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Understanding Precession of the Equinox

Evidence our Sun may be part of a long cycle binary system

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A recent study of the phenomenon known as "Precession of the Equinox" has led researchers to question the extent of lunisolar causation and to propose an alternative solar system model that better fits observed data, and solves a number of current solar system anomalies.

The current (standard) model was theorized before there was any knowledge of the life cycle of stars, or awareness that some stars are non-visible and could thereby exert unseen gravitational influence. The standard model was developed before knowledge of binary prevalence or any understanding of binary star motions. Indeed the idea of a single sun with lunisolar wobble[2] causing precession was originally developed at a time when the Sun had only recently replaced the Earth as the center of the solar system and the Sun was thought to be fixed in space. Consequently, any theory to explain the observed phenomenon of precession of the equinox had to be based solely on movement of the Earth. Although, it has stood for almost 500 years with only minor changes, it fails to answer a number of well-documented solar system anomalies:

- **Angular Momentum:** Why is there an anomalous distribution of angular momentum in the solar system -- why do the Jovian planets have most of the angular momentum when the Sun has most of the mass[3]?
- **Sheer Edge:** Why, just beyond the Kuiper Belt, does our solar system seem to have an unusual sheer edge to it[4]? This is surprising for a single sun system.

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[2] Gravitational forces of the sun and the moon acting on the earth's bulge to cause a torqueing force on the earth, which causes (or partially causes) the axis about which the earth rotates, to slowly shift its direction ("wobble"), which then results in precession of the equinoxes.

[3] Carroll, B. W., and D. A. Ostlie 1998. Pluto, Solar System Debris, and Formation. In *An Introduction to Modern Astrophysics* (J. Berrisford, J. Albanese, Eds.) pp. 890-900. Addison-Wesley Publishing Company, New York.

[4] Allen, R. L., G. M. Bernstein, and R. Malhotra 2001. The Edge of the Solar System. *The AstroPhysical Journal* , **549,** 1241-1244**.**

- **Sidereal vs. Solar Time**: Why is the delta (time difference) between a sidereal and solar day attributed to the curvature of the Earth's orbit (around the Sun), but the delta between a sidereal "year" and solar year attributed to precession?
- **Comet Paths:** Why are many comet paths concentrated in a non-random pattern[5]?
- **Acceleration of Rate of Precession:** Why has the annual precession rate increased over the last 100 years? What would cause it to slow down or speed up?
- **Equinoctial Slippage:** Lunisolar precession theory would cause the seasons to shift were it not for a concurrent slippage of the equinoctial point around the Earth's orbit path (ecliptic). Lunar cycle equations contradict this motion. Why can't it be explained with the current theory?

All of these questions have been answered in different ways; e.g., angular momentum may have disappeared due to an early solar magnetic force which has also disappeared, the sheer edge may be due to a rogue planet that swept by our solar system in fairly recent times but is now gone, etc. We would like to propose a new model, based on a binary system, which provides a single and greatly simplified solution to all these questions.

Introduction

Precession of the Equinox is the observed phenomenon whereby the equinoctial point moves backward through the constellations of the Zodiac at the rate of approximately 50 arc seconds annually.

In examining the mechanics of the motion of precession, one notices:

- The North Celestial Pole on its 23.45 degree incline slowly traces a large circle in the sky, pointing to different pole stars over thousands of years
- An observer on Earth, at the point of equinox changes his orientation to inertial space at the current rate of about 50.29 arc seconds annually. At this rate the entire precession cycle time required to traverse all twelve constellations of the ancient Zodiac, is 25,770 years, although evidence indicates it is declining.

Some years ago it was observed that if the Earth's axis did wobble due to lunisolar forces it would slowly change the seasons within the calendar. For example, in the Northern Hemisphere it would eventually become winter in July and August, and summer in January and February. This is because the seasons are indirectly caused by axial tilt (summer when that hemisphere leans closer to Earth, and winter when it leans away). Therefore, if the axis were tilted for any other reason, such as lunisolar wobble, it would cause a seasonal shift. Noticing that the seasons have not been changing (the equinox still falls at the same time in the calendar each year after adjusting for leap movements synchronizing the Earth's rotation with the calendar), lunisolar precession theory requires that the equinoctial point itself must

[5] Matese, J. J., P. G. Whitman, and D. P. Whitmire 1999. Cometary Evidence of a Massive Body in the Outer Oort Cloud. *Icarus*, **141**, 354-356.

precess around the Earth's orbit path around the Sun. This theoretical solution avoids the occurrence of seasonal shift that the original theory implied, but causes other problems because it implies the Earth does not complete a 360-degree motion around the Sun equinox to equinox.

To visualize the movement, if the Earth's path around the Sun were made of 24,000 fixed positions numbered 1 through 24,000, then in year one the vernal equinox would occur in position 24,000, the next year it would occur in position 23,999, the next year it would occur in position 23,998, etc. slipping one position per year. At the end of 24,000 years, the vernal equinox would have regressed all the way around the Sun to occur once again at its original starting position.

