Diffusion Gravity (5): Perihelion Precessions as Indicators of Galactic Gravity

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Abstract

Diffusion Gravity theory has shown in previous works that the constant velocity profiles of galaxies may be a direct result of equipotential "locking" of stars to the zero-potential balance point between the star and its parent galaxy. This hypothesis was incorporated into the Diffusion Gravity model in a previous paper [9] along with the integral mechanism of gravitational attraction to explain those constant velocity profiles that are otherwise attributed to "dark matter". In this current research report, DG postulates other effects between the Sun-Mercury pair and the Milky Way Galaxy (MWG), and compares them with Mercury precession models from numerous other researchers, some or all of which can account for the precession advance of the perihelion of Mercury. In particular, the acceleration-torque effect of the MWG should also advance precession of the perihelion, thus contributing and adding to the total calculated by mass-ring models to arrive at the measured total precession advance of the perihelion of Mercury of 575.31 arcseconds per century .

Introduction

With the availability and application of spacecraft missions as instrumentation probes, physics has more extensive data and a correspondingly greater accuracy of measurement of phenomena in our solar system, including the precession of planetary orbits. This research article invokes some of the latest data and results from these instruments, including MESSENGER spacecraft mission [8], to validate modeling of the precession advance of the perihelion of Mercury, and to demonstrate Newtonian gravitational conformity, if taken together with galactic gravitational influence. Previous calculation and observation efforts going back to LeVerrier (526.7 arcseconds) and Newcomb [15] have iteratively added influences and accuracy to the precession models for all the gravitational effects of the solar system. Subsequent twentieth century refinements and calculation capability were included by Clemence, Doolittle, and others as reflected in the paper by Clemence in 1947[3]. Price and Rush refined their "mass-ring" approach in 1979 [17], which updated the model to more precisely determine the Newtonian perihelion precession calculation; the total precession given by Clemence and by the Price-Rush model was 532 arcseconds per century for Mercury's precession advance. That same model where the influence of other planets is modeled as a mass-ring, was reviewed and refined by Brown in "Newtonian Precession of Mercury's Perihelion"[1]. According to Brown, when the "mass ring" model is evaluated exactly, with no simplifying approximations, it yields a more precise precession value of 549.61 arcseconds per century. Other modelers such as Burchell [2], and Smulsky [19] have produced varying results, from 526 to 556 arcseconds per century, by varying parameters in the model of a "fixed" vice a "floating" Sun (barycenter), or by varying eccentricities of planetary orbits, and other variables which can be easily inserted and run in simulations. By comparing this to the recent more exact spacecraft data we can gain perspective on the evolution of those models as they have been historically applied, and ultimately improve and validate the Mercury perihelion precession model.

The observed precession has been measured exactly by MESSENGER spacecraft to be 575.31 arcseconds per century; therefore, from the perspective introduced in the previous paragraph, the cited efforts at computer and analytic modeling of the Newtonian precession show a "difference range" of 30 arcseconds (526-556) per century, with the trend towards *increasing* the model-calculated precession due to local solar system planetary gravitation. Realistically, the trend suggests that these modeling efforts will continue to evolve toward 550 arcseconds per century based on the above analyses and histories. This total would then *decrease* to only 25 arcseconds per century the difference to the actual MESSENGER precession advance measurement of 575.31. With this perspective in mind, we look more closely at these Newtonian model refinements and uncertainties. The motivation for re-visiting the precession of Mercury is to understand the model and contributions from an analytic modeling point-of-view, and to compare against the actual measurements, and then ultimately to extend these observations and models to suggest a possible gravitational contribution from the galaxy.

Section 1 Model Evolution of the Sun-Mercury Pair Perihelion Precession

Models that show more precession due to the inner planets, i.e., Earth and Venus, are most credible due to their proximity to Mercury and the Sun; logically the effect should be reflected in the accuracy of the mass-ring model and particularly since from our Earth-centric observational data, this should enable refinement of the model to a very high degree of accuracy. Jupiter also has large influence due to its size. Please see Table 1 for a comparison of the LeVerrier [11] original work to the more modern model by Clemence, and then to the recent model refinements by Brown and others. The objective of this table is to show that the trend of the model effects by the planets on the perihelion of Mercury precession should continue to *increase* over time with more accurate data, resulting in refinement of the gravitational models. Significantly, the model estimates published in the recent work by Park et al., on the MESSENGER results, used essentially the same planetary effect *estimates* as the Clemence paper in 1947.

