Exploration

Mercury's Precession Reconsidered

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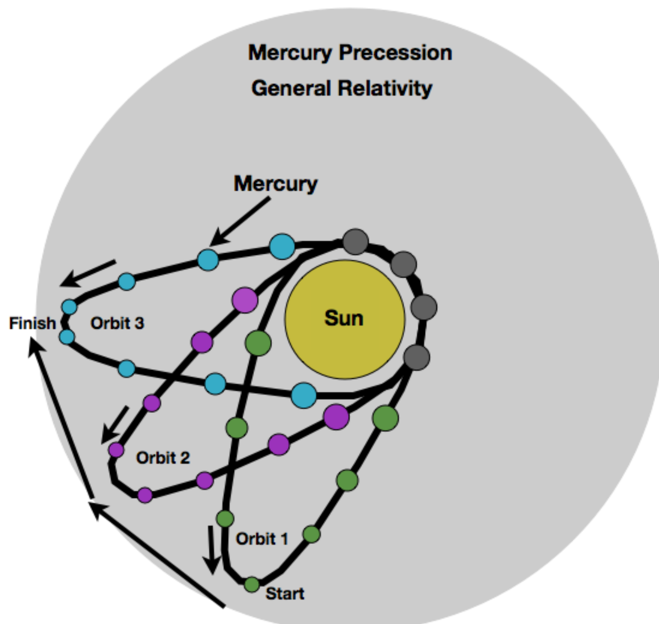
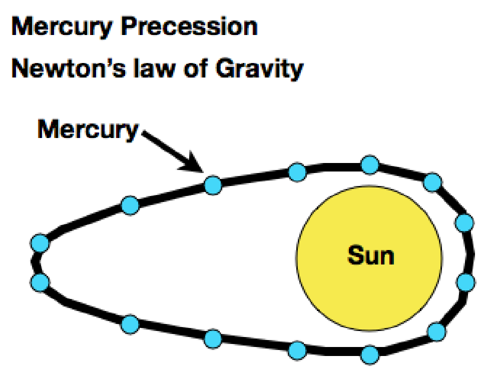
Abstract

In this paper, the case will be made that Mercury precess about the sun because of a mass increases as it gets to perihelion. And furthermore this mechanism for mass increase is the same one causing dark matter and dark energy.

Key Words: Mercury, Sun, precession, mass increase, dark matter, dark energy.





1. **Introduction:** Gravity has been modeled via both Newton's law of gravity and Einstein's general relativity equations. The author holds that both models of gravity have shortcomings and that by examining both of them a new understanding of gravity can be obtained which will give an insight into both dark matter and dark energy.
2. **Mercury's precession:** If Mercury and the Sun where the only objects in the universe then the orbit of Mercury about the Sun using Newton's law of gravity would be

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a perfect ellipse.[1] General Relativity looking at the same system would have Mercury's orbit as precessing about the Sun.[2]

3. **What is wrong with general relativity:** General relativity is very complex and because of this it lacks an intuitive mechanical understanding. The mathematically inclined may respond "who cares we have the equations, that is all that is needed". The problem with this is that important rather obvious features of what is happening are overlooked. Leonard Suskind of Stanford comments that the few people he knows who can work the equations of general relativity say that there is no mechanical visualization.[3]
4. **What did general relativity find:** The orbit of Mercury is a function of the space-time curvature caused by the Sun. And when the numbers are cranked it is found that Mercury's orbit precesses more than that predicted by newton's model. And more importantly it was in better agreement with Mercury's measured precession.
5. **What did general relativity miss:** General relativity missed or overlooked the importance of what was happening physically to Mercury. John Wheeler has encapsulated general relativity in the aphorism ``curvature tells matter how to move, and matter tells space-time how to curve."[4] It is generally agreed that it is the curvature of the space-time that causes the force on a mass. But what if a mass experiences just a flat increase in space-time. There would be no curvature and thus no force, but the object is in a more dense space-time. Flat denser space-times exists in special relativity for high velocity masses, but the cause is attributed to shortening of rods and the slowing of clocks. We could say that the fast moving mass is in a more dense space-time. And in general an object placed in a denser space-time will have a mass increase. In space-time, curvature causes force and density causes mass. Mercury has an elliptical orbit and when it is close to the Sun it has more mass (a denser space-time) than when it is far away from the Sun (less dense space-time).

   General relativity was created to get rid of the "spooky" force at a distance concept that is attached to masses and Newtonian gravity. There was no motivation for general relativity to consider a mass increase for Mercury even if its equations have it embedded.

