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Apparent Relations Between Planetary Spin, Orbit, and Solar Differential Rotation[1]

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Abstract

A correlation is found between changes in Earth's length of day [LOD] and the spatio–temporal disposition of the planetary masses in the solar system, characterised by the *z* axis displacement of the centre of mass of the solar system [CMSS] with respect to the solar equatorial plane smoothed over a bi-decadal period. To test whether this apparent relation is coincidental, other planetary axial rotation rates and orbital periods are compared, and spin–orbit relations are found. Earth's axial angular momentum moment of inertia, and internal dynamics are considered in relation to the temporal displacement between the potential stimulus and the terrestrial response. The differential rotation rate of the Sun is considered in relation to the rotational and orbital periods of the Earth–Moon system and Venus and Mercury, and harmonic ratios are found. These suggest a physical coupling between the bodies of an as yet undetermined nature. Additional evidence for a resonant coupling is found in the relation of total solar irradiance (TSI) and galactic cosmic ray (GCR) measurements to the resonant harmonic periods discovered.

Keywords: Length of day (LOD) changes; solar system center of mass displacement; Sun rotation; rotational and orbital period relations; physical coupling planets and Earth-Moon system.

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1. Introduction

Earth's length of day [LOD] varies cyclically at various timescales. These small variations in the order of a millisecond are believed to be related to exchanges of angular momentum between the atmosphere and Earth, the displacement of oceans away from and toward the equator (Axel-Mörner, 2013), and the changing Earth–Moon distance. On longer timescales, the variation is considerably larger, on the order of several milliseconds, and these variations take place over several decades or more. It is thought by Gross (2007) that the cause of the longer-term variation is due to shifts in the circulation of convecting molten fluid in Earth's fluid outer core. If this is the case, it begs the question: what is the cause of those shifts?

2. Data and method

LOD Data from (Gross, 2007) is plotted against the *z* axis motion of the centre of mass of the solar system [CMSS] with respect to the solar equatorial plane using the NASA/JPL DE14

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ephemeris. This curve is smoothed at around the period of two Jupiter orbits (24 yr) in order to mimic the damping effect of the changes of motion in a viscous fluid (like that in Earth's interior). The curve is shifted temporally to obtain the best fit to the LOD curve, and the period of the lag is found to be 30 yr (Fig. 1).

3. Result

The result is suggestive of a dynamic coupling between changes in the disposition of solar system masses, predominantly the gas giant planets. These planets possess an overwhelming percentage of the mass in the solar system outside the Sun, and also possess a high proportion of the entire system's angular momentum. Resonant coupling between Jupiter–Saturn and the inner planets in the early history of the solar system had significant impact on the planets' eventual orbits (Agnor and Lin, 2011).

If the planets are able to transfer orbital angular momentum to the axial angular momentum of neighbour planets, we might expect to see evidence of this in the axial rotation periods of smaller planets relative to the orbital periods of larger neighbours. To investigate this possibility, the rotation rates and orbital periods of several planets are compared with the rotation rate and orbital period of Jupiter.

Figure 1: z-axis motion of the CMSS relative to the solar equatorial lane plotted against LOD (Gross, 2010) 1840–2005.

4. Inner planet synchrony

It is observed that the ratio of Venus and Earth's rotation rates divided by their orbital periods is 1.08 : 0.0027. This is equivalent to the ratio 400 : 1. During their respective synodic periods with Jupiter, Venus completes 1.03 rotations and Earth completes 398.88. This is close to a 400 : 1 ratio. Looking at Earth and Mars' axial rotation and orbital periods, we observe that:

– Earth 1/365.256 = 0.0027.

– Mars 1.0275/686.98 = 0.0015.

The ratio of these numbers is 0.0027 : 0.0015 = 1 : 0.546.

– Earth completes 1.092 orbits between synodic conjunctions with Jupiter, while

– Mars completes 1.18844.

The ratio of these numbers is 1.092 : 1.18844 = 1 : 1.088.

– The ratio of the ratios is 2 : 1 (99.6 %).

The reason for the 2 : 1 ratio becomes apparent when we observe that the Mars–Jupiter synodic conjunction period is in a 2 : 1 ratio with the Earth–Jupiter synodic period (97.7 %).

