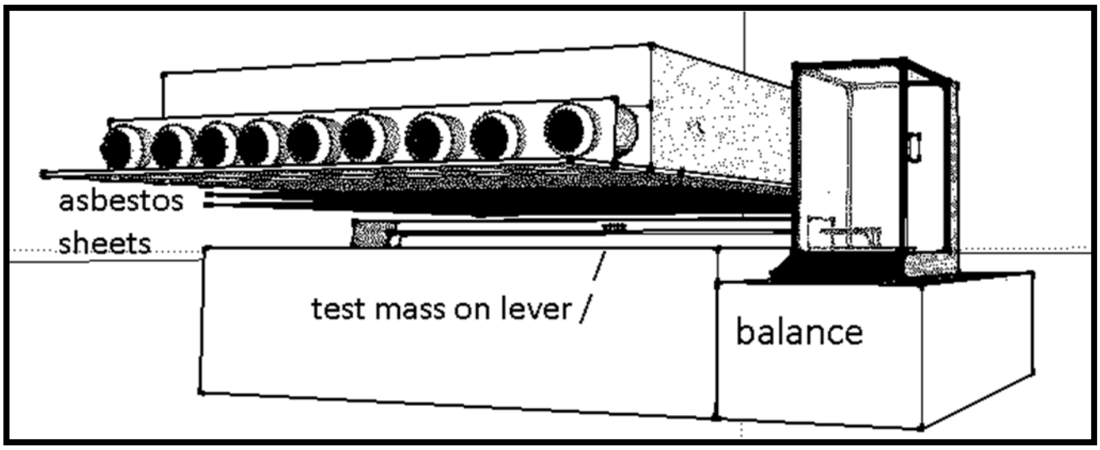

Figure 1. Custom built Light Box

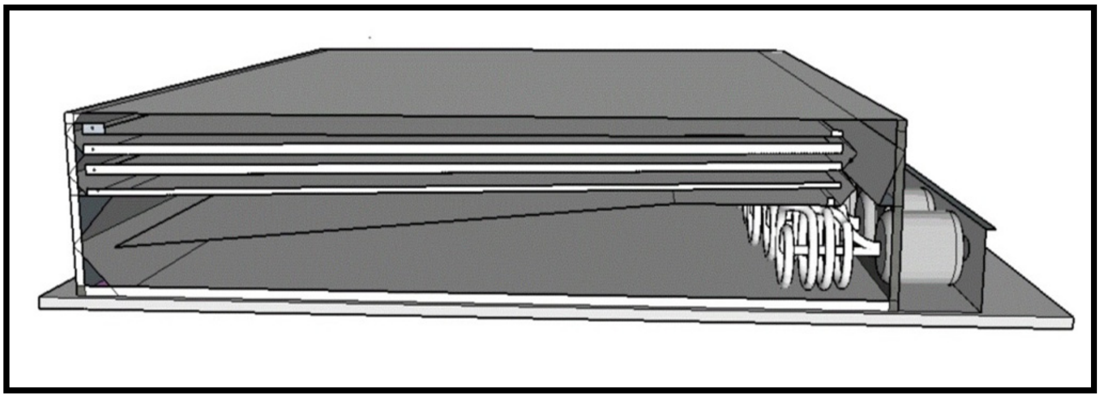

Figure 2. Inside view of the light box showing 6 levels

2.3 Measures Used to Estimate Error Sources and Bias

2.3.1 Blank Run and Temperature Effects

When the box was built and before the internal horizontal divisions were in place, it was tested using a 200 g mass to determine if there was a change in weight. No change were detected when 63000 lumen were shining everywhere in the empty box (no partitions).

A blank test was run with the 200 g mass in place, but without the light source activated. A small change of 2.000 x 10^{-05} Newton was recorded. The results are shown in Table 1.

Table 1. Results of blank run (without lights activated)

May 5, 2014	**Minutes**	**Newton**
Start	0	3.106 208
Finish	320	3.106 188
Delta		2.000 000 x 10^{-5}
% loss		6.438 719 x 10^{-6}
% loss / minute		2.012 100 x 10^{-8}

2.3.2 Temperature Effects

On November 2014, a test was made with 8 lamps only and the temperature was recorded during the test. A sensor able to indicate tenth of Celsius degree was placed in the enclosure near the test mass and another thermometer was located outside the box to measure the room temperature.

