Is the sun's warmth gravitationally attractive?

Peter Fred
521 Zorn Ave G-8
Louisville, KY 40206 USA

Email:pbfred1@gmail.com

Abstract

Experiments show that the gravitational mass of a test mass will increase when heat conducts upwards through it. A ~489 gm copper hemisphere was placed above a 1000 W heat element and below and two ice-filled copper containers. After 400 seconds of heating, the gravitational mass of the hemisphere had increased by 9.6 % or 47gm. If the sun's warmth decreases earth's dayside surface gravity by as little as 0.08 %, the produced pressure imbalance at its center will be enough to account for its centripetal acceleration towards the sun. This calculation suggests that bound systems such as stars, planets, galaxies and clusters have residing in them powerful "three-dimensional lever" that can be activated by the slight warmth of a outside source of heat. Since with all these objects heat conducts from their centers outwards, an experimentally backed means becomes available to explain why they are bound that does not depend on the putative dark matter or the mysterious attractive power of mass. Observations indicate that the cosmic star formation rate declines at $z \approx 1$. They also indicate that at $z_t = 0.61^{+3.68}_{-0.21}(1\sigma)$ that cosmic acceleration commences. If the former causes the latter, an experimentally backed way becomes available to account for cosmic acceleration that does not involve vast amounts of energy coming out of the vacuum.

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1. **Introduction**

In 1916 using a Cavendish torsion balance, P. E. Shaw [1] found that heating the larger masses increased the force on the smaller masses. Later, he learned that this increase was not as large as he first observed [2]. In the lively discussion that followed his initial publication, attention was brought to the "insuperable theoretical objections" that would follow if Shaw's work could be further substantiated [3].

Now, due to the dark energy problem, we find ourselves, according Harvard's Christopher Stubbs, "in the midst of a profound crisis in fundamental physics" where there is clear evidence of new physics and yet "no idea of what it means" [4]. Also because of the dark energy Horvath remarks that the "situation seems completely favorable for a Kuhnian paradigm shift in either physics or cosmology" [5]. The dark matter problem has prompted Scott Tremaine in 1987 to write, "extragalactic astronomy is in the midst of a classic Kuhnian crisis". He describes this crisis as similar to "the distressing state of Ptolemaic astronomy at the time of Copernicus or the late nineteenth century situation in physics brought about by the photoelectric effect and the black body spectrum" [6]. As a way to deal with proliferation of the many uncompelling solutions to the dark energy and dark matter problems offered by theorists, Martinez and Trimble [7] end their paper with a comment by Rocky Kolb:

> Our goal must not be a cosmological model that just explains the observations, the ingredients of the cosmological model must be deeply rooted in fundamental physics. Dark matter, dark energy, modified gravity, mysterious new forces and particles, etc., unless part of an overarching model of nature, should not be part of a cosmological model. We may propose new ideas, but they must wither unless nourished by fundamental physics.

Many of the distressing problems of Ptolemaic astronomy went away when the foundation of geocentric motion was abandoned and replaced with the foundation of heliocentric motion. The old theory was not just modified as is being done with today's gravity theory in order to deal with the quite serious difficulties it is experiencing. It was completely scraped and a new theory put it its place. Because of the success of what might be called a "Copernican switch" or "foundational switch" that was applied to the Ptolemaic theory, it is natural to ask if another foundation can be found other than mass that can be used to explain gravitational phenomena. With a little thought radiation come immediately to mind. It is as ubiquitous as mass. It generally varies inversely as the square of the distance from the center of its source as does the gravitational force. The central parts of a planetary system, of a galaxy and of a cluster are the most luminous as well as the most massive parts of these systems. Unlike mass, radiation is measured in units of power. In the everyday world of prime movers, an increase in power will result in an increase in acceleration and acceleration happens to be the unit with which gravitational phenomena is mostly observed. In contrast, when the mass or the load of the prime mover is increased, a decrease in acceleration will be observed. Because of these promising qualities, it might be even be possible to use radiation to build an "overarching model of nature" that is "deeply rooted in fundamental physics."

These qualities prompted a nearly two-decade effort to see if radiation could attract mass. It was eventually found that this could be demonstrated as long as certain principles are upheld in the design of the experiment. First, materials should be employed that conduct heat well. Secondly, respect should be given to heat's tendency to flow upwards and thirdly, consideration has to be given heat's invariable tendency to flow from a hot place to a cold one. Figure 1 shows a photograph of a hollow copper sphere with a mass of ~1068 gm suspended above a 1000 W heat element. A wooden dowel suspends the sphere to a force sensor that is located above inside a wooden box. The copper sphere is suspended below three copper hemispheres filled with ice. Their function is to facilitate the upward flow of heat. After power was applied to the heat element for 400 seconds, the means of the first and last ~6 force measures indicate that the weight or gravitational mass of the sphere increased by 1.9% or 20 gm. At the 400-second point, power was shut off. After cooling for another 400 seconds, the sphere's weight decreased to a value close to its original value. Figure 2 shows a ~489 convex-up copper hemisphere hovering over a 1000 W heat element. A wooden dowel attaches it to a force sensor above that is housed above and located in a wooden box. Above the hemisphere are two copper containers filled with ice. After power was applied to the heat element for 400 seconds, the means of the first and last ~6 force measures indicate that the gravitational mass of the hemisphere increased by 9.6 % or 47 gm. After the hemisphere cooled down for another 400 seconds, the means of the first and last ~6 force measures indicate the gravitational mass of the hemisphere decreased by 26 gm. Figure 3 shows a hollow copper sphere with a mass of ~1102 gm that is initially at room temperature and hovers above an ice-filled copper container. A wooden dowel suspends the sphere to a force sensor that is housed above in a wooden box. The recording of the weight and temperature measures began when a copper container filled with ice was placed under the sphere. After cooling for 5 minutes, the means of the first and last ~6 force measures indicate that the weight or gravitational mass of the sphere decreased by 4.9 % or 54 gm. Figure 4 shows a photograph of a 1000 W heat element with a mass of 248 gm that is suspended below two copper hemispheres filled with ice. A wooden dowel suspends the heat element to a force sensor that is housed above in a wooden box. After power was applied to the heat element for 5 minutes, the means of the first and last ~6 force measures indicate that the weight or gravitational mass of the heat element increased by 8.9% or 22 gm. After the heat element cooled for 5 minutes, the force sensor measurements indicate that its weight or gravitational mass decreased by 22 gm.