Under lunisolar precession theory it is thought that the Sun and Moon's gravitational influence acting upon the Earth's bulge causes the Earth's axial gyration that in turn results in the Earth's changing orientation to inertial space, observed as Precession of the Equinox. The theorized annual axial tilt of about 50 arc seconds per year is thought to cause the equinox to occur slightly earlier in the Earth's orbit path around the Sun, resulting in an orbit geometry of 359 degrees 59' and 10" equinox to equinox. While this proposed solution works mathematically and avoids the problem of seasonal shift it does not agree with lunar cycles which indicate the Earth does indeed travel 360 degrees around the Sun in an equinoctial year. This can be proved by carefully examining lunar cycle equations and eclipse predictions. Indeed, eclipses have been accurately predicted for many years, long before the latest nuances of lunisolar precession theory required the Earth to have a like equinox approximately 22,000 miles short of a complete revolution around the Sun.

The authors of this paper would like to put forth a new model that more simply explains precession and current solar system mechanics. In the new model, our Sun curves through space. This motion of the Sun causes an apparent wobble to an observer on Earth, thus producing a precession of the equinox without creating any seasonal shifting issues, and without requiring any movement of the equinoctial points on the Earth's orbit path, or new interpretations of equinoctial years, thereby allowing the equinoctial year to which we adjust UTC (Coordinated Universal Time) to reflect a 360 degree motion of the earth around the Sun.

New Solar System Model

According to Newtonian physics the only force that could cause the Sun to display such a curve would be another large mass to which the Sun is gravitationally bound, which is by definition a binary star system. In this model, the Copernican Third Motion of the Earth[6]

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[6] The First Motion of the Earth is its daily rotation about its axis. The Second Motion is the yearly revolution of the earth around the sun. The Third Motion of the Earth is the apparent "wobble". An extension of the earth's rotation axis out into space traces a circle that takes around 24,000 years to complete (current astronomers believe it takes 25,770 years to complete). Another way of saying this is that the earth's axis does a 360-degree retrograde motion around the perpendicular to the ecliptic. The issue is whether luni-solar forces cause all or

would be caused primarily by the Sun's curved path in a binary orbit, rather than by lunisolar forces.

Visually, the new model is one of a rotating object (the Earth) in an almost circular orbit around a second object (the Sun), which in turn is an elliptical orbit around a third object (the binary center of mass of the Sun and a companion star). If the Earth's orbit and the Sun's orbit are given, then the equations of classical mechanics predict that the axis of rotation of the first rotating object (the Earth) will precess (relative to inertial space) at a rate dictated by the Sun's path around its binary center of mass. To an observer on Earth the first object's axis will appear to precess by 360 degrees in the same amount of time it takes the second object to undergo a complete orbit around the third object, independent of the masses and distances involved. In this model the Earth's axis does not really wobble, or change relative to the Sun, but it produces the same observable now attributed to lunisolar precession -- a precession of the equinox. From this we conclude that acceleration (and eventual deceleration) of the rate of precession will depend on the eccentricity of the binary orbit. From Kepler's Third Law, we know that all orbits are elliptical and objects leaving apoapsis accelerate to periapsis and then decelerate leaving periapsis. Consequently, we now have an explanation for why the precession rate is accelerating, and we also have a logical reason for why the rate cannot be extrapolated *ad infinitum*. Indeed, the most significant clue that precession represents a binary orbit is its universally recognized but until now, unexplained acceleration.

Beyond explaining why precession now seems to accelerate, a binary star model also better explains other observed phenomena. For example, it explains the unusual distribution of angular momentum, a fact that has long perplexed scientists developing solar system formation theories[7] (Figs. 1 and 2).

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most of the Third Motion observable (an approximate 50 arc second annual change in the earth's orientation), or if the cause is primarily due to our solar system revolving around the center of mass between our solar system and a binary companion.

[7] Carroll, B. W., and D. A. Ostlie 1998. Pluto, Solar System Debris, and Formation. In *An Introduction to Modern Astrophysics* (J. Berrisford, J. Albanese, Eds.) pp. 890-900. Addison-Wesley Publishing Company, New York.