It was noticed that the temperature changed slowly followed the change in room temperature. There was no abrupt change of temperature when the light source was activated. The temperature measurements are shown in Figure 3.

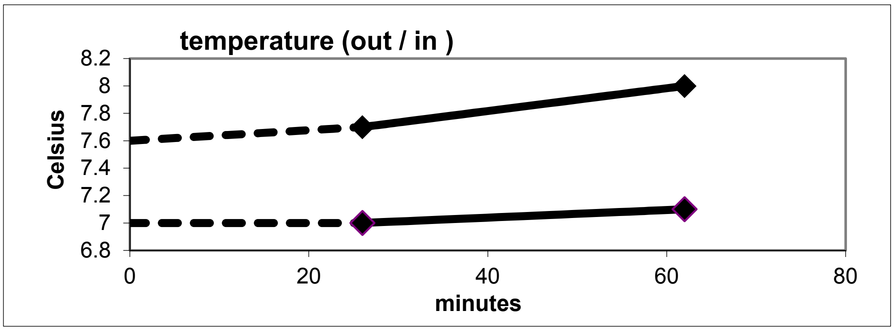

Figure 3. Results of temperature measurements with 8 lights activated. The solid line indicates the results when the 8 lamps were activated (upper line is outside; lower line is inside the apparatus)

The temperature outside the apparatus increased by 0.3 degrees from 7.7 to 8 degrees during the period when the lamps were on. The temperature in the enclosure containing the test mass increased by 0.1 degree during that time, from 7 to 7.1 degrees. The increase inside the enclosure was continuous and slower than the increase in the laboratory. The increase was not caused by the operation of the 8 lamps.

It was concluded that the small temperature change was not significant.

2.3.3 Vibration Effects

To prevent any vibration, the metal table supporting the apparatus was about 1 cm away from the table supporting the balance and the electric controls. The tables were located on the thick concrete floor. The floor sits on over 70 cubic meters of rocks. The soil is glacier compacted sand and very stable. Since the test centre is in the country, far from roads, there were no noticeable vibrations coming from outside. When the tests were performed there were no personnel present in the laboratory area.

2.3.4 Magnetic and Radiofrequency Effects

Magnetic effects were determined by bringing a sensitive compass in close proximity to the light box assembly with 9 lamps operating. No deflection of the compass needle was noted.

Radiofrequency noise arising from the lamps when in operation was not measured, however a literature source suggest electromagnetic fields in the 10 kHz to 500 kHz range are typical (Note 6)

According to a consulting an engineer at an Ottawa laboratory, it seems almost impossible that the small RF emitted by the fluorescent lamps had any substantial effect on weight change (Note 7).

3. Results

Four experiments were conducted using differing light intensities with masses placed above and below the light box in order to test the effect of light box position in relation to weight measurements.

On May 10, 2014 an experiment was conducted with the 200 g mass located under the light box. The web camera (Note 4) recorded the weight readings appearing on the readout of the analytical balance. For the first 21 minutes, the lights were deactivated. At 21 minutes, the 9 lamps were activated. After 71 minutes the 9 lamps were turned off and the recording stopped after 102 minutes. The results were transferred on a Microsoft® Excel sheet and the graph was plotted (see Figure 4.). Because the 200 g mass was at the center of the rigid support, the balance indicates both half of the mass of the support plus the 200 g. The readout is multiplied by 2 because of the lever principle and by 9.80665 to convert the weight to Newton (Note 8). The dark unbroken line indicates when the lights were activated.