Table 1 Evolution of Modeled Precession of Mercury Perhelion

Source of Mercury Precession Newtonian - Solar System	La Verrier arc sec/100 yr	Clemence MESSENGER 2017	Brown[1] Burcell [ ] mass-ring model
Venus	280.6	277.42	281.6
Earth	83.6	90.89	95.9
Mars	2.6	2.48	2.4
Asteroids	–	.0012	0.13
Jupiter	152.6	153.99	161.6
Saturn	7.2	7.32	7.8
Uranus	0.1	0.143	0.14
Neptune	–	.042	0.04
Total	526.7	532. 286	549.61

The evolving and refined mass-ring model implies that the perihelion of Mercury should exhibit somewhat *more* precession than expected based on an analytic rigorous mathematical model from Newtonian theory, i.e., which predicts and accounts for approximately 24 arcseconds per century over the original model calculations of LeVerrier of 526.7. Noticeably, the increases are due to the planets Venus, Earth-moon, and Jupiter, implying more precisely refined calculations for the nearest and largest neighbors. The equation for the mass-ring model as calculated by Brown is given as equation in Figure 5-0,

$$\Delta\theta_{\text{per rev}} = \frac{\pi B}{M r_0} = \frac{\pi}{M}\left(3\alpha_1 r_0^{\,3} + 5\alpha_2 r_0^{\,5} + 7\alpha_3 r_0^{\,7} + 9\alpha_4 r_0^{\,9} + \ldots\right)$$

$$= \pi\left(\frac{m}{M}\right)\left[\frac{3}{2}\left(\frac{r_0}{R}\right)^3 + \frac{45}{16}\left(\frac{r_0}{R}\right)^5 + \frac{525}{128}\left(\frac{r_0}{R}\right)^7 + \frac{11025}{2048}\left(\frac{r_0}{R}\right)^9 + \ldots\right] \qquad (6)$$

Figure 5-0 Brown's Mass Ring Model Equation (6)

where R is the radius of the mass-ring, r_0 is the location of particles in the ring, m is the mass of the ring, α are the respective accelerations for particles, and M is the central mass (B is a constant derived from accelerations). This model provides the precession in units of radians per revolution of Mercury. To convert this to units of arcseconds per century, noting that Mercury completes 414.9 revolutions per century, we multiply the above expression by

$(\Delta\theta)(414.9 \text{ orbits})(360°/2\pi \text{ rad})$ (3600 arcseconds/degree) = precession per century

Mass-ring models are elaborated and detailed in the references given. Consensus of the recent mainstream literature on Mercury's perihelion precession stubbornly remains on the 532 arcseconds per century model estimates, as in the work cited by Park et al.[8], which essentially re-states the Clemence table from 1947, adding decimal places to the same values, but with almost no revision or change of the modeled estimates for planetary effects. However, as we have shown, the trend in modeling the Newtonian precession has been to revise planetary influence *upward*. According to Brown, "when the mass-ring model is calculated exactly, with no simplifying approximations, the result is precession of 549.61 arcseconds per century". The observed and measured precession is 575.31, so this recent modeling does validate that Mercury has greater Newtonian solar system ("local") precession by about 24 arcseconds per century over the original 526 arcseconds of LeVerrier. This would follow logically as the refinement and accuracy of the modeling. There appears to be a contradiction between the evolving estimates for planetary influences, and particularly the Venus, Earth, Jupiter contributions. In addition to this discrepancy between the mass-ring model evolution and the current estimates for precession advance, this report will also suggest, and demonstrate previously not-included galactic influence.

The Gerber Equation [10] of precession advance relied upon the baseline modeling of the Newtonian-Kepler precession of Mercury and sought to quantify and predict a precession to "explain" the anomalous 43 arcseconds per century observed. This should be examined relative to the time that the Gerber Equation was published in 1902, and presented as an empirical-Newtonian based model which was a rigorous and phenomenological accomplishment that inspired further theoretical work. The Gerber Equation model will be discussed further in Section 3 and its application to this current research.