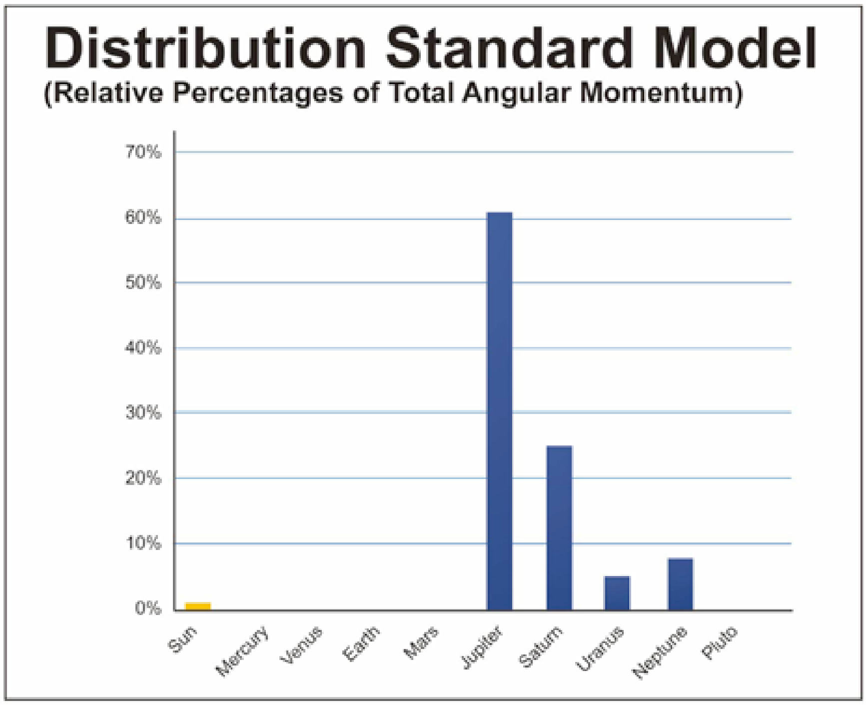

Fig. 1 Angular momentum distribution of our solar system (standard model). Note that most is in the Jovian planets. The Sun has less than 1%.

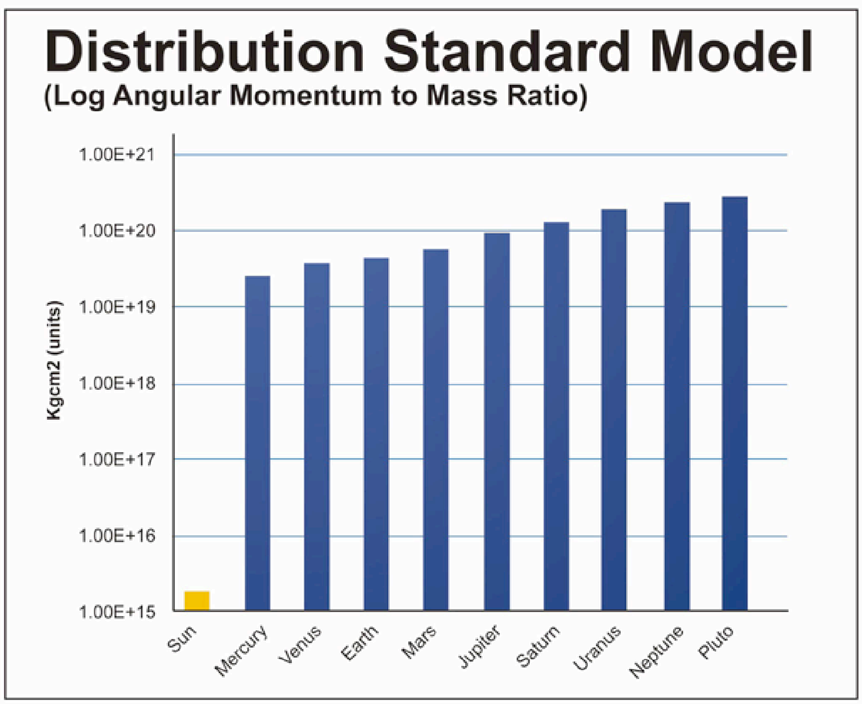

Fig. 2 Log angular momentum to mass ratio of our solar system (standard model).