Since without much temperature change in the test mass, a change of 20 to 54 gm in the gravitational mass of the test mass was observed, it should be pointed that such a finding is not predicted by Einstein's formula $E = mc^2$. In 1950, he wrote [8]:

> Now we may reverse the relation that an increase of E in the amount of energy must be accompanied by an increase in E/c^2 in the mass. I can easily supply energy to the mass--for instance if I heat it by 10 degrees. So why not measure the mass increase.... The trouble here is that in the mass increase, the enormous factor of c^2 occurs in the denominator of the fraction. In such a case the increase is too small to be measured...

It should be pointed out that using heat or radiation to produce a 20 to 54 gm change in the gravitational mass of the test masses, also raises some questions about the how to interpret Einstein's principle of equivalence. These changes in the gravitational mass suggest that it might be possible to devise an experiment where masses of equivalent inertial mass but of different temperature fall towards the earth at a different rate.

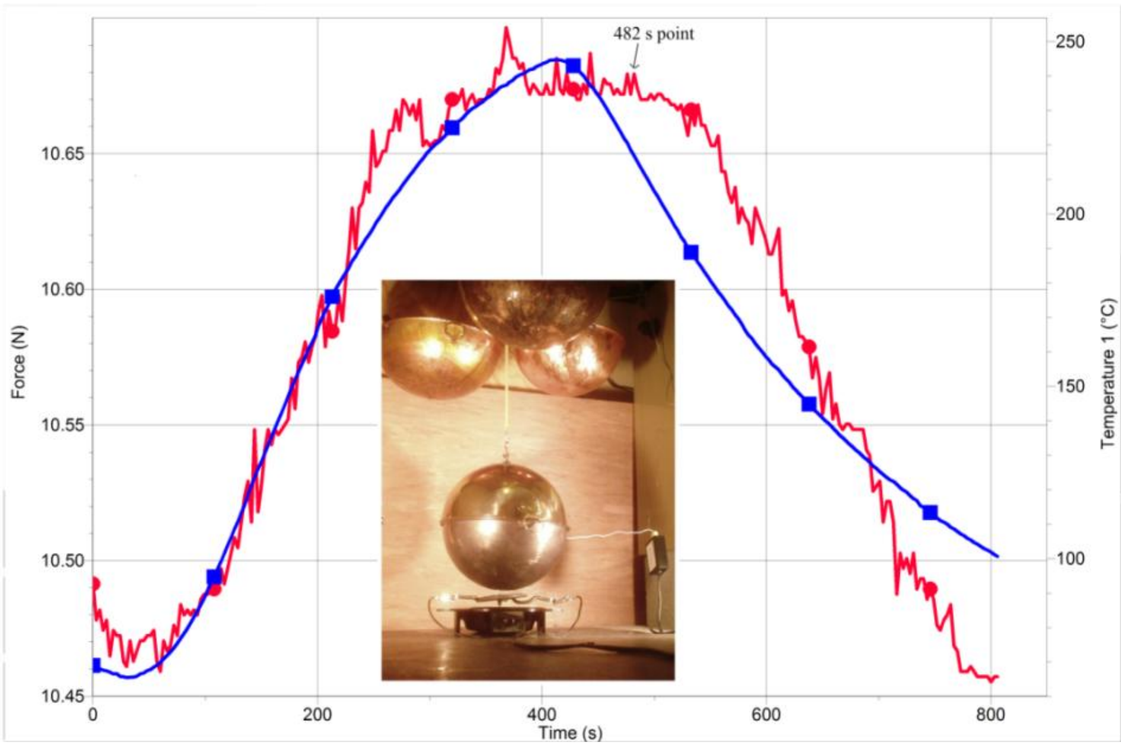

Figure 1: A ~1068 gm hollow copper sphere hovers above a 1000 W heat element. The sphere is attached to a wooden dowel, which in turn is attached to force sensor that is located above and is housed in a wooden box (not shown). In order to facilitate the upward flow of heat, three copper hemispheres filled with ice were placed above the sphere. After power was applied to the heat element for 400 s, the means of the first and last ~6 force measures indicate that the sphere's gravitational mass increased by 1.9 % or 20 gm. At the 400-second point, power was turned off. After 400 s of cooling time, the means of the first and last ~6 weight measures indicate that the sphere's `gravitational mass decreased by 2.0% or 21 gm. The graph with the circles depicts the sphere's weight as a function of time. The graph with squares depicts the temperature as a function time of the lowest point inside the sphere as sensed by a thermocouple wire.