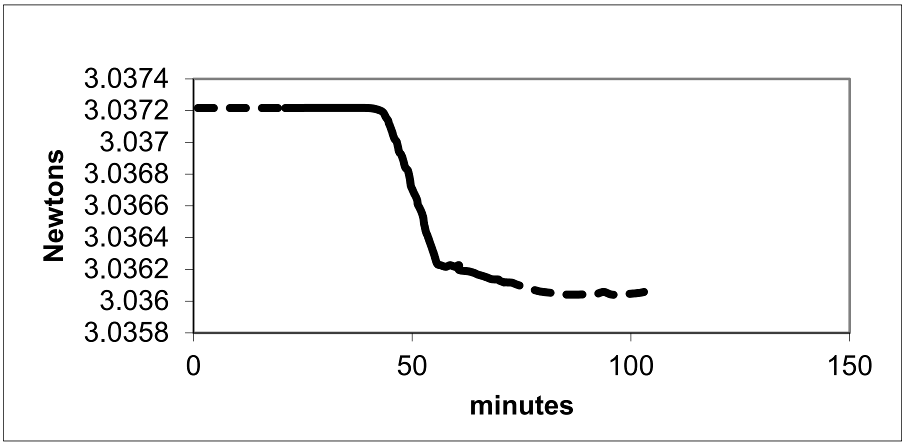

Figure 4. May 10, 2014 Test with 200 g mass under light box with 63000 lumen

Before the lamps were activated, the weight was stable at 3.037 216 N. When the lamps were turned on, the weight remained constant for 22 minutes. At 43 minutes the decrease in weight was constant until 57 minutes, at which time the weight reading began to plateau, changing only slightly. At 71 minutes, the lamps are turned off and the weight remained constant. Summary data is shown in Table 3.

Table 3. Data values for Figure 4

May 10 2014	Minutes	Newton
Start	43	3.037 216
Finish	71	3.036 118
Delta	28	0.001 097 6
% loss		0.03614
% loss per min.		0.001 291

The change in weight did not begin as soon as the lamps were activated. It was noted that the fluorescent lamps take a few minutes to give the maximum light due to the electronic controls in the lamp itself. That might explain the delay. The weight loss was 0.001 291% per minute. The vector force called weight is directed downward. It seems that vector force was partly cancelled. It appears that the horizontal beam of light caused a decrease of weight. Possible causes will be discussed in a later section.

On May 12, 2014, another test was made with the brass test mass under the box with 35000 lumen. Only 5 lamps were used for 426 minutes (Figure 5). The continuous dark line indicates the period when the lights were activated.

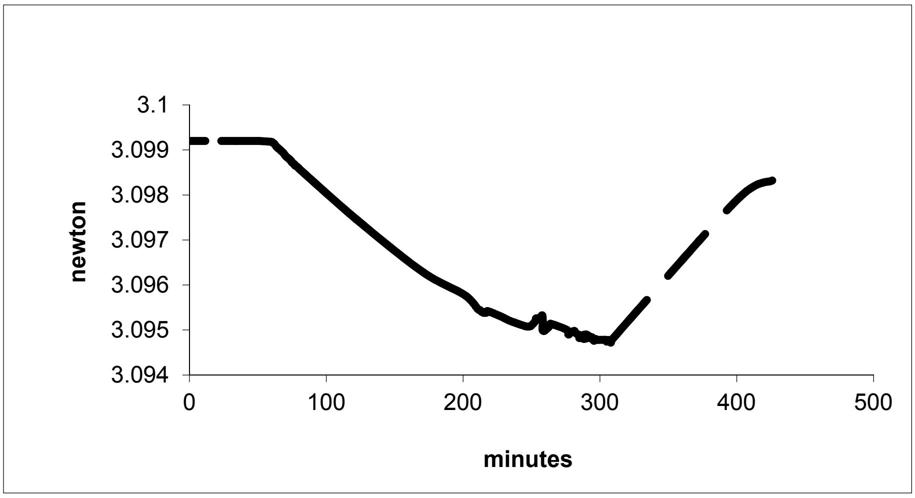

Figure 5. May12, 2014 test mass under the light box with 35000 lumen

The weight of the test mass was stable for 34 minutes. The lights were activated at the end of this period. The weight remained constant (3.0992 N) for a further 26 minutes (with lights activated) and at 60 minutes the weight began to drop away from 3.0992 N to 3.0951 N (at 258.5 min.). The lights were shut off at 308 minutes and the weight started to increase (broken line on the graph). The recording was stopped after 426 minutes when the weight reached 3.09832 N. The percentage loss was 0.000 527 per minute. Summary data is shown in Table 4. The slow return of the weight to its starting value is obvious in this graph due to the extended monitoring time (compare with Figure 4.).