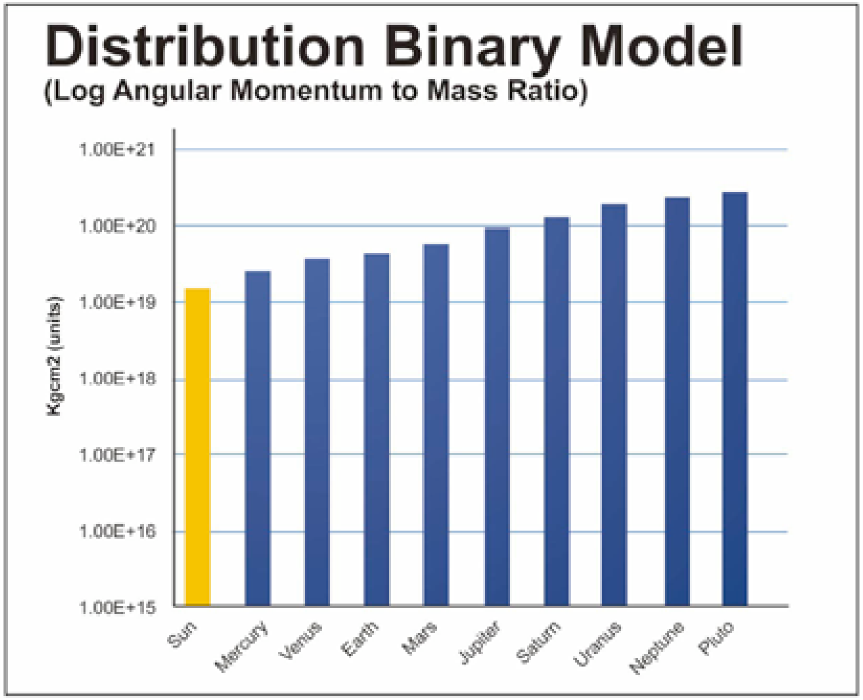

Fig. 3 Binary model; log angular distribution to mass ratio assuming the solar system is in a binary orbit with an object 8% of the Sun's mass at a distance of 1000 A.U.

In a binary model the Sun's angular momentum is not just in it's spin axis but also in its movement through space (Fig. 3). The binary model might also help explain the non-random path of certain long-cycle comets[8], without requiring the existence of a tenth planet or huge quantities of dark matter within the solar system. Also, recent finding that our solar system has a sheer edge[9] is now readily explainable (Fig. 4), indeed expected in a binary system.

[8] Svitil, K. A. 2001. One of Our Planets Is Missing. *Discover Magazine*, October 2001.
[9] Allen, R. L., G. M. Bernstein, and R. Malhotra 2001. The Edge of the Solar System. *The AstroPhysical Journal*, 549, 1241-1244.

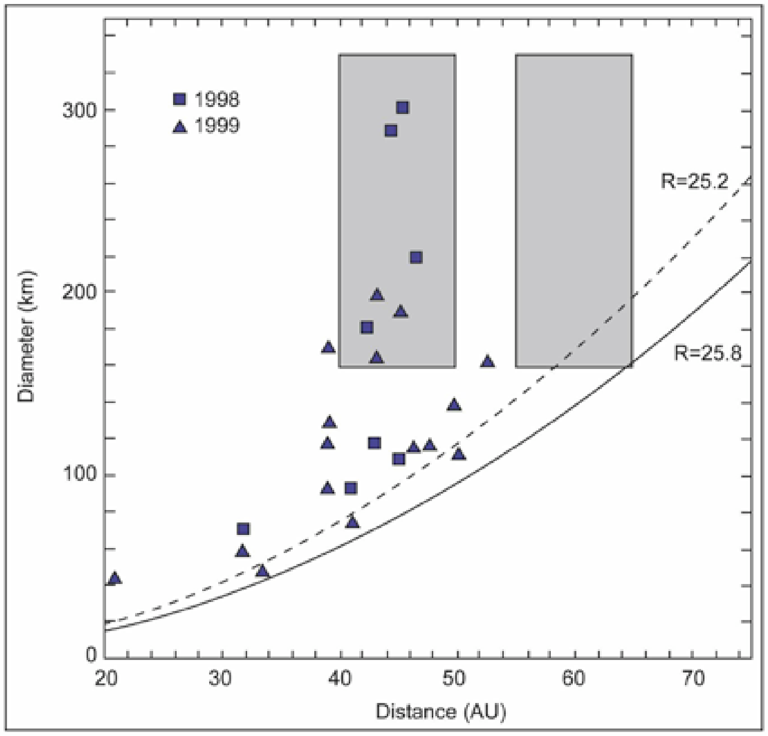

Fig. 4 Raw data showing that traceable objects of any size seem to end abruptly at about 53 A.U.

In this paper we argue that the following statements are consistent with observed data:

- Our Sun is probably part of a binary system, gravitationally bound to another star, likely a dark companion, which is estimated to be 1000 to 4,000 A.U. distant.
- The Sun's path currently curves at about 50.29 arc seconds per year (one degree every 71.5 years) around its apparent binary center of mass, and the Sun is now accelerating, at the approximate rate of 0.000349 (arc seconds per year) per year.
- The apparent binary orbit plane is expected to be the same as, or within a few degrees of, the invariable plane (the angular momentum plane of the solar system).
- The Earth's changing orientation to inertial space (as required by any binary orbit of our Sun), can be seen as Precession of the Equinox. This fact has been masked by the lunisolar explanation of precession.
- The current apparent binary orbit speed is one cycle every 25,770 years, but due to acceleration (as we move away from apoapsis), is expected to average approximately 24,000 years per complete orbit.
- Models based on Kepler's Law for elliptical orbits appear to predict the changing precession rate better than current wobble theory.
- The third motion of the Earth (wobble) does exist as an observable phenomenon, but not as axial movement relative to the Sun. Independent axial movement is probably limited to nutational nodding and Chandler wobble.

Occam's Razor requires consideration of the binary star concept unless physical evidence is available that is clearly inconsistent with the model.