Once again there appears to be a quantisation of spin and orbit into simple ratios involving the largest planet in the system, the Sun and the inner planets between them.

As a further test, it is observed that:

– The Neptune rotation rate divided by the Uranus rotation rate = 1.0701427.

– The Jupiter–Uranus synodic period divided by the Jupiter–Neptune synodic period is 1.0805873.

– 1.0805873/1.0701427 = 1.00976 (99.03 %).

These observations strongly suggest that Jupiter affects the rotation rates and orbital periods of both Earth–Venus and Earth–Mars. In combination with the other gas giant planets, the combined effect produces the curve seen in Fig. 1, notwithstanding the much smaller contributions of the inner planets. Having established that the spin and orbit of the four inner planets relates to Jupiter's orbital period, greater weight can be given to the possibility that Earth's decadal LOD anomalies may have a celestial cause in planetary motion.

4.1 Inertia and fluid damping

Earth's high axial rotation rate, along with its density, cause Earth to have a high angular momentum which resists changes in angular velocity. A theory developed from the observation of magnetic anomalies on Earth's surface suggests that columnar vortices surround Earth's core which produce flows in the viscous mantle and liquid outer core (Lister, 2008). Modelling such fluid dynamics as these is beyond the scope of this paper, but the temporal stability of these magnetic structures suggests that small, externally applied forces will take a considerable period of time to produce a terrestrial response. The effect of these stabilising structures will produce a terrestrial response which can be characterised as a fluid-damped oscillation. The signature of Jupiter's motion above and below the solar equatorial plane over the course of its orbital period of around 11.86 yr is not seen in LOD data.

If the correlation in Fig. 1 is indicative of a physically coupled relationship, it is then evident that the damping of the oscillation is sufficient to smooth out both the Jupiter orbital period and the Jupiter–Saturn conjunction period of 19.86 yr. It is found that the best fit of the celestial data to the LOD variation magnitude is at two Jupiter orbital periods. This matches well with the temporal lag between the celestial data and the LOD data of around 30 yr. The peak-to-peak oscillation period seen in the celestial data indicates a cycle of around 180 yr. This period was found by José (1965). The lag of the terrestrial response appears to be at around 1/6 of this periodic length. This is around the half period of the major oceanic oscillations observed on Earth (Axel-Mörner, 2013). These oceanic oscillations are in phase with the changes in LOD and the lagged celestial data.

4.2 Differential solar rotation rates relating to planetary motion

The periods in which the Sun's visible surface makes one sidereal rotation vary with latitude. Near the equator the period is near 24.47 days. This period is known to vary on a period relating to the orbits of Jupiter, Earth and Venus (Wilson et al., 2008). Near the poles, the period of rotation is around 35 days. These periods relate to variation in total solar irradiance (TSI) (Scafetta and Willson, 2013).

Considering the relationships between the spin and orbit of Mercury (three rotations per two orbits of the Sun) and Venus (three rotations per two Earth orbits and two rotations per synodic conjunction with Earth), a test is made to see if similarly simple harmonic relations exist between these planets and the Sun's differential rates of rotation.

Firstly, it is noted that the lengths of day of Mercury and Venus form a ratio that is close to 2 : 3 ratio, and that the equatorial and polar rotation rates of the solar surface also form a ratio close to

2 : 3.

Mercury makes one sidereal rotation per 2/3 (240 degrees) of orbit in 58.65 days. A point on the Sun rotating at a rate which brought it directly between Mercury and the solar core in the same period would have a sidereal period of 35 days (184 days making one full rotation plus 2/3 of a rotation, i.e. 240 degrees). Mercury makes two sidereal rotations per 480 degrees (1, 1/3 orbits) in 117.3 days. A point on the Sun rotating at a rate which brought it directly between Mercury and the solar core in the same period would have a sidereal period of 27.06 days, making four sidereal rotations plus 1/3 of a rotation (120 degrees). It is noted that this is close to the Carrington period.

In summary, it can be seen that Mercury has a 3 : 2 spin-orbit ratio which is in 3 : 5 spin–spin and 2 : 5 orbit–spin ratios with a solar rotation period of 35.18 days, and is in 6 : 13 spin-spin 4 : 13 orbit-spin ratios with a solar rotation period of 27.06 days.