6. **What did Newton's gravity Find:** Newton's law of motion also predicted that the orbit of Mercury would precess when other objects are nearby, for example the other planets. However, it did not predict any precession due to the Sun itself. The Sun and Mercury were expected to produce perfect ellipses as predicted by Kepler.[1]
7. **What did Newton's gravity omit:** Newton's gravity failed to predict that Mercury would precess around the Sun even if the Mercury-Sun System were alone in the universe.
8. **A possibility:** Newton's law of gravity has been shown to be contained in general relativity.[5] Can we go the other way and modify Newton's law and make it perform more like general relativity? It is worth a try!
9. **Self-Gravity, a wild guess:** It is postulated that a mass can have a force of gravity with respect to itself. And that this self-gravity is the new foundation of Newton's law of gravity. The rest of this paper is devoted to investigating the reasonableness of this assumption. Newton's Law: $F=Gm_1m_2/d^2$ will become $F=Gm^2/d^2$.
10. **Self-Gravity of the Earth:** To show that the concept of self-gravity is a reasonable assumption it will be used to make a calculation. We can investigate a single mass (the earth) using its self gravity equation $F = G[m^2/d^2]$. We will equate this self gravity with the acceleration due to gravity at the earth's surface: $F = G[m^2/r^2] = ma$, Solving for the distance r (distance to the center of gravity) we get $r = (Gm/a)^{0.5}$

    The mass of the earth m is $5.9742\text{x}10^{24}$ kg

    The acceleration due to gravity a is 9.81 m/s^2

    The gravitational constant G is $6.673\text{x}10^{-11}$

    After making the appropriate substitutions we get that r = 6,374.8 km

The radius of the earth is measured as 6,378.1 km which is in good agreement with the just calculated 6,374.8 km. This shows that the concept of self gravity can be used to calculate the radius of the Earth. This is not a rigorous proof of self-gravity, but it shows shows that it may be a reasonable assumption.

11. **Modifying Newton's law to accommodate self-gravity:**
    We will start with self-gravity $\mathbf{F = G[m^2/d^2]}$ and make it into a new modified law of gravity (Newton's New Law)) by saying that $\mathbf{m = m_1+m_2}$. The Force F is now:

$F = [G/d^2][(m_1+m_2)^2]$ and expanding we get: $\mathbf{F = [G/d^2][(m_1^2 + m_2^2 + m_1m_2 + m_2m_1)]}$

The Modified Newtonian Law of Gravity has three terms:

a. Gm_1m_2/d^2 : Force produced by m_2 on m_1. As per Newton's original law of gravity.

b. Gm_2m_1/d^2 : Force produced by m_1 on m_2. As per Newton's original law of gravity.

c. $[G/d^2]\ [m_1^2+m_2^2]$: A force of self-gravity for the mass (m_1+m_2). This is the new find ing, A system of two masses has a self-gravity.

12. Generalizing Newton's New Law:

Newton's new law is a general relationship for any number of forces. It works like this:

1. A single mass only has a self-gravity $\mathbf{F=Gm^2/d^2}$.
2. Two masses have a self-gravity $\mathbf{F=[G/d^2]\ [m_1^2+m_2^2]}$.
3. Three masses have a self-gravity $\mathbf{F=[G]\ [m_1^2/d_1^2 + m_2^2/d_2^2 + m_3^2/d_3^2]}$. Where d_1 is the center of gravity of all the masses excluding m_1. Where d_2 is the center of gravity of all the masses excluding m_2. Where d_3 is the center of gravity of all the masses excluding m_3.
4. etc.

13. The meaning of self-gravity for distributed objects: The force of self-gravity for something like the earth is easy to visualize and calculate (as done in section 10 above) where the mass of the system was simply the mass of the earth. We need to do something different when we consider a system like Mercury orbiting the Sun. The self-gravity of the Mercury-Sun system is $\mathbf{F = [G/d^2]\ [m_m^2+m_s^2]}$ and it does not have a uniform mass distribution as does the earth. To handle the Mercury-Sun system we will first convert the force of self-gravity to an energy by multiplying by the distance d. The Energy in the Mercury-Sun system is now $\mathbf{e = [G/d]\ [m_m^2+m_s^2]}$. This energy e is in the Mercury-Sun system as a whole and it can be thought of as a mass $\mathbf{m_x}$ where $e=m_xc^2$. We now have: $[G/d]\ [m_m^2+m_s^2] = m_xc^2$ and $\mathbf{m_x = [G/(dc^2)]\ [m_m^2+m_s^2]}$. This mass $\mathbf{m_x}$ is termed the **subtle mass** of the Mercury-Sun system.