Evidence in Support of the New Model

Lunisolar wobble required the pole to move by about one degree every 71.5 years based on the current precession rate, hence the pole should have moved about 6 degrees since the Gregorian Calendar change (420 years ago), thereby causing the equinox to drift about 5.9 days. This has not happened; the equinox is stable in time after making leap adjustments. Therefore, it was theorized that the equinox must slip about 50 arc seconds per year along the ecliptic and the equinoctial year is only 359 degrees 59' and 10" not 360 degrees. Although this solves the seasonal slippage problem it does not agree with lunar cycle data.

Astronomers sometimes use a 360 degree geometry to describe the Earth's motion around the Sun, and they sometimes use 359 degrees 59' and 10". The 360 degree motion in an equinoctial year works for calculating the Moon's position, eclipses, Saro's cycles and the like, but the lunisolar model of 359 degrees 59' 10" in an equinoctial year works best for calculating the position of stars, quasars, and other extra solar system phenomena. In other words the lunisolar model works fine relative to the fixed stars but the other works well for purposes where the position of the fixed stars do not matter. Although both are useful for various calculation purposes, there can be only one physical reality and therefore only one geometry. The only model that works for both is one in which the entire solar system is curving through space at the rate of about 50 arc seconds per year. In this way, the Moon can travel with the Earth, the Earth and Moon and Sun can keep the integrity of their mathematical relationships, and the Earth can still appear to precess relative to the fixed stars.

If one assumes the cause of the equinoctial point slipping backward around the Earth's orbit path at a rate of 50.29 arc seconds per year is due simply to the Earth wobbling at this exact same rate, then one must look deeper and realize that this implies the barycenter (center of mass) of the Earth stays the same with each 360 degree motion of the Earth around the Sun, and the reason the equinox happens earlier and earlier is because the Earth's axial shift has caused the equinoctial position to appear earlier and earlier. This would mean that the center of the Earth travels exactly 360 degrees, or once around the Sun each equinoctial year. Because the equinoctial year is now presumed to be less than 360 degrees (by the amount of precession) and only the sidereal year is presumed to represent a complete 360 degree motion of the Earth around the Sun (supposedly this is why we line up with the same stars in a sidereal year), then the barycenter to barycenter motion of the sidereal year would have to be more than 360 degrees. If the slippage is not due solely to precession then why is the time delta between an equinoctial year and sidereal year attributed to precession, and why does the barycenter of the Earth slip at the same rate as precession?

If the delta between a sidereal day and a solar day is compensation for the curvature of an orbit (per textbooks), so too is the delta of a sidereal year vs. a solar year compensation for the hypothesized orbital motion of our solar system (Fig. 5). The former is the orbit of the Earth around the Sun, the latter, the Sun around its binary center of mass. Just as the Earth's delta between a sidereal day and a solar day times the Earth's orbital period is equivalent to the daily rate of change around the Sun (4 minutes x 365 = 1 day), so too should the Earth's delta between a sidereal year and a solar year times the Sun's orbital period be equal to the annual rate of change around its apparent binary center of mass (20 minutes x 25,770 years = 1 year).