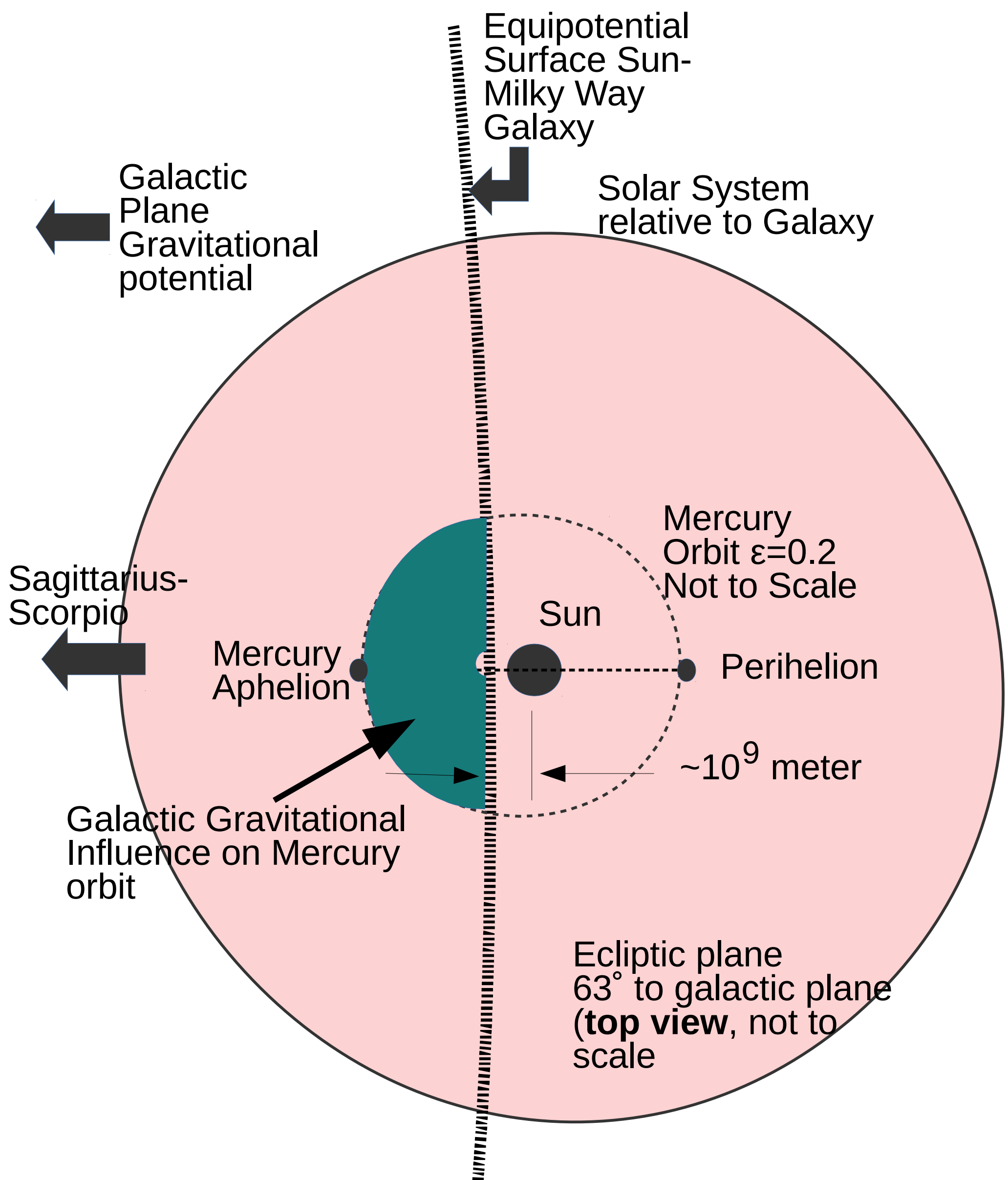

Figure 5-1 Top View Sun-Mercury Galaxy Orientation

With these data and models as perspective, this current DG research proposes that an additional source of gravity from the galaxy should affect the total calculated from the refined Newtonian model. The influence of galactic gravity has apparently been assumed as insignificant in the study of planetary motions for our solar system. In fact, it is not been included in the more recent estimates of gravitational and dynamical sources for the perihelion precession. Yet, we unequivocally accept that the Sun orbits in the Milky Way Galaxy, and that it displays the characteristic constant velocity of stars in galaxies (the "flat rotation curve" profile), independent of the distance from the center of the galaxy. As the Diffusion Gravity theory has proposed [8], gravitational potential theory requires the existence of a "balance point", or equipotential (zero) point-surface between our Sun and the center of the MWG. Although there is uncertainty in the estimates of the total mass M of the Milky Way (mainly due to the confusion about dark or "missing matter"), the equipotential point, or "surface" where the gravity of the MWG and the Sun sum to zero, does not vary substantially in the calculation of that point-surface location, due to the enormous mass difference between the MWG and the Sun, which is estimated to be $M/m \approx 10^{11}$ (without dark matter). DG theory has shown that the distance of this equipotential surface between the Sun and MWG is approximately one solar diameter from the surface of the Sun, or about 10^9 m. from the Sun, with its center pointing in the direction of the MWG center, toward Sagittarius A*. Diagrammatically, this is shown in Figure 5-1.

Note that the major axis and aphelion of Mercury's orbit is toward Sagittarius-Scorpio, and therefore the influence of the MWG would be at maximum during the aphelion excursion of Mercury in its orbit around the Sun, due to a longer time of the excursion and the increased MWG gravity beyond the equipotential point-surface, with a resultant torque on the Sun-Mercury pair as a "spinning-top" model, subject to the MWG acceleration. The aphelion portion of the orbit is actually demarcated and outlined by the equipotential surface which bisects the orbital ellipse of Mercury, as shown in Fig 5-1. This is what may very well be happening in the case of perihelion-aphelion precession of Mercury; since the precession requires over 22,000 Earth years, the aphelion-perihelion major axis a will remain very stable over the relatively short time in which recorded astronomy, since LeVerrier first noted and recorded the precession in 1859, i.e., 160 / 22571 <1% of the precession period. In other words, this is too small a sample to extrapolate to the total period of precession, given that there may be other precession differences due to galactic influence at aphelion.