Table 4. Data values for Figure 5

May 12, 2014	Minutes	Newton
Start	34	3.0992
Finish	308	3.09472
Delta	274	0.00448
% loss		0.1446
% loss / minute		0.000 527

As seen on the graph, if the recording had been a few minutes more, the weight would probably have returned to the baseline value. That indicates that even if the lights were activated for more time, the weight lost would not go to zero. A certain amount of light would decrease the weight only by a certain amount. That is consistent with the observation of May 10 where 9 lamps (63000 lumen) caused a decrease of 0.00129% per minute compared to 0.000 527 % per minute with 5 lamps (35000 lumen). That is about twice the loss compared with that for 5 lamps. Increased lumen leads to a greater change in weight per minute.

When light shines horizontally over a test mass without touching the mass, the weight decreases. The weight loss depends on the amount of lumen used and the amount of time the mass is under the light.

On December 20, 2014, the test mass was placed over the box and the results were recorded (Figure 6). Summary data is shown in Table 5. The dark unbroken line indicates the period when the lamps were activated.

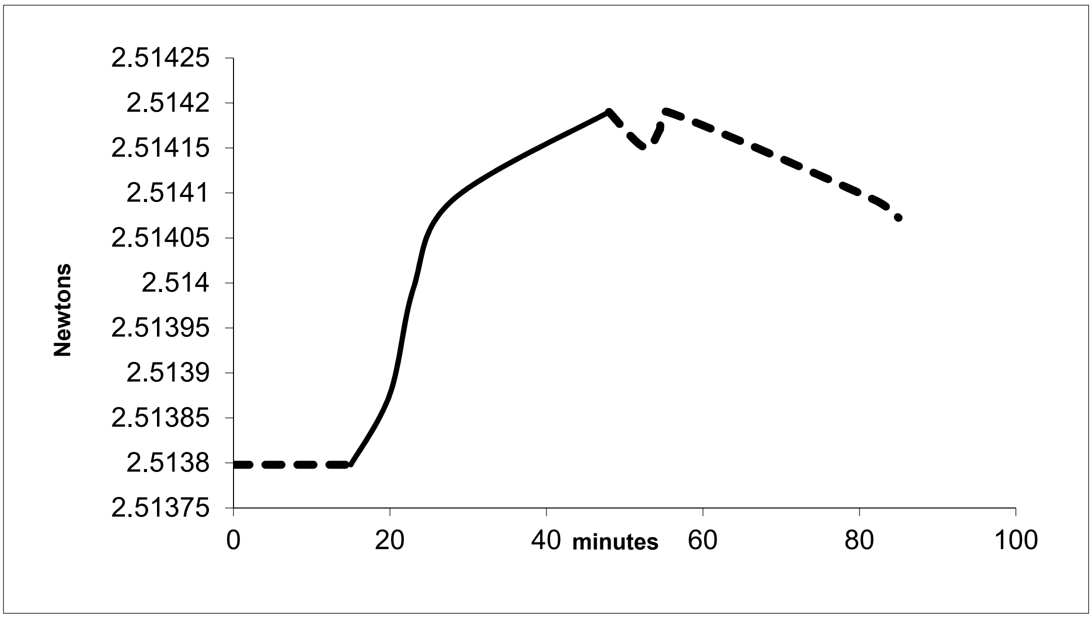

Figure 6. December 20, 2014 test mass over the light box with 63000 lumen

Table 5. Data for Figure 6

Dec 20, 2014	Minutes	Newton
Start	15	2.513 798
Finish	48	2.514 190
Delta	33	0.000 392
% gain		0.015 594
% gain/minute		0.000 473

The weight was stable and after 15 minutes, the 9 lamps were activated. The weight increased rapidly at first and more slowly from 28 minutes to 48 minutes. The lamps were shut off and the recording continued up to 85 minutes. The weight started to decrease when the lamps were shut off. A vibration is visible on the graph when the lights were shut off at 48 minutes.