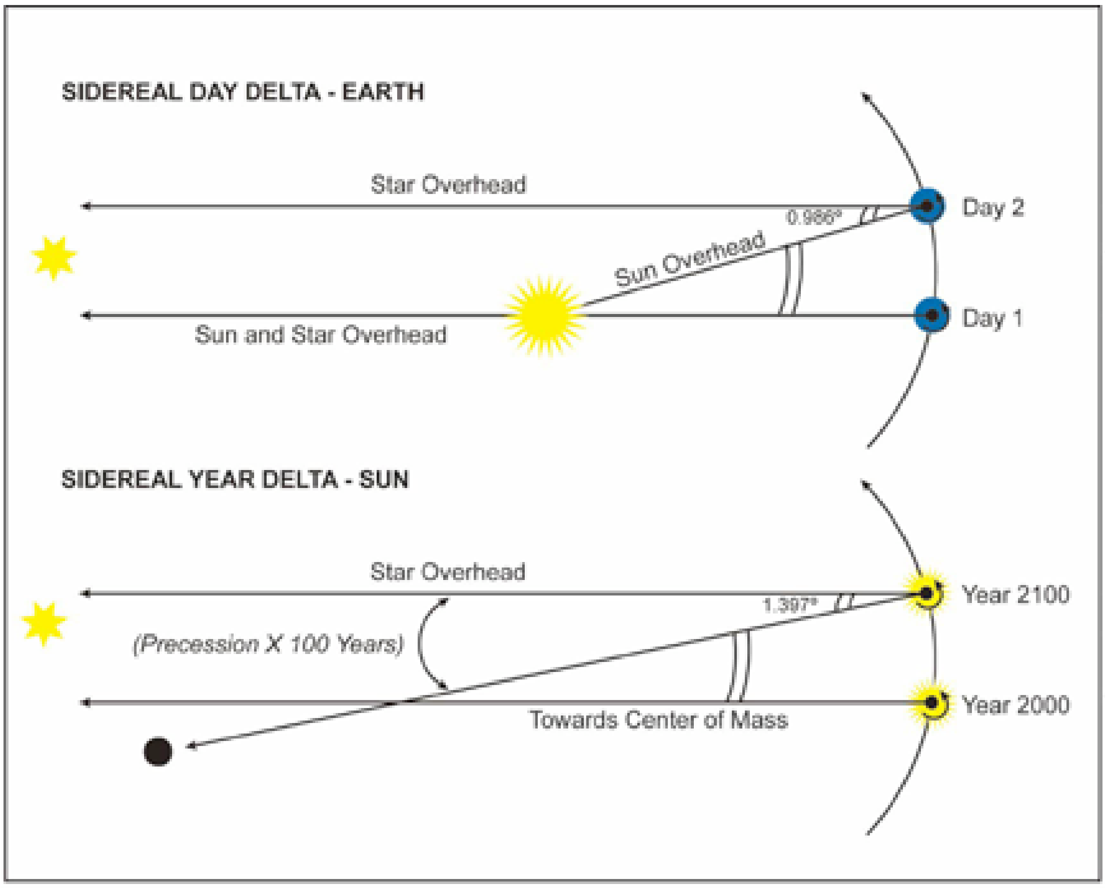

Fig. 5 Sidereal day delta compared to sidereal year delta. Note that both deltas account for orbits.

A simple way to produce all the same observables as lunisolar precession theory - a precessing equinox and changing pole star without any motions that are unexplained by classical mechanics - is a Sun curving through space in a binary system. In this model, planets gravitationally bound to stars curving through space, experience a changing orientation to inertial space, commensurate with the stars rate of motion, unless offset or exaggerated by other local forces.

Proposed Binary Model

While many potential binary system configurations are possible, we have narrowed the range by making three assumptions:

1. The orbital period for the Sun around the gravitational center of the binary system is approximately 26,000 years (rounding from the currently calculated precession cycle of 25,770 years) if it is in a circular orbit.
2. The actual orbital period will be greater or lesser than 26,000 years if the Sun's orbit is non-circular, which is most likely. The degree to which the actual orbit is greater or lesser than the currently perceived period depends upon the eccentricity and the position of the Sun on that orbit relative to apoapsis or periapsis (this is because the Sun would be accelerating as it departs from apoapsis and decelerating as it departs from periapsis). Thus, if the Sun is closer to departing from apoapsis, the actual orbital cycle would be less than approximately 26,000 years, since that figure would have been derived from observation during the Sun's slowest passage along its orbital path.
3. Because the calculated change in the precession cycle has increased by 0.034" over the last century, the Sun and solar system are assumed to be increasing in speed as the Sun accelerates away from apoapsis. So the annual increase in precession is attributed primarily to the increasing angular velocity of the Sun's elliptical orbit around its binary companion.

With these assumptions, we tested orbital parameters at 1000 year intervals ranging from 24,000 years to 28,000 years, and for each orbital period, tested for assumed apoapsis at 500-year intervals into the past from 2000 A.D. A very close fit was found between observed data and the orbital model assuming an orbital period of 24,000 years and with apoapsis 1,500 years in the past (500 AD). Indeed, this is the orbit pattern one would derive if you connect the dots between Newcomb's calculations for 1900 and the latest precession rates in the Astronomical Almanac[10] for 2002 (see trend line in Fig. 6).

[10] 1900-1980 The American Ephemeris and Nautical Almanac; 1981-2002 The Astronomical Almanac. United States Naval Observatory.