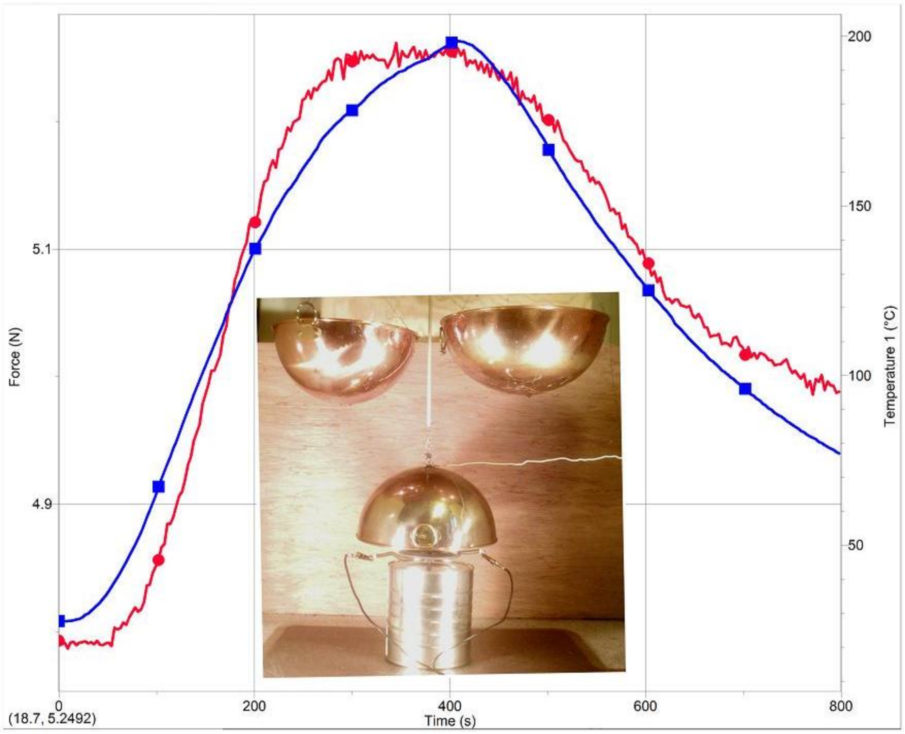

Figure 2: A ~489 gm hollow copper hemisphere hovers over a 1000 W heat element. A wooden dowel attaches the hemisphere to a force sensor that is housed in a wooden box above (not shown). Also above the hemisphere are two copper hemispheres filled with ice. After power was applied for 400 seconds, the means of the first ~6 force measures and last ~6 force measures indicate that the gravitational mass of the hemisphere increased by 9.6 % or by 47 gm. Four hundred seconds after power was turned off the gravitational mass decreased by 26 gm. The graph with circles reflects the change in gravitational mass as a function of time. The graph with squares reflects the temperature of the hemisphere's highest point as a function of time as sensed by a thermocouple wire.