Two Mercury rotations occur in 117.3 days. In a similar period of 116.8 days, Venus makes a full rotation with respect to the Sun, while orbiting 180 plus 6.18 degrees (0.52 orbits) and rotating (retrograde) 180 minus 6.18 degrees in the sidereal frame. A point near the solar equator rotating at a rate which brought it directly between Venus and the solar core in the same period after 4.52 rotations would have a sidereal solar rotation period of 25.84 days.

Points near the solar poles rotating at a rate which brought them directly between Venus and the solar core in the same period after 3.52 rotations would have a sidereal period of 33.2 days. It is noted that the average of these two solar rotation periods is 29.51 days, which is close to the period of rotation of the Earth–Moon system with respect to the Sun (29.53 days). A solar rotation period of 29.32 days is found to be in a 1 : 3 ratio with a period of 87.97 days; the Mercury orbital period, and 1 : 4 ratio with a period of 117.3 days; the period of two Mercury rotations and close to one Venusian day.

The relationship of Venus with the Earth–Moon system is more clearly seen by considering that the period of a Venus rotation with respect to the Sun of 116.8 days is exactly 1/5 of the Earth–Venus orbital synodic conjunction period of 1.6 yr. Five synodic conjunctions occur over a period of 8 Earth years as Venus makes 13 orbits, bringing the two planets back to within two degrees of their original longitude. At the end of this period, the various solar periods calculated in the preceding observations make whole numbers of sidereal rotations: 113×25.84 days, 108×27.06 days, 88×33.18 days, and 83 × 35.18 days.

5. Discussion

A physical mechanism linking solar rotation rates with planetary rotation and orbital periods may involve resonance if the ratios are 1 : 2 or ratios such as 1 : 4, 2 : 3, 2 : 5, 1 : 3, 3 : 5, 5 : 8 etc. (Agnor and Lin, 2011). As a first approximate observation, the rotation rates of the solar equator and solar poles are in a 2 : 3 ratio.

The average of the periods relating to Venus, 25.84 and 33.2 days, is 29.51 days. This is very close to the Earth– Moon system rotation period relative to the Sun (29.53 days). The ratio of 25.84 to 29.51 is 7 : 8. The ratio of 29.51 to 33.2 is 8 : 9.

The ratio of the periods relating to Mercury, 27.06 and 35.184, is 20 : 26. The average of the periods is 31.12 days. The ratio of 27.06 to 31.12 is 20 : 23. The ratio of 31.12 to 35.184 is 23 : 26. There are 12 Mercury orbits in 26 periods of 27.06 days each.

These observations indicate that in addition to resonance between the orbital and rotation periods between individual planets and the Sun, we may hypothesise that there is also resonance between the solar rotation rates at various latitudes reinforcing the effect. If there is an effect of this resonance on solar activity levels, we would expect to see evidence of it in accurate TSI measurement, such as the strong peaks seen at periods around 25–27 days and 33–35 days in spectrographic

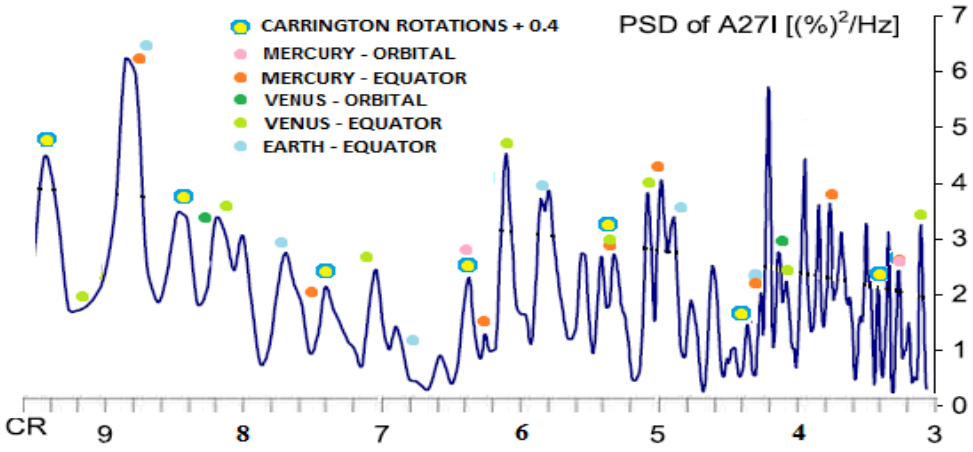

Figure 2: Comparison of GCR measurements over Carrington rotations with planetary frequencies

analysis of TSI (Scafetta and Willson, 2013).