The equipotential point-surface is well-studied in potential theory and from analogous electromagnetism, and has been integral to physics for well over a century. Gravitational fields have the same superposition behaviors as other fields, and are subject to the same methods and analyses, such as the Gaussian, Poisson, and Laplace equations. The smaller magnitude of gravity compared to electromagnetism (by magnitude of 10^{-41}) has delayed the development of scientific understanding of its nature and behavior; however, the larger scale data will help to provide perspective and clarity, and help to resolve some of the details of gravitational physics. We use this perspective and data to propose the DG model as it applies to the galactic contribution to precession of Mercury's perihelion through the mechanism of torque. The following explanation will show the actual torque calculation for the model of precession discussed above for the mass-ring model, with an additional contribution from the Milky Way Galaxy.

An important objective in this report is to estimate and include the external factor of torque induced by the Milky Way Galaxy on the Sun-Mercury pair system. From Newtonian mechanics, torque is exerted at right angles to the spinning of the Sun-Mercury Pair (SMP) which can be modeled as a "spinning top", around the Sun-Mercury axis, with its radius that of

Mercury's orbit. (Note: torque applied perpendicular to the spin axis may or may not affect the angular momentum of the spinning system). Please see Figure 5-2 and Figure 5-3 for the geometry of this model. This modeling shows the calculated torque from MWG can have a further additional effect on the precession, which is computed via the Newtonian equation for total time of precession as:

$$T_p = \frac{4\pi^2 I_{SM}}{\tau\, T_{spin}} \qquad (2)$$

The SMP will have a spin rate T_{spin} of Mercury's orbital period, a reduced mass and a moment of inertia I_{SM}, and an axial point of spin that lies within the body of the Sun. The model is used to derive an equivalent total torque τ from the known precession rate (as measured to high accuracy by MESSENGER). Then a separate torque will be computed for the SMP due to the MWG gravity alone. This will be taken as a percentage of the total derived equivalent torque and used to calculate the percentage of the precession measured by MESSENGER, assuming a linear relation between torque and precession, as indicated in equation 2.

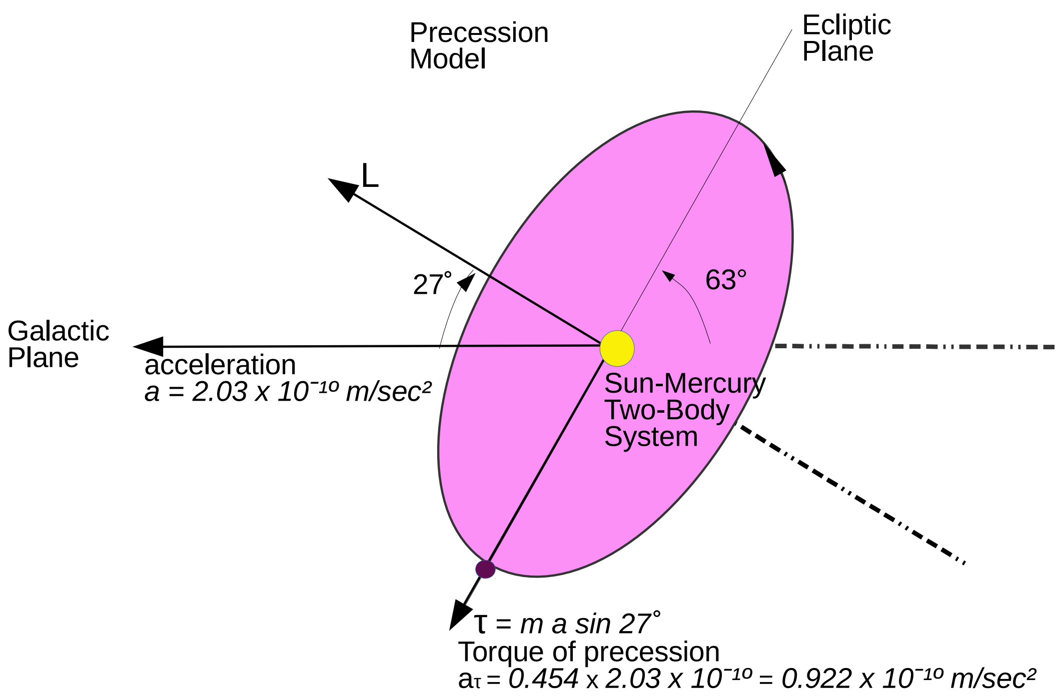

Figure 5-2 Mercury Perihelion Precession Geometry

The precession of perihelion of Mercury has been exhaustively measured, studied and analyzed. The model of Newtonian effects from the solar system has been incorporated to arrive at the mass-ring model total of 550 arc seconds (as discussed previously). The gravitational acceleration due to the MWG should have been historically considered in calculations of the Mercury perihelion precession, but apparently was not. Newtonian physics requires that a torque is imposed on the Sun-Mercury pair from the external galactic influence, which should be modeled as a spinning top with the spin orbital period of Mercury around the Sun. There is also the effect of the galaxy due to the proximity of the equipotential point-surface with the galaxy to the Sun. The previous works on the Diffusion Gravity model show the equipotential point-surface as being approximately a million kilometers (10^9 meters) from the Sun towards the MWG center. Figure 5-1 illustrates the concept of the equipotential surface and its proximity to the Sun. The orbit of Mercury and all the planets cross the equipotential surface of the Sun's orbit in the MWG, and so are influenced in their precessions accordingly. The case of Mercury's perihelion is different, due to its more unusual eccentric orbit, its proximity to the Sun, and its smaller mass (than the other planets); in Section 2 that follows, we will show that Mercury in its "spinning" pairing with the Sun, will precess in the usual Newtonian formulation, but with an added torque from the galactic acceleration. In this model, Mercury becomes an indicator of the galactic influence on the Sun-Mercury pair, with the impact measurable on its perihelion precession over time. The challenge since LeVerrier has been to "sort out" the influences from the solar system planetoids, the Sun, and other gravitational sources. Mercury, therefore, can provide us an "instrument" to measure, or indicate, galactic influence upon the solar system, with its sensitivity due to its unique orbit and pairing with the Sun as a "spinning top" model for precession by the galaxy-imposed torque. This will be demonstrated in the following section.