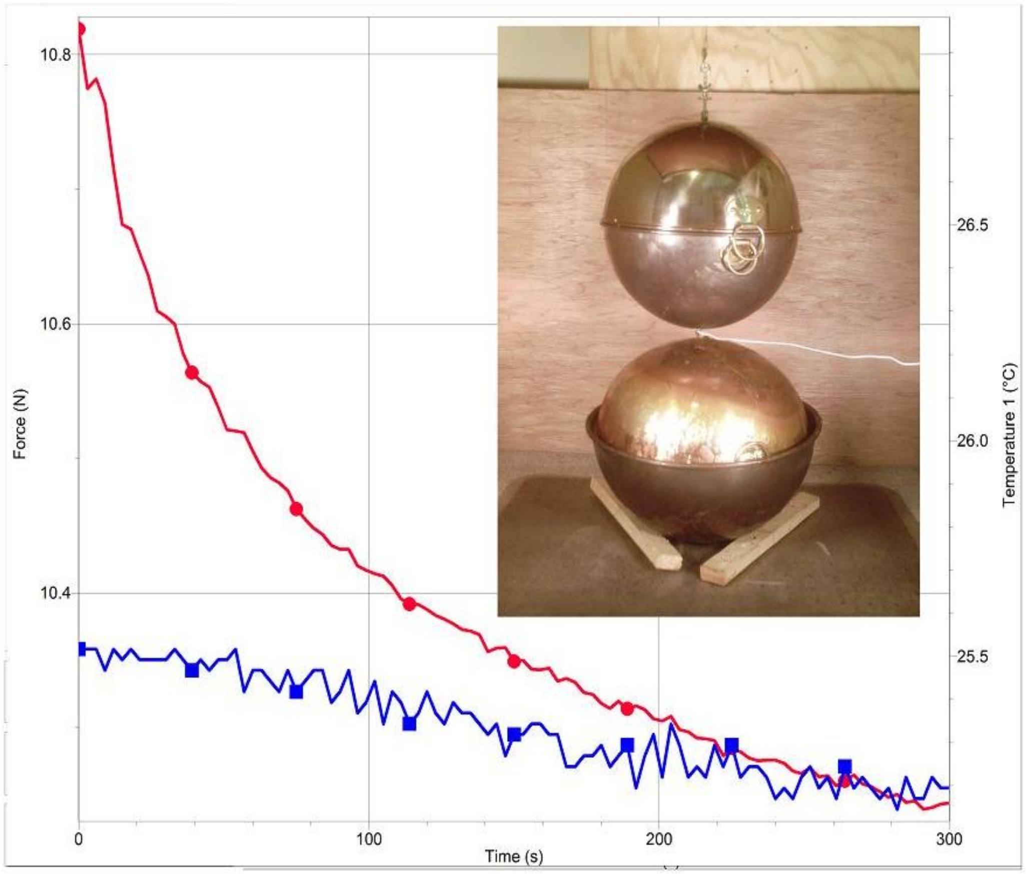

Figure 3**:** A hollow copper sphere with a mass of ~1102 gm hovers above a copper container filled with ice. The sphere is attached to a wooden dowel, which in turn is attached to force sensor that is located above and is housed in a wooden box (not shown). Weight and temperature measurements of the sphere, which initially was at room temperature, began to be recorded when an ice-filled copper container was placed under the sphere. After 5 minutes of hovering above the container, the means of the first and last ~6 force measures indicate that the sphere's weight or gravitational mass decreased by 4.9 % or 54 gm. The graph with circles reflects the weight of the sphere as function of time. The graph with the squares reflects the temperature as a function of time of the lowest point on the outside of the sphere as measured by a thermocouple wire. Weight and temperature graphs with similar slopes have been observed when a hot sphere, hemisphere or heat element was allowed to cool to room temperature.

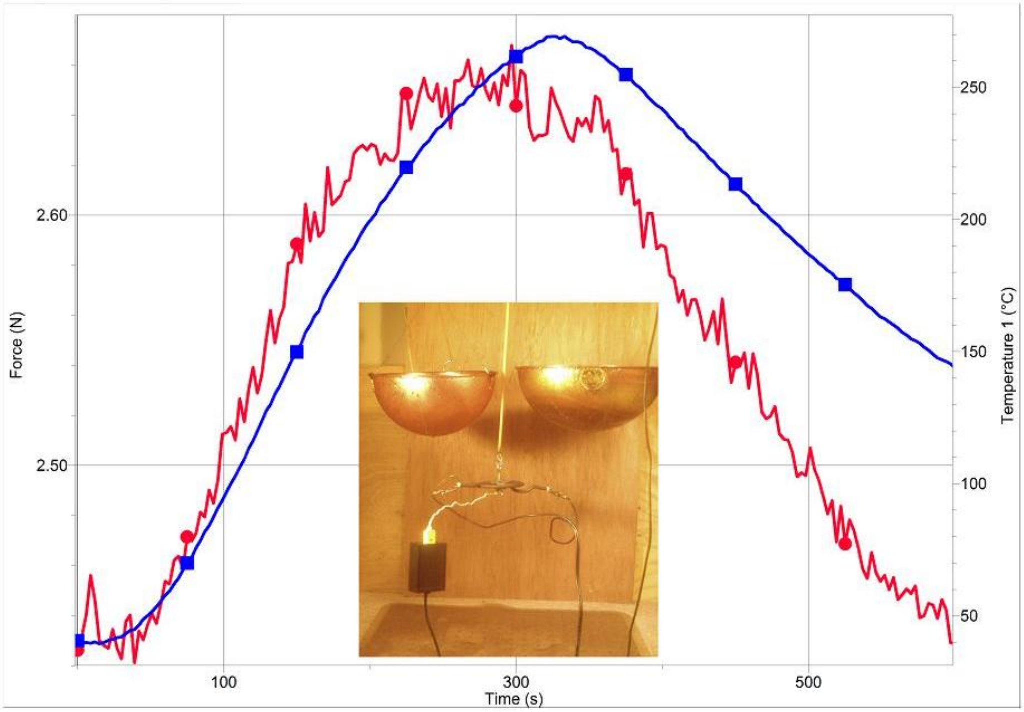

Figure 4: A 1000 W heat element with a mass of ~248 gm is placed underneath 2 ice-filled copper hemispheres. The heat element is attached to a wooden dowel, which in turn is attached to force sensor that is located above and is housed in a wooden box (not shown). After power was applied to the heat element for 5 minutes, the means of the first and last ~6 force measures indicate that the gravitational mass of the heat element increased by 8.9% or 22 gm. After power was off for another 5 minutes the means of the first and last ~6 force measures indicate that the gravitational mass of the heat element dropped by 22 gm. The graph with the circles depicts the weight of the heat element as a function of time. The graph with the squares depicts the temperature as a function of time of the central part of the heat element as measured by a thermocouple wire. Hanging wires were used to make the electrical leads and the thermocouple wire extend in the horizontal direction to guard against the effects from their possible linear expansion from the generated heat.

2. Accounting for possible spurious effects

In the experiments shown in figures 1-3, an increase in weight was observed. It is difficult to make the case that this increase was due to a buoyancy or hot air effect. For a hot air effect to be an explanation, a decrease in weight would have to have been observed. A decrease in weight was observed in the experiment described in Fig. 3. However, this occurred without the generation of heat and thus it cannot be claimed that this result was due to a hot air effect. The experiments described in figures 1, 2 and 4, hanging wires were used to make the electrical leads extend from the heat element initially in the horizontal direction. This was done to prevent the linear expansion of the electrical leads from adversely influencing the force measures. The experiment described in Fig. 5 was carried out to see if the linear expansion of the electrical leads was primarily responsible for results of experiment founds in Figs. 1, 2 and 4. In this experiment, the electrical leads attached to the heat element were allowed to fall directly to the ground. After power was applied to the heat element for ~6.6 minutes , the means of the first and last ~6 force measures indicate that the weight or gravitational mass of the heat element increased by 16% or 31 gm. If the linear expansion of the electrical leads had major influence on the force measurements, this would have caused a decrease in the measured weight because the expanding length of the electrical leads would have pushed up on the heat element and thus would have reduced its weight. Thus, it is difficult to make the argument that the observed increase in weight was due to the linear expansion of the electrical leads.