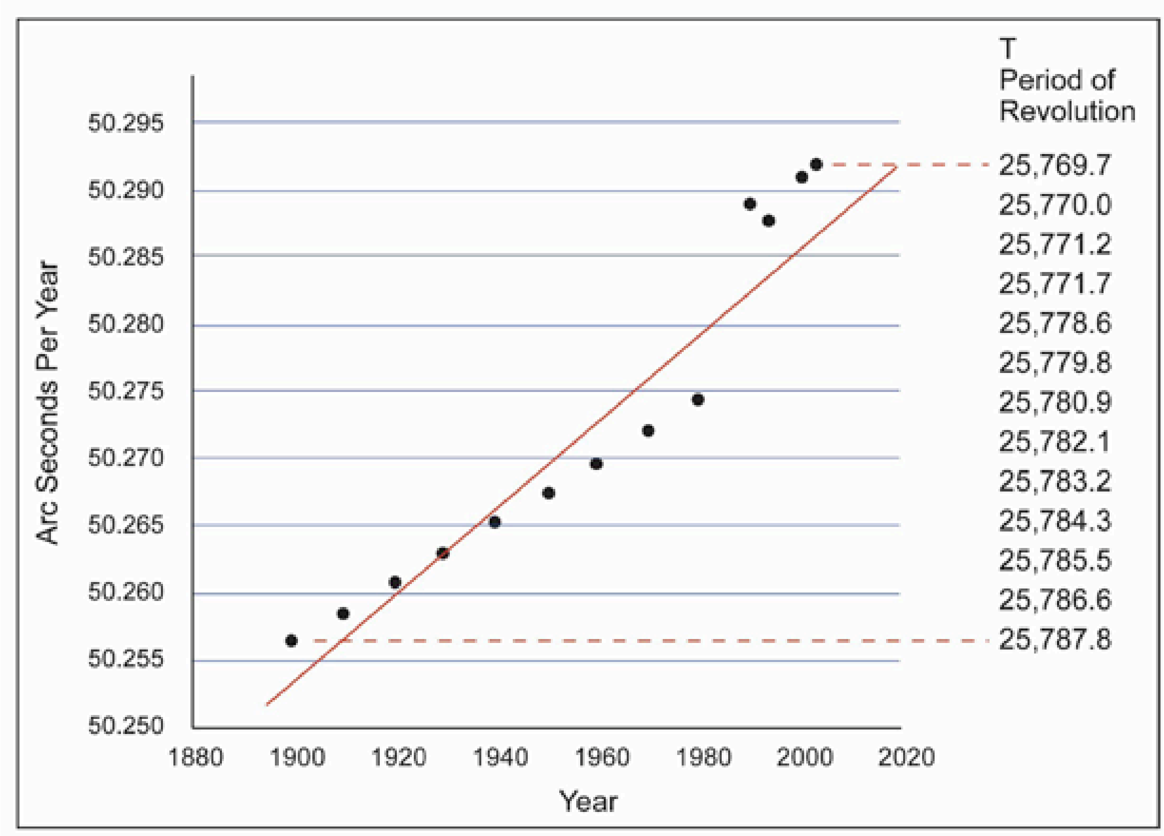

Fig. 6 Current trends in annual precession rate.

Using the current Constant of Precession (epoch 2000) of 50.290966"/year the calculated period of revolution comes to 25,770.035 years. Calculating the annual change in precession of an orbit that has a period of revolution of 24,000 years, and at a point 1500 years past its apoapsis, that has an angular velocity of 50.290966 arc sec per year, returns an eccentricity of about 0.038. If we are moving away from apoapsis as proposed, our orbital velocity should be increasing – we are speeding up with respect to the binary center of mass – which means that the period of revolution perceived over astronomically short periods of time is decreasing; this in turn requires the constant of precession to increase as time goes by. Currently the yearly change is about 0.000349"/year, but that will continue to increase slowly for about 10,500 years, until the Sun reaches periapsis (12,000 years ascending, 12,000 years descending = 24,000 year total orbital period). In terms of the calculated period of revolution, that corresponds to a yearly decrease of 0.178 years, ignoring the short cyclic influences of nutation, etc. This roughly corresponds with the changes in precession calculations that have been reported in the literature.

Therefore, we make the following estimates for the years 2005, 2010, and 2100:

Year	2000	2005	2010	2100
Precession Rate (seconds/year)	50.290966	50.292711	50.294456	50.325866
Period of Revolution (years)	25770.035	25769.142	25768.247	25752.164

In 1900, Simon Newcomb offered a formula for precession:

50.2564" + 0.000222 * (year – 1900)

We offer the following alternative formula based on the proposed binary system model:

50.290966" + 0.000349 * (year – 2000)

Observed precession has changed by 0.0337 from 1900 to 2000, for a yearly change of 0.000337" (Fig. 6). This precession delta is approximately ten times closer to our proposed annual precession of 0.000349" than Newcomb's annual precession adjustment of 0.000222".

Minimum precession is about 1 degree every 72 years when the Sun is at apoapsis, and the maximum precession is about one degree every 60 years when the Sun is near periapsis. The Earth will average about one degree of precession per 66.6 years over the 24,000 year cycle.

In a binary system, the celestial bodies revolve around each other. More precisely, both stars orbit around a center of mass, which corresponds to one of two focal points in each orbit (focus). In our proposed Binary Model, our Sun and its so-far unidentified companion rotate around each other every 24,000 years, and thus around their combined Center of Mass every 24,000 years.