Section 2 Precession and torque from observations and measurements

Standard Newtonian mechanics[5] gives this equation of Torque and Precession:

$$T_p = \frac{4\pi^2 I_{SM}}{\tau\, T_{spin}} \tag{3}$$

where T_p = Time of Precession = 22571yrs = 7.109×10^{11} sec (extrapolated from measurements and observations)

$T_{spin} = T_{orbit}$ = One "spin" = one orbit (Mercury) = 7.69×10^6 sec

$I_{SM} = 7.747 \times 10^{43}$ kg-m^2 calculated below

τ = torque on spinning pair Sun-Mercury

Using the Kepler law, we obtain (based on velocity and distance from MWG center) the calculated acceleration due to the Milky Way Galaxy on the Sun-Mercury Pair

$$a_G = v^2/r = (230{,}000)^2 / 2.6 \times 10^{20} = 5.29 \times 10^{10}/2.6 \times 10^{20} = 2.03 \times 10^{-10} \text{ m/sec}^2$$

With this acceleration from the galaxy in the region near the Sun, we can calculate the torque on the Sun-Mercury two body system. The acceleration will be imposed at the angle of 27˚ from the galactic, due to the ecliptic being inclined 63˚ to the galactic plane. Please refer to Figure 5-2 and Figure 5-3.

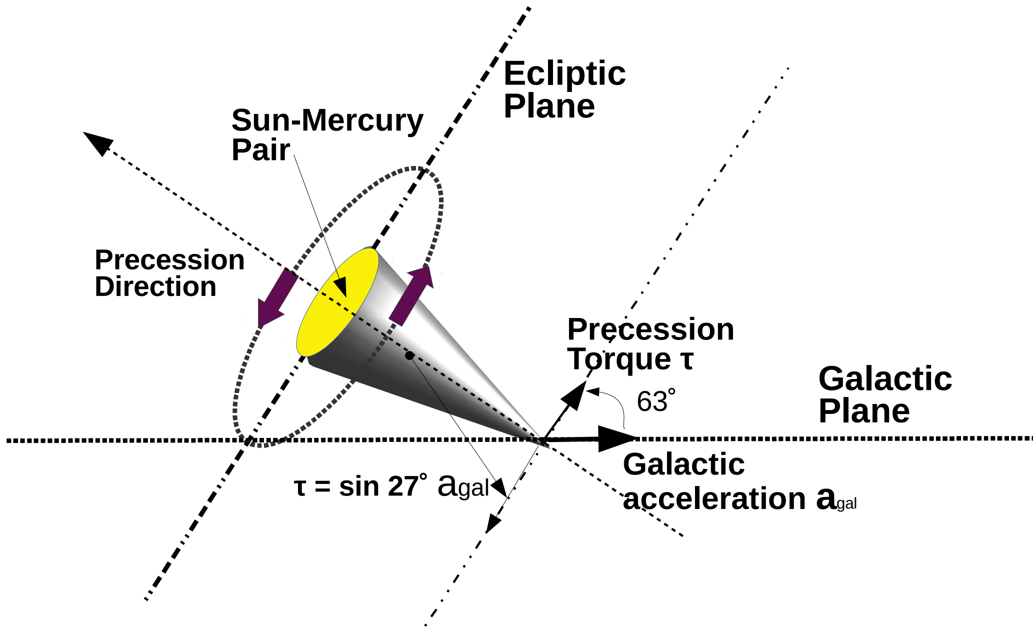

Figure 5-3 Sun-Mercury Pair in Spinning Top Model Mercury's Perihelion

Next, we apply the standard formula for torque

$$\tau = \text{mass x acceleration x radius arm} \qquad (4)$$

where • mass = reduced mass of Sun + Mercury = Mm/M+m

• radius arm = Mercury aphelion distance to Sun (greatest galactic influence) = 69.9 x 10^9 m. The aphelion distance is used because this is where the maximum acceleration from the galaxy occurs; the major axis of the ellipse of mercury's orbit is aligned with the MWG center, so during the excursion of mercury beyond the equipotential gravity point of the sun, the acceleration has maximum effect (torque) on the precession of mercury.