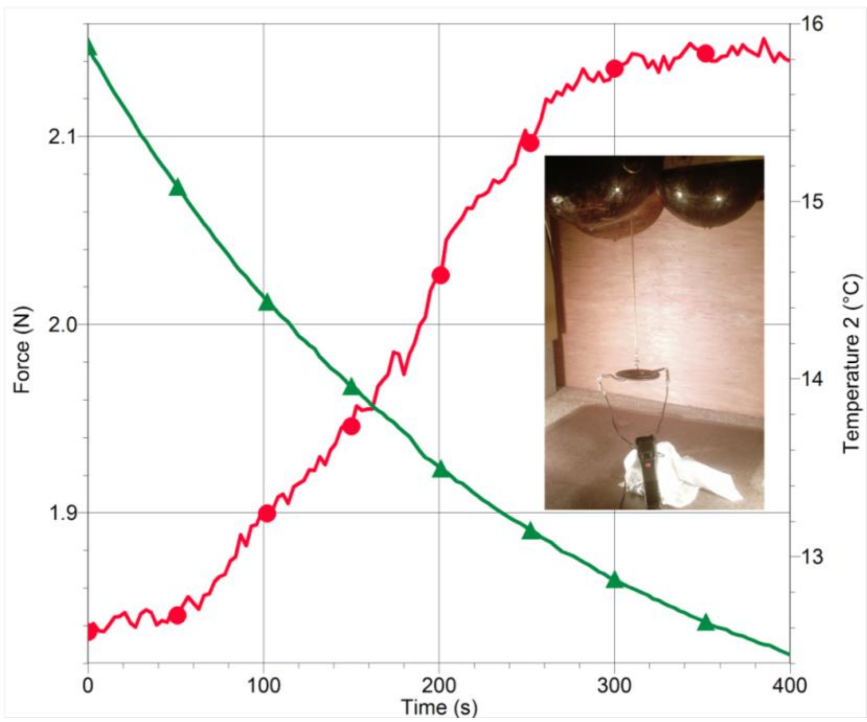

Figure 5: A 1000 W hot-plate heat element with a mass of 194 gm is placed underneath 3 ice-filled copper hemispheres. The heat element is attached to a wooden dowel, which in turn is attached to force sensor that is located above and is housed in a wooden box (not shown). After power was applied to the heat element for 6.6 minutes, the means of the first and last ~6 force measures indicate that the weight or gravitational mass of the heat element increased by 16% for or 31 gm. The graph with the circles depicts the weight of the heat element as a function of time. The graph with the triangles depicts the temperature as a function of time of the short metal rod

that connects the wooden dowel to the force sensor. This graph decreases with time because ice was placed inside the wooden box. The electrical leads the heat element were allowed to fall vertically towards the ground. leaving

In the experiments described in figures 4 and 5, a non-contact infrared thermometer was used to measure the temperature of the heat element. In the experiments described in figures 1 and 2, a thermal couple wire was used the measure this temperature of the sphere and heat element. Since in all four experiments a change in weight was observed, it is difficult to make an argument that the linear expansion of the thermocouple wire solely produced the observed change in weight

In all five experiments, the temperature of the short rod connecting the wooden dowel to the force sensor that was located in the wooden box was monitored. It has been found that if the force sensor was heated by as much as 20-30 C°, a spurious increase in the force measurements would be observed. To guard against this possibility, ice was placed in the wooden box in the four experiments where heat was generated. The graph with squares in Fig. 5 shows the decrease in temperature as a function of time of the short metal rod connecting the dowel to the force sensor. The graph with circles shows the increase in weight of the 1000 W heat element with an initial mass of 103 gm. The weight of the heat element increased by 16 % after power had been on for 6.6 minutes. This represents a gravitational mass increase of 31 gm. This graph is similar to the other three graphs in the experiments where heat was employed. Since the temperature decreased in these four experiments, it is difficult to argue that the observed increase of weight of the test mass was due to a spurious force sensor reading.

In figure 3, where a cold source was placed underneath a copper sphere that was initially at room temperature, containers filled with hot water were placed inside the wooden box. Then while the experiment was taking place, the temperature was monitored of the short metal rod connecting the wooden dowel to the force sensor. A temperature graph similar to the one in Fig. 5 but opposite in direction was observed in this experiment. Because the temperature inside the wooden box increased, it cannot be argued that the observed decrease in the weight of the test mass was due to the excessive cooling of the force sensor.

It has also been noticed that if a copper wire is used to suspend a test mass, the linear expansion of the copper wire will produce a spurious decrease in the force sensor readings. This is why in all five experiments a wooden dowel was used to suspend the test mass. Wood has a coefficient of linear expansion ~3.4 times smaller than that of a copper wire. Using a wooden dowel may have been an unnecessary precaution because in the four of the experiments where heat was employed an increase in weight of the test mass was observed and thus it is difficult to make the argument that the observed increase in weight was due to the linear expansion of the wooden dowel. In the one experiment where a decrease in weight of the test mass was observed no heat was ever generated and thus it is unlikely that a heat produced linear expansion of ever occurred.

The experiment described in Figure 2 provides another way to discredit the possibility that the increase in weight observed in the experiments is somehow due to air movements. The convex-up hemisphere captures most of the rising hot air produced by the heat element. This should produce a decrease in weight of the hemisphere. However, a 2.9 % increase in weight was observed.