14. Subtle Mass: Self-gravity was postulated as an "upgrade" to Newton's law of gravity to make it more like general relativity. Self-gravity made sense when we applied it to the Earth in section 10 above, where it predicted the radius of the Earth. This does not necessarily make self-gravity true, but it makes it worth pursuing. From the concept of the self-gravity of two masses we deduced (in 13 above) the possibility of something called a subtle mass. The subtle mass equation was developed for a two mass system, but as with self-gravity it is applicable to single masses and any number of discrete masses.

15. Does the subtle mass concept have any applicability to the real world?

This will be investigated by looking at the following: 1. the subtle mass of the earth 2. the subtle mass of the Mercury-Sun system and 3. the estimated subtle mass of the entire Universe.

16. The subtle mass of the earth: $m_x = [G/(rc^2)] [m_e^2]$.

The mass of the Earth m_e is 5.9742×10^{24} kg

The gravitational constant G is 6.673×10^{-11}

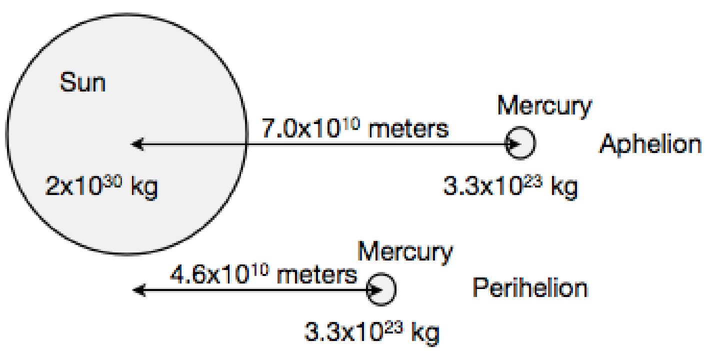
The radius of the Earth is 6.3781×10^{6} m

After making the appropriate substitutions we get that $\mathbf{m_x = 4.15 \times 10^{15}}$ **kg**

The subtle mass of the Earth seems large at 4.15×10^{15} kg but it is a small fraction of the mass of the Earth 5.9742×10^{24} kg.

The ratio of the $\mathbf{m_x/(m_x+m_e)}$ for the Earth $\mathbf{= 6.95 \times 10^{-10}}$

17. The subtle mass of the Mercury-Sun system: $m_x = [G/(dc^2)] [m_m^2+m_s^2]$



The mass of Mercury m_m is 3.3×10^{23} kg

The mass of the Sun m_s is 2.0×10^{30} kg

The minimum distance is 4.6000×10^{10} m

The maximum distance is 6.9820×10^{10} m

The gravitational constant G is 6.673×10^{-11}

After making the appropriate substitutions in $\mathbf{m_x = [G/(dc^2)] [m_m^2+m_s^2]}$ we get:

1. At Minimum distance (perihelion) $\mathbf{m_x = 6.3849 \times 10^{22}}$ **kg**
2. At Minimum distance (aphelion) $\mathbf{m_x = 4.2066 \times 10^{22}}$ **kg**

3. **$\Delta m_x = 2.1783x10^{22}$ kg**
4. **Ratio of Δm_x to Mercury's mass: $\Delta m_x / m_m = 6.59\%$**

Newton's new law predicts a mass change for Mercury in its pass around the Sun. I am going to have to leave it to an expert in general relativity to say whether this fits with the field equations.

18. Estimating the subtle mass of the Universe: $m_x = [G/(rc^2)] [m_u^2]$.

In this calculation the universe is considered a uniform density sphere. This is similar to the calculation made for the subtle mass of the Earth in section 16.

The mass of the Universe m_u is $1.8x10^{54}$ kg [6]

The radius of the Universe is $0.95x10^{26}$ m [7]

The gravitational constant G is $6.673x10^{-11}$

Making appropriate substitutions in **$[G/(rc^2)] [m_u^2]$** we get **$m_x = 2.53x10^{55}$ kg**

This is a tremendous mass and this subtle mass in the Universe is larger that the "real" mass of the Universe.

The ratio of the **$m_x/(m_x+m_u)$** for the Universe **= 93.4%**

19. Results of the three Subtle Mass calculations:

a. The subtle mass of the earth is extremely small, $m_x/(m_x+m_e) = 1.86x10^{-10}$

b. The subtle mass of the Mercury-Sun system showed a 6.59% change from perihelion to aphelion. When Mercury approaches the sun there is more mass causing it to speed up $[v = (Gm/r)^{1/2}]$ pushing the orbit ellipse as shown in the illustration at the beginning. It is this mass change that powers the precession movement.

c. The subtle mass in the Universe is 93.4% of the observed mass of the Universe. This is close to the measured 95% total for dark matter and dark energy.[8]

d. Conclusion: These results correlate with the puzzling dark matter and dark energy components in the universe.[8] When the masses observed are about that of the earth the subtle mass is an undetectable fraction of the total mass. When the mass observed is that of the Mercury-Sun system the subtle mass is a small fraction of the total mass. When the mass observed is the entire universe the subtle mass is 93.4% of the total mass.[9]

20. Dark Matter and Dark Energy:

Dark matter and dark energy are explained via the same subtle mass equation. Dark energy is the form subtle mass takes when we look at a uniform distribution of static stars. The distances between the stars may be big (decreasing the subtle mass) but the distance effect is overwhelmed by the contribution of the mass squared term of the subtle mass equation. This results in large distributed subtle mass components.