The weight increase was very rapid at the beginning and it was still increasing slightly when the lights were shut off. Although it is not possible to find the maximum effect because the experiment did not last long enough, it is clear that when the light passes horizontally over the test mass, its weight increased and when the lights were shut off, the weight slowly returns to the original baseline value. The weight gain was 0.000 473% per minute. The next results show that more clearly.

On December 22, 2014, the test mass was placed over the box and the results were recorded for a longer period (Figure 7). The solid black line indicates the weight change when the light was active. Summary data is shown in Table 6.

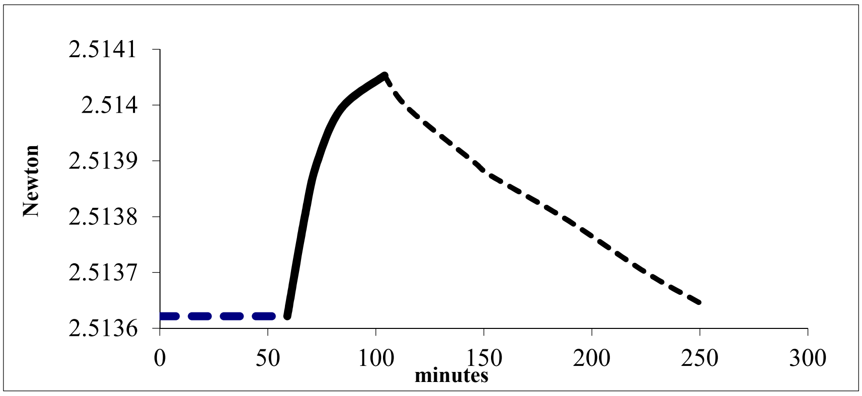

Figure 7. December 22, 2014, test mass over the light box at 63000 Lumen

Table 6. Data for Figure 7

Dec 22, 2014	Minutes	Newton
Start	59	2.513 622
Finish	104	2.514 053
Delta	45	0.000 431
% gain		0.017 146
% gain/minute		0.000 381

The weight was stable for 59 minutes before the lights were activated. As soon as the light was activated under the mass, the weight increased rapidly at the beginning and levelled off toward the end of the period of light activation. The lights were shut off and the weight returned to almost the original baseline value.

The abrupt change in weight when the light was activated is further evidence of the effect of light on weight. As previously discussed it is not a temperature change nor a disturbance in the air surrounding (movement or density) the test mass that causes the effect. A comparison of the rate of weight increase from the December 20th experiment to that of the December 22nd experiment reveals a much slower rate for the latter experiment. On checking the lamp assembly in the setup for December 22nd it was found that one lamp was not functioning correctly.

4. Discussion

4.1 Comments on Sources of Error and Bias

There is a vast literature reporting the difficulties and problems associated with experiments involving measurements of gravitational effects (Luo & Hu, 2000; Moskowitz, 2013; Faller, 2013; Gillies & Unnikrishnan, 2014) all refer to and reference many sources of potential error. Uncertainties in measurements of G for instance can be quite high and has been quoted as being much higher than that for all other fundamental constants (Luo & Hu, 2000). The source of the uncertainty is thought to reside in systematic errors. Systematic or determinate errors are defined as “Those that have a definite value and an assignable cause…” (Skoog & West, 1982). In the experiments reported in this paper steps were taken to measure and control such errors, e.g. air movement, magnetic and electromagnetic effects. Of all the potential error sources identified the one thought to have the greatest effect would be air movement and air density changes leading to buoyancy issue. Ideally conducting the experiments under vacuum conditions would have largely limited this potential error source, but practical issues prevented us from using such a set up. That said we believe that the data presented does indicate an effect caused by light. The light box setup would no doubt have produced heating when the lights were activated, but an increase in temperature (reduction in air density) would not have caused the weight loss reported in Figures 4 and 5. In terms of weight changes caused by air movement the temperature changes were not enough to explain the rapid weight changes reported in Figures 6 and 7 (see also Figure 3). We would suggest that the temperature effects cannot produce both a decrease in weight in one instance and an increase in another depending on the location of the test mass (above or below that light box).

Another class of errors is indeterminate or random error. This class of error is defined as "Indeterminate error arises from uncertainties in a measurement that are unknown and not controlled…" (Skoog & West, 1982). Indeterminate errors are difficult to control and are typified as a background noise or fluctuation. While many of the measurements reported in this paper do display an apparently random noise or variation (as seen in the graphical data) there is no indication that random errors have significantly affected weight readings.