1. Can a central pressure imbalance move a large astrophysical body?

The radiation falling on a spherical astrophysical body from a neighboring radiation source will always divide that body into two hemispheres: a dayside hemisphere and a nightside hemisphere. If the sun's radiation falling on the earth is attractive, it will decrease earth's dayside surface gravity by a certain amount. The fact that earthquakes can travel straight through the earth is an indication that earth's surface gravity is dynamically liked to its central gravity. Thus, a dayside decrease in surface gravity should produce a one-sided decrease in central gravity. Since this decrease comes from only one hemisphere, a pressure imbalance should be produced at earth's very center.

In order to determine Δg the amount by how much the sun's radiation must decrease earth's dayside surface gravity sufficient to produce a central pressure imbalance strong enough accelerate the earth towards the sun at its observed rate of $g_{obs} = 0.006\,\mathrm{m\cdot s^{-2}}$, let us suppose that this decrease in surface gravity is equal to

$$\Delta g = \frac{4}{3} g_{obs} . \tag{1}$$

Since the earth's surface gravity is $g = 9.8\,\mathrm{m\cdot s^{-2}}$, this amounts to only a 0.08% decrease in its surface gravity. If earth's surface gravity is denoted by g , its density by ρ and its radius by r , an estimate [9] of its central pressure, which does not take into account the variation of g or ρ with radius is

$$P = g\rho r . \tag{2}$$

Then, the central pressure that is dynamically linked to earth's nightside surface gravity will be given by

$$P_{night} = g\rho r. \tag{3}$$

Its central pressure that is dynamically linked to its dayside surface gravity will be given by

$$P_{day} = (g - \Delta g)\rho r. \tag{4}$$

Since the cross-sectional area [10] of a sphere is πr^2, the force that nightside hemisphere places on the dayside hemisphere will be given by will be

$$F_{night} = (g\rho r)\pi r^2 . \tag{5}$$

The force that dayside hemisphere places on the nightside hemisphere will be

$$F_{day} = \left[\left(g - \Delta g\right)\rho r\right]\pi r^2 . \tag{6}$$

When (6) is subtracted from (5), we arrive at the net force that theoretically could accelerate the earth towards the sun given dayside surface decrease of Δg

$$F_{net} = \Delta g \rho \pi r^3 . \tag{7}$$

With the use of (1), this becomes

$$F_{net} = \frac{4}{3} g_{obs} \rho \pi r^3. \tag{8}$$

This simplifies to

$$F_{net} = g_{obs} m_{\oplus} . \tag{9}$$

This is the force required to accelerate the whole earth towards the sun at its known rate. It also equals the force predicted by Newton's Law of Universal Gravitation that is thought to be produced some yet-to-be-specified property of the mass of the sun

$$F_{Newton} = \frac{G m_{\odot} m_{\oplus}}{r_{AU}^2} . \tag{10}$$

Since the density of an astrophysical body increases with depth, (1) is an underestimate of the central pressure. Thus the estimate of a 0.08% decrease in dayside surface gravity that would be necessary accelerate the earth towards the sun would actually be something less than 0.08% of g .

The above derivation suggests that a powerful three-dimensional "gravitational lever" resides inside any large astrophysical body that can be called into action by the slight attractive capacity of the radiation falling on it by a source of radiation. It provides a mechanical, close-to-experience[1] way to explain the orbital motion of an astrophysical body that avoids the action-at-a-distance problem[2] or the unfamiliar idea that mass has the ability to warp space.

Earth's diurnal and semidiurnal atmospheric tides [13] might provide the evidence for that difference between the dayside and nightside surface gravities that would be needed to accelerate the earth towards the sun[3]. Alternatively, Maurice Allais' observation of a diurnal variation in the surface gravity [14] might provide observation evidence for that needed difference.

3. Why outward flowing heat produces a center directed force

Consider a solid sphere of uniform density inside a cold bath that has an infrared heat source at its center. Inside that sphere, the force per unit mass, which is directed towards the center, increases with radius similar to the way it is traditionally thought to increase. It is well known that infrared radiation energizes the vibratory modes of the atoms of a solid material [15]. Thus, it can be imagined that as the radiation spreads out from the center of the sphere, it will not only energize the vibratory modes but also *align* these vibrations along the radii of the sphere. d many of the atoms will vibrate linearly along the radii of the sphere. Since the heat flows outward from the center, it is natural to suppose that the aligned vibrations would be capable of producing more momentum and hence force in outward direction than in the inward direction. However, it can be argued that two factors influences operate so that the aligned vibrations produce more momentum and force in the inward direction.

One factor is due to the geometry of the sphere. If a sphere that is divided into a series of concentric shells of uniform width, each shell will have a volume given by $4\pi r^2 \Delta r$ where Δr is the width of each shell. Thus, with any two adjacent shells, the outer shell will always have more volume than the inner shell. Hence, there should always be more atoms vibrating along the radii of the outer shell than atoms vibrating along the radii of the inner shell. Because atoms in the inner shell are outnumbered, it will be very difficult for them to transfer more momentum outwardly than the atoms in the outer shell can transfer momentum inwardly. Thus, the downward momentum from the aligned vibrating atoms should always preponderate over the outward momentum.

The other factor has to do with the decrease in the temperature of the sphere with radius. Consider an atom that attempts to vibrate in simple harmonic motion along the radius of the sphere. When this atom moves radially outward, it will move from a hotter region to a cooler region. As it moves outward, it will lose some of the kinetic energy it has acquired from being in the hotter region. When it moves inwardly from a cooler region to a hotter one, it will gain kinetic energy. Thus an atom that vibrates along the radii of the sphere will always be able to transfer momentum inwardly than outwardly.