6. Additional analysis

Further evidence to support the hypothesis may be found in spectrographic analysis of galactic cosmic ray incidence at Earth, which is also indicative of solar activity levels, and is found to be modulated at the Carrington-period length (Gil and Alania, 2012).

A comparison of periods at which various fractional multiples of the solar equatorial rotation rate which bring a point on the solar equator directly between the inner planets and the solar core, and the peaks in the galactic cosmic ray measurements (A27l) is made in Fig. 2.

The coincidence of peaks in the galactic cosmic ray (GCR) curve with multiples of the Carrington Rotation (CR) pe-riod indicates a resonant effect of this frequency (27 days). Similarly, the coincidence of other peaks in the GCR curve with multiples of the periods at which a point on the solar equator passes between inner planets and the solar core is indicative of resonant effects. Also shown are Mercury and Venus orbital and half-orbital periods. Venus orbital periods lie close to multiples of the Venus–Solar rotation periods near the peaks in GCR activity at 4.15 and 8.3 CRP. The sharp, high amplitude peak at 4.2 CRP lies between the half peri-ods of Venus' orbit and sidereal rotation, which are four days apart.

7. Conclusions

Harmonic ratios between the planets orbital periods are the principle cause of their quantised semi-major axes. These ratios also affect the rate at which planets rotate, which sets their LOD. The discovery of simple ratios of LOD between planets further underlines the resonant nature of the effect which quantises their relations. These resonances also affect the Sun, which has developed a differential rotation in response to the resonant forces to which it is subjected by the planets, whose orbital elements may be modulating the resonant periods. Cyclic variations induced in the rate of rotation of various latitudinal plasma belts on the solar surface affect its activity cycles such as the Hale, Schwabe and Gleissberg cycles which are found to be in synchronisation with planetary alignment cycles. (Wilson, 2013). Further research is required in modelling the resonant frequencies present and studying their resultant interactions in order to better understand the magnitudes of inertia and damping present in the oscillating subsystems which constitute the rotating solar surface layers.

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References

Agnor, C. B. and Lin, D. N. C. 2011: *On the migration of Jupiter and Sat-urn: Constraints from linear models of secular resonant coupling with the terrestrial planets*, Astrophys. J., 745, p. 143.

Gil, A. and Alania, M. V. 2012: *Cycling Changes in the Amplitudes of the 27-Day Variation of the Galactic Cosmic Ray Intensity,* Sol. Phys., 278, 447–455.

Gross, R. S. 2007: *Earth rotation variations – long period*, in: Physical Geodesy, edited by: Herring, T. A., Treatise on Geophysics, Vol. 11, Elsevier, Amsterdam.

José, P. D. 1965: *Sun's motion and sunspots*, Astron. J., 70, p. 193.

Lister, J. 2008: *Earth science, Structuring the inner core*, Nature, 454, 701–702.

Mörner, N. A. 2013: *Solar Wind, Earth's Rotation and Changes in Terrestrial Climate*, Physical Review & Research International, 3, 117–136.

Scafetta, N. and Willson, R. C. 2013: *Multiscale comparative spectral analysis of satellite total solar irradiance measurements from 2003 to 2013 reveals a planetary modulation of solar activity and its nonlinear dependence on the 11 yr solar cycle*, Pattern Recogn. Phys., 1, 123–133. https://doi.org/10.53234/scc202504/17

Wilson, I. R. G. 2013: *The Venus–Earth–Jupiter spin–orbit coupling model*, Pattern Recogn. Phys., 1, 147–158. https://doi.org/10.53234/scc202504/14

Wilson, I. R. G., Carter, B. D., and Waite, I. A. 2008: *Does a Spin-Orbit Coupling Between the Sun and the Jovian Planets Gov-ern the Solar Cycle?*, Publications of the Astronomical Soci-ety of Australia, 25, 85–93, http://www.publish.csiro.au/paper/ AS06018.htm.