To reiterate, accurate and precise measurements associated with G are notoriously difficult and complex. In the case of G itself measurements over a period of several hundred years have still not produced a result of acceptable uncertainty. One source (Moskowitz, 2013) in quoting several researchers reports:

> *"Measuring such small forces on kg-objects to 10^{-4} or 10^{-5} precision is just not easy. There are a many effects that could overwhelm gravitational effects, and all of these have to be properly understood and taken into account…This inherent difficulty has caused big G to become the only fundamental constant of physics for which the uncertainty of the standard value has risen over time as more and more measurements are made. Though the measurements are very tough, because G is so much weaker than other laboratory forces, we still, as a community, ought to do better…"*

Of interest too is a further comment from the same source (Moskowitz, 2013):

> *"Still, it's possible that the incompatible measurements are pointing to unknown subtleties of gravity—perhaps its strength varies depending on how it's measured or where on Earth the measurements are being made?"* Although perhaps a 'passing comment', this is thought to be significant.

Assuming that the random errors in the experiments reported in this paper are not significant and that systematic errors are largely known and accounted for we would speculate that electromagnetic energy does cause weight changes in selected masses. Our experiments have suggested that electromagnetic energy causes a positive or negative change in an object's weight depending on its position relative to the light source. It is possible therefore that electromagnetic energy in some way interacts with gravitational force. After many hours of observation and measurement, we believe that light does affect gravity. In order to fully explain this, we need a better and deeper understanding of the exact nature of both light and gravity.

4.2 Significance of Findings

The results of the extensive series of experiments show that light has an effect on gravitational force. Light moving horizontally under a mass causes an increase in weight, whereas a light source above a mass causes a decrease in its weight. It seems that when light is reflected back and forth through a number of levels it will not interfere with itself thus causing a substantial effect on the weight of a given mass.

It is clear that light can change the force that causes weight. For instance, in the case of light directed above a mass the vector of horizontal light beam is at 90 degrees compared to the vector of the gravitational force (weight). Using vector laws (as shown in Figure 8), the force at 90 degrees is zero, suggesting that light is not the cause of the changing force (weight) but is acting on that force to change its magnitude. Increases in light intensity causes increased effects in gain or loss of weight depending on the position of the test mass in relation to the light source because $\cos(90^0)$ is zero. In all cases the gain and loss of weight is not instantaneous, indicating some kind of build-up during the period when lights are activated and a slow dissipation when the lights are deactivated.

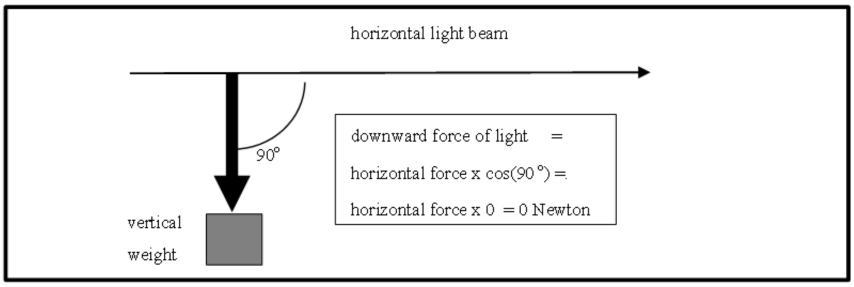

Figure 8. Vector analysis of vertical weight and horizontally imposed light beam

4.3 Theoretical Implications and Speculations

According to Crowell, it is believed that light itself may be a source of gravitation influence, mediated through the stress energy tensor effect (Crowell, 2009). That said it is still not clear whether electromagnetic energy would possess a gravitational force and therefore account for the results reported in this paper. One source suggests that

> *"… .When it comes to electromagnetic radiation rather than static fields, I don't know of any really direct empirical tests. However, cosmological models are sensitive to this effect, because the early universe was radiation-dominated. I believe that observations of the CMB are good enough these days that if EM waves didn't gravitate, discrepancies would have shown up by now. This is actually kind of an interesting question, so maybe I'll post in the cosmology forum and see if anyone knows."* (Do photons create gravity, 2010).