Dark matter is the form subtle mass takes when massive objects rotate about each other. With rotating masses the distance between the masses can be small and the sum of the masses large. This produces the larger amounts of "subtle mass" in compact spaces like those found in spiral galaxies.[9]

21. A final speculation: Subtle mass and "Space-Time Density" could be the same phenomena seen form different viewpoints. Both concepts only become significant at large mass values and both are associated with mass value changes. If they are equivalent viewpoints then the new Newtonian viewpoint shows that general relativity has missed dark energy and dark matter. It is not that generality relativity cannot account for them. I believe that in the future the field equations of generality relativity will be demonstrated to contain dark energy and dark matter. The solution is in the equations as they stand now, but no one can "see" them because they are hidden in a complex mathematical theory that has no mechanical visualization.

General relativity has "locked on" to space-time change as being associated with single large masses and black holes, it has not considered a distributed space-time increase due to distributed masses that has the effect of increasing the masses.

22. **Conclusion:**

The case has been made that Mercury precess about the sun because of a mass increases as it gets to perihelion. And furthermore this mechanism for mass increase is the same one causing dark matter and dark energy.

23. **An Experiment that has a problem:** Monitor the official kilogram standard continuously throughout the year and plot its mass change. The Earth has an elliptical orbit and even though it is not as extreme as that of Mercury it should be enough to measure a subtle mass effect. If we take a 1kg standard and measure its mass (in a

way that does not uses other masses) we should be able to see its mass gain when the earth is closer to the Sun. The expected mass change can be calculated as follows:

a. Calculate the $\mathbf{\Delta m_x}$ for the Earth-Sun system following the method in section 17.

The mass of Earth m_e is 5.97×10^{24} kg The minimum distance is 1.47×10^{11} m

The mass of the Sun m_s is 2.0×10^{30} kg The maximum distance is 1.52×10^{11} m

The gravitational constant G is 6.673×10^{-11}

After making the appropriate substitutions in $\mathbf{m_x = [G/(dc^2)]\,[m_m^2 + m_s^2]}$ we get:

1. At Minimum distance (perihelion) $\mathbf{m_x = 1.998 \times 10^{22}}$ **kg**
2. At Minimum distance (aphelion) $\mathbf{m_x = 1.932 \times 10^{22}}$ **kg**
3. $\mathbf{\Delta m_x = 6.57 \times 10^{20}}$ **kg**
4. **Ratio of $\mathbf{\Delta m_x}$ to Earth's mass: $\mathbf{\Delta m_x / m_e = 0.011\%}$**

b. This experiment is designed to show that a kilogram on Earth will have values that vary from a low of 1kg - 0.05 gram at aphelion to a high of 1kg + 0.05 gram at perihelion.

24. **The experiment above seems reasonable**, but it will never record any mass changes in the standard kilogram because of the general principle of relativity**: "**All systems of reference are equivalent with respect to the formulation of the fundamental laws of physics."– C. Møller The Theory of Relativity, p. 220

Nature conspires to always have the rest mass of an object as measured by a local observer be fixed. This happens because the measurement is done with local "clocks and rods" in the same space-time as the mass. The 1kg test mass we have on earth will remain 1kg as long as we are making a local measurement of it at rest. This is a fundamental law of physics. However if this 1kg were on Polaris and we measured it from Earth we would see an increase in its mass (according to the theory presented here) because the space-time density near Polaris is greater.

Having objects that are not local have mass changes is not unknown. Special relativity has objects gain mass if they have velocity with respect to an observer. However if the observer were on the moving mass no mass increase would be measured. Special relativity says that objects with kinetic energy will experience a mass gain. This is agreed upon science and has been experimentally verified many times.

It is forecast (as outlined in this paper) that general relativity will say that objects with potential energy will also experience a mass gain. This is not agreed upon science and will need to be experimentally verified. There are hints of this in 1. the precession of Mercury, 2. dark matter and 3. dark energy.

Making logical or mathematical models is an interesting and exciting exercise. Designing and making precision experiments that show the theoretical phenomena definitively is the hard work. My apologies for not doing the hard work.

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