A similar kind of scenario could be developed for a spherical shaped cloud of gas that is cold on the outside and has a heat source at its center. The geometry of the cloud would make it difficult for the

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[1] In describing and defending General Relativity to the public Einstein wrote, "On the other hand, it must be conceded that a theory has an important advantage if its basic concepts and fundamental hypotheses are 'close to experience' and greater confidence in such a theory is certainly justified" [11].

[2] Newton wrote, "That gravity should be innate, inherent and essential to matter, so that one body may act upon another at a distance through a *vacuum*…is to me so great an absurdity... [12].

[3] A visual but somewhat ambiguous indication that radiation is attractive is the behavior of the tops of cumulous clouds. When heated by the sun's radiation the tops will expand upwards along the vertical. They will also tend to point towards the sun at it moves away from or towards that it reaches in the sky.

force for the outward moving molecules to preponderate over the inward moving molecules and the decreasing temperature with radius would make it difficult for a molecule that moves outwardly to have as much velocity when it reverses direction and moves inwardly.

The above explanation provides a way to explain why the equivalency of inertial mass and gravitational mass is normally observed. Consider a solid sphere that is divided up into a series of concentric shells that has a heat source at its center and the temperature outside the sphere is much colder than within the sphere. Further assume that in a particular atoms of a small density exists and atoms of a large density exists. Since heat has the tendency to flow from a hot place to a cold place, it will use the maximum amount of energy possible to move the atoms with two different densities outward along the radii of the shell. As a specific example let us assume that one atom #1 is five times more massive than the other atom #2 and the amount of energy needed to move each atom outwardly the same distance d is

$$\begin{aligned} E_1 &= m_1 a_1 d \\ E_2 &= m_2 a_2 d. \end{aligned} \tag{11}$$

Since $m_2 = 5m_1$, the amount of energy flowing outwards from inside the sphere to m_2 will be the maximum amount possible that is $E_2 = 5E_1$. By dividing E_1 by E_2 and rearranging, we find that

$$a_2 = a_1. \tag{12}$$

Due to the geometry of the sphere, the decrease of temperature with increasing radius of the sphere and their vibratory nature, both m_1 and m_2 should reverse direction and accelerate inwardly with a greater amount say g_1 and g_2 respectively. For the same reasons that would make $a_2 = a_1$, then they should be equal that is

$$g_2 = g_1. \tag{13}$$

5. Can dark matter and dark energy be made unnecessary?

A formula has been developed that should help with future experimental and theoretical work that explores the radiations attractive ability. Consider a hollow spherical shell that has a heat source at its center. Let be the amount of radiation that is absorbed by the mass m of the shell in time t, g be the force per unit mass and h the distance that a small portion of the mass of the shell would accelerate towards the center in time t. If absorbed radiation becomes transformed into the gravitational potential energy, then that potential energy can be expressed as

$$Lt = mgh. \tag{14}$$

Because $h = 1/2gt^2$, g can be written as

$$g = \sqrt{\frac{2L}{mt}}. \tag{15}$$

Since $F = L/4\pi r^2$ is luminosity per unit area and $\sigma = m/4\pi r^2$ is the mass per unit area, g can also be written as

$$g = \sqrt{\frac{2F}{\sigma t}}. \quad (16)$$

Equation (14) can be rearranged so that it is in one form of the Tully Fisher relation.
By substituting $g^2 = V^4 / r^2$, $m = \sigma 4\pi r^2$ and $h = 1/2gt^2$ into (14) it becomes

$$L = (\sigma 2\pi t)V^4. \quad (17)$$

If $(\sigma 2\pi t)$ is constant, then (17) becomes the same form as the Tully Fisher relation that has been employed be Milgrom's MOND [16] to predict the flat rotation curves of galaxies

$$L \propto V^4. \quad (18)$$

In studying the rotation curves of galaxies, Renzo Sancisi has noticed a link between the luminosity output of a galaxy and its rotation curves. He writes [17]:

> There is a striking correspondence between the shape of the rotation curves and the shape of the radial distribution of luminosity in spiral galaxies…. The rule suggested here can be seen perhaps as a Tully-Fisher kind of relation, between the distributions of light and the run of rotational velocities….

The highly researched and well-established Tully-Fisher (TF) relation (18) provides a direct link between a galaxy's total luminosity and its highest orbital velocity. Unfortunately, because, among main sequence stars, there is a high correlation between a star's mass and its luminosity [18], this relation can be interpreted in two ways. There is the direct, littoral one where it can be thought of as an expression of the ability of radiation to attract mass and there is the indirect one where it can be thought of as an expression of the ability of mass to attract other mass or warp space. For the later to be valid it must be assumed that each galaxy is encased in a halo of unseen dark matter, which is more massive than the galaxy itself and which, after almost of two decades of a multi-million dollar, multi-team effort, has yet to be detected in the laboratory. For the former to be valid it must be assumed that radiation has the ability to attract mass. The relatively inexpensive experiments described in Figures 1-5 provide an indication that radiation does indeed have this ability.

A galaxy's shape is ideal for the phenomena of light bending to act so that some of the radiation leaving its inner parts will collect in its outer parts. This will tend to make the radiation in those parts fall off as $1/r$ rather than $1/r^2$. If this radiation is attractive, then a way is opened up to explain the flat rotation curves of galaxies that avoids assuming that a galaxy is surrounded by a halo of dark matter that has yet- to-be-detected in a laboratory. The central part of the intergalactic medium of a cluster emits large amounts of radiation. Since this radiation could be gravitationally attractive as my experiments suggest, then a similar way is opened up to explain the gravitational binding of clusters that does not assume that the central parts of a cluster is filled with large amounts of yet-to-be-directly-detected dark matter.