• acceleration = from the galaxy acting on the Sun-Mercury pair, at the angle of 27 degrees, which will then result in (sin 27°)a_G = .4540 x 2.03 x 10^{-10} m/sec^2 = .922 x 10^{-10} m/sec^2 .

The galactic gravitational torque acting on the Sun-Mercury system can be calculated from (4) as

$$\tau = (3.3011 \times 10^{23}\,\text{kg})\,(0.922 \times 10^{-10}\,\text{m/sec}^2)\,(69.9 \times 10^9\,\text{m}) = 2.125 \times 10^{24}\,\text{N m}$$

which should "factor in" as torque from the galaxy acting on the Sun-Mercury system in the standard calculations for perihelion precession of Mercury. The radius of the arm is taken as the aphelion distance since the greatest galactic torque occurs during the aphelion excursion portion of Mercury's orbit, at the farthest distance from the Sun, and beyond the equipotential point-surface proximate to the Sun. In fact, the time of aphelion when the planet is most influenced by the galaxy is the most effective time period for the galactic torque to advance the precession. The resultant

$$\tau_{Galaxy} = 2.125 \times 10^{24} \text{ N m}$$

will be the torque applied perpendicular to the axis of spin rotation of the Sun-Mercury pair, and so results in a slight increase in angular momentum. As far as can be determined, this galactic influence has not historically been added into the models for perihelion precession of Mercury; logically this effect should be properly quantified and applied against the total precession, just as the other influences from planets and other sources. To continue these calculations using the Newtonian precession relation, the moment of inertia of two bodies (Sun-Mercury pair) spinning around a center of gravity axis, would have a total moment of inertia:

$$\frac{T_p \, T_{spin} \, \tau_{Galaxy}}{4\pi^2} = I_{SM} \qquad (5)$$

or which can also be calculated from the relation

$$I_{SM} = \Sigma \, m_n r^2 \qquad (6)$$

where m is each individual mass times its distance to the center of rotation.
For the Sun-Mercury pair, the distance r for each mass is proportional as

$$r_S = (m/M+m)\, d$$

and $$r_m = (M/M+m)\, d$$

and then using the average distance d of Mercury from the Sun

$$r_s = 3.3011 \times 10^{23}/2 \times 10^{30} = 1.65 \times 10^{-7}\, (57.9 \times 10^9) = 95.5 \times 10^2 \text{ m}$$
$$r_m = 2 \times 10^{30}/2\mathrm{x}10^{30}\, d = 57.9 \times 10^9 \text{ m}$$

We find the moment of inertia calculated sum is then

$$Mr_s^2 = (2\mathrm{x}\ 10^{30})\,(95.5 \times 10^2)^2 = (2 \times 10^{30})(9120 \times 10^4) = 1.824 \times 10^{38} \text{ kg m}^2$$
$$+\, mr_m^2 = (.070)(3.3011 \times 10^{23})(5.79 \times 10^{10})^2 = 7.75 \times 10^{43} \text{ kg m}^2 \qquad (7)$$

where .070 is provided by NASA[5] as the modifier or "Sun factor I_{SM}/MR^2 " (Note that Mercury's effect is too small to change the Sun's much larger contribution).

$$I_{SM} = 7.75 \times 10^{43} \text{ kg m}^2$$

Now, substituting values into equation 5 we obtain the torque derived from this calculated moment of inertia I_{SM} as

$$I_{SM} = \frac{(7.69 \times 10^{6}\,\text{sec})(7.109 \times 10^{11}\,\text{sec})\tau}{4\pi^2} \qquad (8)$$

which leads to

$$\tau_{Obs} = \frac{(7.75 \times 10^{43})\,39.478}{54.67 \times 10^{17}} = \frac{305.97 \times 10^{43}}{54.67 \times 10^{17}} = 5.60 \times 10^{26}\ \text{N m} \qquad (9)$$

This is an average torque for the period of spin T_{spin} as measured precisely with other parameters (from MESSENGER and other spacecraft). This result can therefore be designated the observed torque, τ_{obs}, as a good value derived from recent accurate measurements using the Newtonian expression in (8).

Now this torque can be used to characterize the fraction of the total Mercury perihelion precession as the gravitational influence from the galaxy, which as we have shown, exerts a torque on the Sun-Mercury two-body system, as diagrammed in Figure 5-2 and Fig 5-3. Specifically, the torque is perpendicular to the axis of spin, which is at an angle of tilt to the ecliptic with the galactic plane, and which is the difference between the vertical spin axis of the Sun, 90˚ - 63˚, or 27˚ . The torque is the force from the Galactic center upon the Sun-Mercury pair as it revolves, or "spins" as a precessing top.