There are however alternative theories that posit the force of gravity as having its origins in a pushing force (Anonymous, ND). One of the more prominent is the theory refined by Lesage (the so called Fatio-Lesage model of gravity). Essentially the theory proposed a mechanical explanation for Newton's gravitational force. The origin of the force was conceptualized as streams of tiny unseen particles (Lesage termed the particles 'ultra-mundane corpuscles') impacting all material objects from all directions. According to this model, any two material bodies partially shield each other from the impinging corpuscles, resulting in a net imbalance in the pressure exerted by the impact of corpuscles on the bodies, tending to drive the bodies together. Over the years the validity of the theory has been seriously questioned, especially with the advent of Newton's theory and its refinement in the form of General Relativity.

In order to account for the observations and measurements in his pendulum experiments Louis Rancourt (2011) suggested that gravity could be conceptualized as a pushing force coming from all directions in space. Planet Earth can block some of the pushing force and the net sum of all the vectors of these forces is a downward vector pointing to the ground. That would be the cause of the weight force.

As the force seems to vary little during 24 hours it would suggest that the speed of movement of the force itself is much faster than the movement of the Earth. If the force was moving at a speed close to that of the Earth, one would expect a noticeable change in weight during the day. The fact that light can interfere (perhaps as a form of destructive interference) with the force also suggest that the force is perhaps similar in nature to light itself (Note 9). That would also explain why gravity is always positive and not negative, compared to electrical forces which have two polarity aspects. Some scientists attribute the gravitational force to the existence of gravitons.

With respect to general relativity (GR) it is too early to speculate as to the significance of these findings as further experiments are needed to test the findings reported here. In any case it is possible that the central mathematical tenets of GR may still stand. In other words elucidating the underlying causes of gravity may not influence the ways in which its effects are calculated or predicted. This, in our view is a key point. In terms of our understanding of cosmology a confirmation of the findings reported in this paper would prove to be significant, as the existence of some kind of influence (possibly arising from zero point field (Rueda & Haisch, 2005)) permeating the entire universe, would be firmly on the agenda and would require a reconceptualization of the nature of space and in particular the way in which it interacts with matter.

Acknowledgements

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Notes

Note 1. Strictly the Effect is a prediction arising from QFT. The radiation of a uniformly accelerated charge is thought to involve Unruh phenomena. According to Hawking , an observer outside a black hole experiences a bath of thermal radiation of temperature T = h(bar)g/ 2πck , where g is the local acceleration due to gravity, c is the speed of light, h (bar) is Planck's constant and k is Boltzmann's constant. (Retrieved from http://www.hep.princeton.edu/~mcdonald/accel/unruhrad.pdf)

Note 2. The per tube luminosity was 7000 lm based on the manufacturers specification. Self-ballasted Spiral CFL, 105T5/27 105 watt; T5 Compact Fluorescent; 2700K; 85 CRI; Mogul base; 120 volts, https://www.1000bulbs.com/product/55185/FC105, Retrieved from https://www.satco.com/s7394.html

Note 3. Mettler, type 80, Max: 159.9999 g

Note 4. Logitech orbit sphere web camera, Retrieved March 15, 2014, from http://support.logitech.com/product/quickcam-sphere-af

Note 5. The laboratory area was closed off to eliminate air movement and traffic.

Note 6. Retrieved from www.ieice.org/proceedings/EMC09/pdf/22S3-3.pdf

Note 7. Pers. comms. Luc Savard, consulting engineer.

Note 8. Actual weight values depend on the positioning of the mass on the balance platen beam. For example: when the balance reads 134.0000 g, the total real mass was 134.0000g x 2 = 268.0000 g. That means the support had a mass of 68 g that was added to the 200 g mass. The total weight as force in Newton in this example is therefore 2 x 134g x 9.80665m.s^{-2}/1000g.kg^{-1} or 2.628182N.

Note 9. This leads one to speculate that the ‘force’ itself may be a form of electromagnetic energy, perhaps similar to the phenomena suggested by Rueda & Haisch (2005), namely a form of ZPE.

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