A theory has more validity if it can explain a serious observational anomaly that it was never initially designed to designed to address[4]. The basic paradigm or foundation of the theory presented in this paper was first conceived in 1977 in order to deal with the non-Keplerian rotation curves that were being observed at that time. Since cosmic acceleration was discovered much later, the theory that has been presented was never meant to address this unexpected observation. After power was cut off at the 400-second point in the experiment described in Figure 1, the force graph shows that the hollow copper sphere began to be less and less gravitationally influenced by the radiation coming from the heat element. Something similar to what happened to the sphere seems also to have happened to galaxies [19] at around

[4] However, increased confidence should not be given to a theory whose prediction of an unanticipated observation misses the mark by 120 orders of magnitude.

$z \sim 1$. As Figure 6 shows that at this point time in the universe's history galaxies began to receive less and less interchanged radiation. Following this decline in star formation rate and possibly caused by it cosmic acceleration occurred. A recent study [20] has determined that the transition redshift—the point where decelerating expansion changes to accelerating expansion—occurred at $z_t = 0.61^{+3.68}_{-0.21}(1\sigma)$. The vertical arrow in Figure 6 points to this transition redshift in the graph of the history of the star formation rate. Since galaxies tend to revolve around each other in a random way, when they become less gravitationally bound, they will tend fly off in a straight line in a direction that is random. This random direction will produce the observation of accelerated expansion or comic acceleration, which also allows for the interpretation that the so-called dark energy is smooth or not clumpy.

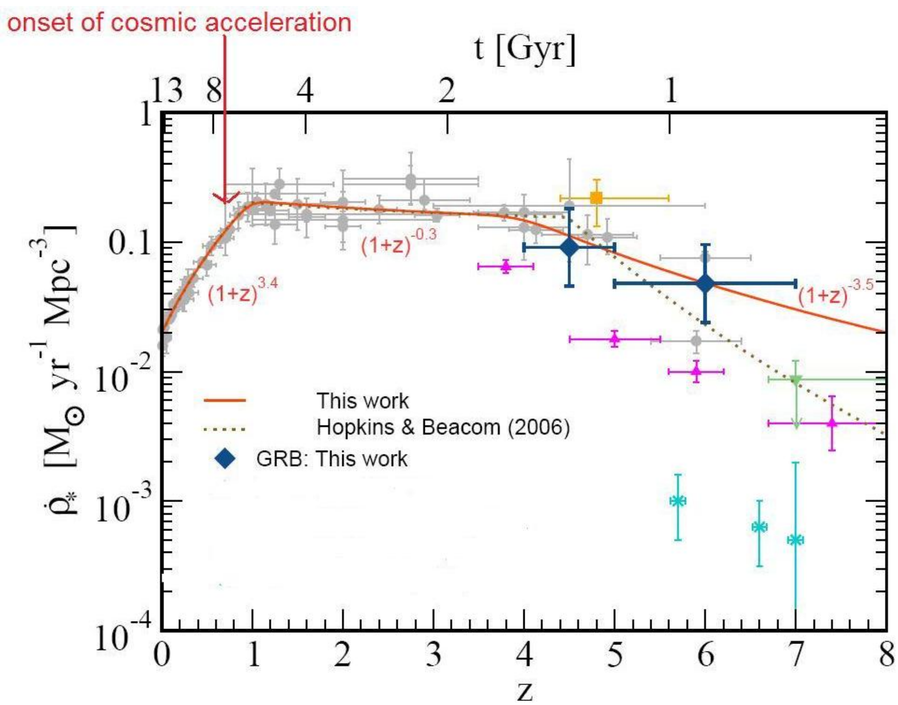

Figure 6: This is a modified graph of the cosmic star formation history where gamma ray bursts have been employed to extend the high z part of the graph [19]. The arrow at the top of the graph shows the time of onset of cosmic acceleration which has recently [20] been estimated to have occurred at $z_t = 0.61^{+3.68}_{-0.21}(1\sigma)$.

The graph in Figure 1 provides some insight into the delay between the onset in the decline of star formation rate and the onset of cosmic acceleration shown in Figure 6. The first graph shows that after power was cut off at the 400-second point, it took 82 s before the gravitational binding between the copper sphere and the central part of the heat source sphere started to decrease (see vertical arrow at the 482-second point in Figure 1). To see if this delay of 82 s was just a random event or something inherent with the phenomena, two runs of the same experiment were carried out five days later. The first run found a delay of 127s between when power was cut off at the 400-second point and when the force graph started to decline. In the next run of the same experiment, a delay of 95 s was observed between the 400-second point and the beginning of the decline in the force graph.

5. Summary and conclusions

Simple experiments, which could have been performed centuries ago, indicate that spreading infrared radiation is gravitationally attractive. A theory based on this finding, employing such ideas as *central pressure imbalance*, *the alignment of the molecular vibratory modes* and the ability of *light bending* to place extra radiation at a galaxy's edge has the potential to account for the orbital motion of astrophysical bodies, the flat rotation curves of galaxies and the gravitational binding of clusters. It can also explain cosmic acceleration in a close-to-experience way that cannot be matched by a mass-based theory. Because mass-based gravitational theories have been dominant for the last 300 years, there was much hope that the gravitational force could be manipulated for practical purposes. However, with a gravity theory founded on the attractive ability of radiation, it may be possible to harness the gravitational force in much the same way the electromagnetic force was harnessed in the later part of the 19th and the early part of the 20th century.

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