Comparing this torque of the galaxy to the total (derived from equation 9)

$$\frac{\tau_{Galaxy}}{\tau_{Observed}} = \frac{2.125 \times 10^{24}}{5.60 \times 10^{26}} = .425 \times 10^{-3} = .00425 \qquad (10)$$

and, by applying this ratio, we can obtain a fraction of the total derived torque as a fraction of the total precession for 100 years, and thus attribute to the galactic gravitational influence:

.00425 x (1.58˚ per 100 years x 3600 arcsec per degree) = 24.17 arcseconds per 100 years

This gives a straightforward derivation of the number of arcseconds of precession due to galactic influence as a fraction of the total Mercury perihelion precession. The significance of this value is that it should have been accounted for in the total as to modeling component contributions (as in Table 1) to the total measured precession of 575.31 arcseconds per century, since all of the measured precession influences have supposedly been accounted for, including 43 arcseconds traditionally "reserved" for general relativity. Now this value of 24.17 arcseconds should be compared to that of the already presented (Section 1) model precession analyses that have refined the estimates and calculations for the contributing components of precession from all the other planets and planetoids in the solar system. Of the total amount observed of 575.31 arc seconds per 100 years, the Brown model [1] calculates 549.6 arcseconds as an analytically exact mass-ring total for the *n-body* perturbations and interactions within the solar system (shown in Table 1). Adding the galactic value of 24.17 arcseconds to that model total of 549.6, the proposed revised total precession model is 573.77, which is very close to the total observed. The difference of 1.54 arcseconds is likely due to some uncertainties or remaining model errors.

The overall result suggests that the "assignment" of 43 arcseconds as a "test" of general relativity may have been premature, and presumptive of exclusively local (i.e., solar-system-**only**) gravitational effects. In 1915, when general relativity was presented, the 43 arcseconds had already been derived by Paul Gerber for the perihelion precession, which he demonstrated rigorously from gravitational potentials [10]. This he presented in his paper "The Spatial and Temporal Propagation of Gravity" in 1902, with his formula for the advance of perihelion of Mercury. Further discussion of that derivation and the subsequent comparisons and applicability to the galactic influence are presented in Section 3.

Section 3 Results of Perihelion Precession of Mercury Model Including Galactic Influence

The previous section proposed the torque for galactic acceleration on the Sun-Mercury pair using the model of precession with the galactic gravity as the typical *mgr sinθ* "downward" force in the exact analogy to the precession of a spinning top. Section 1 reviewed the mass-ring model calculations from Brown (and others) as upwardly revised and updated to 549.4 arcseconds; so the combined galactic and local gravitational modeled influences within this current research add up to almost the measured total of 575.31 arcseconds (573.77), with no "reserved" allocation for the theory of general relativity. This raises the question about the completeness and viability of the existing model of Mercury's perihelion precession component contributions that were fixed since 1947 to be 532 arcseconds per century. Computational research works such as in Roy [18], have produced extensive calculations that show higher Newtonian contributions to the model than the tables that were essentially "locked in" with Clemence. To understand the overall precession more completely, it is insightful to re-examine the original Gerber Equation that showed the anomalous precession from his equation

$$\psi = \frac{24\pi^3 a^2}{T^2_{spin}\, c^2\, (1-\varepsilon^2)} \qquad \textit{(11)}$$

where the advance ψ is calculated from the semi-major axis a, the time of orbit T_{spin}, and the eccentricity of the orbit ε. Other researchers have produced similar formulae that invoke the Lorentz factor, such as D. Burkhard, who examined the contributions from the various gravitational and kinematic sources, and showed the results in [13] as a correction to the gravitational constant G as

$$G\,(1+6v^2/c^2) \qquad \textit{(12)}$$

Burkhard itemized and attributed the perihelion advance to several sources as determined from other experts such as Page and Adams [14]. The Schwarzchild correction was evaluated by Burkhard to be a *negative*, or, **-** v^2/c^2 contribution to perihelion advance. The conclusion from these earlier modeling efforts is that various forces and phenomena could contribute to the precession of perihelion of Mercury, including the Lorentz factor, and other forces that might impose torque. Accordingly, we conclude that the sum of these classical and Lorentz effects may very well be *the source* of the observed perihelion advance. If we look more closely at the Gerber equation and the Lorentz factor we find that his precession uses that same approach, albeit not as obvious, and derives the actual perihelion advance value from gravitational potentials and motion, to arrive at a net Lorentz factor of

$$\text{precession} = v^2_{galactic}/c^2 = 4.789 \times 10^{-7} \text{ rad/revolution}$$

for $v_{galactic}$= velocity of the sun in the galaxy = 211 km/sec, and c = 3.055 x 10^8 m/sec (*c* as derived by Gerber). This links the Lorentz factor to the galactic scale for the precession of the perihelion of Mercury. We have the relation of the sun's motion along its constant velocity