Kepler's law for circular orbits for the proposed system:

$$N^2 * D^3 = G * (M_{sun} + M_{companion})$$

where $N = 2\pi / T$, G is the gravitational constant ($= 6.672 * 10^{-11}\ m^3 kg^{-1} sec^{-2}$), T is the period of revolution in seconds, D is the average distance between Sun and it companion in meters, $M_{sun} = 1.9891 * 10^{30}$ kg. If $M_{companion} = 0.08\ M_{sun}$ then D = 0.01344 light years or 853.8 A.U; if $M_{companion} = 6\ M_{sun}$ then D = 0.02384 light years or 1514.6 A.U. Note that these represent average distances. At the furthermost point in their orbits (apoapsis), they may be much further apart, depending on the eccentricity of their elliptical orbits, perhaps by a factor of as much as 20 times the average distance, based on observed data of other binary star systems. Also note that relative velocity of a celestial body is slowest at its apoapsis, and fastest at its periapsis (point closest to its focus). Thus with an average period of 24,000 years, the measured relative velocity at apoapsis may correspond to 26,000 years and to 23,000 years or less at periapsis.

Summary

Table 1 compares our proposed binary model to the current solar system model.

Table 1 Binary vs. standard model comparisons

Proposed Binary Model	Current Model
Majority of star systems are binary[11]	Minority of star systems
Curved path of Sun through space explains the Earth's changing orientation to inertial space	No significant curvature in Sun's path requires E changing orientation to inertial space to be expla unproven complex theories (Occam's Razor app
Sidereal and solar year delta are natural result of binary orbit	Sidereal and solar year delta explanation conflic sidereal and solar day explanations
Angular momentum balances with dual star	Peculiar distribution of angular momentum amor planets still unexplained
Sheer edge of solar system expected, since mass is separated between companion stars	Observed sheer edge of solar system is unexpe and not easily explained
Precession accelerates past apoapsis	Lunisolar precession should be constant but in f precession calculations are continually altered
Precession conforms to elliptical equation	Precession should be relatively constant but is r
Curved path of Sun explains apparent wobble without causing rotational time problems, or requiring equinoctial slippage	Rotational wobble creates time paradox that req unexplained concurrent motions
Some long cycle comet paths should be channeled by dual mass	Comet paths should be random but are not[12]

Since the majority of stars form in multiple system relationships, it is not unlikely that our Sun is also in a binary or multiple system relationship. The angular momentum distribution of our solar system is a problem that has frustrated attempts at developing a reasonable theory of how the solar system developed. This problem disappears using a binary model as the Sun's angular momentum is now proportional to its mass, along with the other planets. The gravitational effect of a binary companion could easily cause a non-random distribution of long-range comets.

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[11] Richichi, A. and C. Leinert 2000, Binary Stars and the VLTI Research Prospects, *Proc. SPIE* **4006**, 289-298.

[12] Murray, J. B. 1999. Arguments for the Presence of a Distant Large Undiscovered Solar System Planet. *Monthly Notices of the Royal Astronomical Society* 309, 31-34.

In a single sun system, an abrupt edge like the one just beyond our Kuiper Belt would not be expected. In a binary system a sheer edge would be normal and expected. The current model of precession (spinning top slowing down) would mean a very different value of precession 100,000 years ago. In a binary relationship model, precession 100,000 years ago would be about the same as today because it would be cyclical. This is in keeping with the accepted Milankovitch (Precession) Cycle[13].

The binary system is a better model for explaining the mechanics of our solar system and the motions of the Earth. Unlike lunisolar theory the new model does not require concurrent slippage of the equinoctial point in order make precession work.

- An equinoctial year, tropical year and solar year all represent a 360 degree motion of the Earth around the Sun
- The equinox occurs at the same place in the Earth's orbit path each year (relative to the Sun)
- The ecliptic plane and celestial equator are fixed at the point of the equinox
- Our calendar year represents a complete orbit of the Earth around the Sun.

The binary model does not require complex equations to predict precession:

- The Earth's changing orientation to inertial space is only minimally affected by the planets, tides, geo-physical movements, asteroids, etc. The principal source of movement is caused by the binary motion and the Sun curving through space, slowly changing the Earth's orientation.
- Precession's annual increase is attributed primarily to the increasing angular velocity (curved motion) of the Sun's elliptical orbit around its binary.
- Precession rate waxes and wanes with the elliptical orbit of our Sun around its binary center of mass. In this model precession is cyclical and the current accelerating precession trend, expected in elliptical orbit, is now understandable.

The new model does not require one cause to be given to explain the difference between a solar and sidereal day (orbital curvature) and another completely different principal to be given to explain the difference between a solar and sidereal year:

- The sidereal year is 360 degrees plus precession due to the Sun's motion
- The sidereal year realigns with the same stars of a year ago, 20 minutes later than an equinoctial year (50.29 arc seconds), only because the solar system has curved through space by 50.29 arc seconds, along it's binary orbit.
- Just like the delta between a sidereal day and a solar day, the delta between a sidereal year and solar year is also due to curvature of an orbit. The day delta is due to curvature of the Earth around the Sun. The year delta is due to curvature of the Sun around its binary center of mass.

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[13] Berger, A. L. 1977, Support for the Astronomical Theory of Climatic Change, *Nature*, 269, 44-45.

It is our conclusion that the binary model is a simpler, more logical model for explaining the mechanics of our solar system and the motions of the Earth.