($v_{Galatic}$) galactic orbit as a ratio of the constant velocity of the Sun-Mercury Pair to the speed c of propagation of light and gravity. It is somewhat surprising to see the v^2/c^2 Lorentz factor appear naturally in the physics of galactic orbits as they relate to Mercury's perihelion precession. This suggests very strongly a dependence of the precession advance on the galaxy, and thereby on the galactic orbital motion. Earlier researchers (19th and 20th century) could not have associated these seemingly disparate phenomena, since our perspective from Earth is purely Sun-centric, as the sole determinator of solar system physics. Moreover, there was no knowledge at that time about the constant velocity rotation curves of the stars in galaxies If we equate the Gerber equation to the Lorentz factor:

$$\psi = \frac{24\pi^3 a^2}{T^2_{spin}\, c^2\, (1-\varepsilon^2)} = k\,\frac{v^2_{galactic}}{c^2} = 4.789 \times 10^{-7}\ \text{rad/rev} \qquad (13)$$

the equation shows a^2/T^2 as the familiar Newtonian $x^2/t^2 = v^2$ and some multiplier constant k. The model suggests also that the galaxy and the Sun's orbit are a much stronger influence on our solar system, and specifically that the precession advance is an indicator of that influence, rather than from a mathematical relativity metric model. Mercury's perihelion precession shows there may be sufficient and compelling reason to re-visit the currently accepted model of Mercury's perihelion precession, and its use as an originating or defining "test" of general relativity. In fact, equation 13 implies that the so-called anomalous perihelion precession advance may be *galactic* in origin, and so cannot be a *basis* of the theory of general relativity, as it is widely known and accepted. The original models of Gerber, Burkhard, et al., are more indicative of an occam's razor *simpler* explanation of heretofore unrecognized effects from Newtonian physics, and from galactic influence for the advance of Mercury's perihelion, rather than the complex model of general relativity. Torque from galactic gravity and the equipotential point-surface between the galaxy and the Sun-Mercury pair evidently plays an important role in the perihelion precession. This is shown schematically in Figure 5-3 by analogy to the spinning top. In conjunction with the Diffusion Gravity effects as presented previously in [9], which were proposed as the cause for the constant velocity profiles of the galaxies due to the equipotential surfaces with orbiting stars, we now see that a concomitant gravitational effect is likely imposing a torque and resultant precession on the Sun-Mercury pair. As explained herein and in the referenced DG work, the equipotential surface occurs relatively close to the Sun, about 10^9 meters (million kilometers) from the Sun's surface, which places a substantial portion of the orbit of the solar system planets, including Mercury, beyond the equipotential, or least-energy contour as covered in research paper DG(4): "An Alternative to Dark Matter"[9].

Mercury is affected more than the other planets due to its eccentric elliptical orbit and proximity of the perihelion to the equipotential point-surface. A net increase in torque from the galaxy is imposed at aphelion and averaged over the entirety of Mercury's orbit. This would indicate then, that there is a higher torque during the excursion to the aphelion for the elliptical orbit of Mercury. Bootello stated in his work on Mercury perihelion [20] that "The maximum instantaneous precession comes in the aphelion." The time of aphelion excursion, therefore, acts as the time of maximum sustained torque influence by the galaxy perpendicular to the axis of spin for the Sun-Mercury pair. Considerable evidence has been presented herein to show the influence of external galactic gravity on the perihelion precession of Mercury. This has been presented in conjunction with the planetary mass-ring models that analytically suggest a greater solar system planetary effect than previously calculated and attributed. The mainstream of physics and astronomy has apparently become locked to the planetary precession effect of 532 arcseconds per century since Clemence in 1947, due to the "reserved" status for the 43 arcseconds towards the theory of general relativity. This paper has shown how other effects must be accounted for on at least a par level with general relativity: perhaps GR needs other more conclusive validation than the perihelion advance of Mercury.

Further research will continue with Diffusion Gravity and its component models to show applications to existing physics problems, and to clarify and even suggest refinement to settled science. Subsequent efforts will show further modeling of the Galaxy-Sun equipotential surface on light deflection behavior and further implications for gravity theory at large scales.

Conclusion

The Diffusion Gravity model and related effects have shown how the influence of the galactic gravitation should be included in the modeling of Mercury's perihelion precession. The torque induced by the galaxy was not previously factored into the Mercury precession models as they have evolved since LeVerrier. The presumption is that no separate galactic gravitational factor was included due to Mercury's proximity to the Sun, such that any effect would have been subsumed into the Sun's gravity. However, this research report has proposed that an effect of 24.17 arcseconds per century from the galactic gravity torque is not insignificant as Mercury travels out to its aphelion, with the orbit of Mercury's major axis pointing toward the MWG center. The aphelion portion of the orbit is in the region where Mercury has crossed beyond the gravitational equipotential point surface to the galaxy, and where it is most subject to a torque due to the gravitational acceleration from the galaxy. No previous accounting for the galactic acceleration or torque has been found in the literature; the likelihood is that it has been considered insignificant, or overshadowed by the effect of general relativity. But with the *increasing* estimates indicated from models of precession effects from nearby planets, researchers may be signaling that the precession influences are not completely understood, and that the current model does not lend itself to contributions from other sources such as galactic torque. The consequence of the results presented here is that a prevailing *assumed* model of Mercury's precession as inclusive of *all* the gravitational influences involved up to the galactic level may not be complete or accurate. The findings herein show that when the mass-ring model is refined to include more correct solar system influences, and when galactic gravitational influence is included, the Mercury perihelion precession model will finally accurately account for the observed and measured precession of 575.31 arcseconds per century.

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