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Energy Transfer in the Solar System[1]

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Abstract

Different types of energy transfer are presented from the literature and are approached and commented on. It follows from these articles that energy transfer in addition to solar irradiation is less well understood by contemporary scientist. The transformation of energy between kinetic and potential energy in planetary orbits might be of crucial importance for understanding energy transfer between celestial bodies and the development of commensurabilities. There is evidence pointing to interactions (friction) between space and satellites producing volcanism. The reversible transfer of energy between the orbit of Moon and Earth's rotational energy is crucial to the creation of the 13.6-day and 27.3-day periods in both solar variables and Earth bound climate variables. It is hypothesized that the Earth–Moon system is modulating the sunspot numbers and creating both these periods, and that the great planets are responsible for the 11 yr solar cycle

Keywords: Solar system energy transfer; transformation of potential to kinetic energy; commensurabilities; Moon – Earth energy; Moon-Sun energy.

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1. Introduction

The title might seem ambitious but it is chosen for emphasizing the importance of grasping the whole picture related to energy transfer. Doing so makes it easier to identify the most important subsystems, narrowing the perspective and focus on what is most needed to investigate in the very complex system where we all live, our solar system.

We know that the source of solar energy has a nuclear origin. We also know that nuclear energy is produced inside Earth and that this type of energy, to a very small extent, is reaching the surface of Earth. This situation is different on Jupiter and the other giant planets. On these planets, a prominent part of the energy flux leaving the planets seems to come from their interiors. However, most scientists are persuaded that the satellites of our planets do not produce nuclear power that melts their interior. Still, the most volcanic celestial body in the solar system is Io, the innermost Galilean satellite orbiting Jupiter (Hamilton, 2013). There was great surprise among scientists when it turned out that the biggest of Neptune's moons, Triton, was also actively volcanic, despite an outer surface temperature of around 38 K, not very far from absolute zero temperature. Neptune itself is the windiest planet among the atmosphere bearing planets.

There is little doubt that solar irradiation energy is the main reason for deciding the approximate steady state temperature situation on the surfaces of celestial bodies in our solar system. However, when an atmosphere exists on a planet or satellite the situation becomes more complex.

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Figure 1: Geometry of galaxies; Left: M 87, Right: NGC 891.

The outer part of Venus' thick atmosphere is in thermal balance with solar energy flux and is about −89 ◦C, which is in stark contrast to its surface temperature around +460 ºC. The corresponding values on Earth are −18 and +15 ºC (NASA, 2013). We know from our own experience that the tilt of Earth's axis and the distance from our Sun affects the surface temperature of Earth producing summers and winters as well as polar and tropical climate. We also understand that an enormous energy flux is carried by winds to keep the polar winter temperatures, although low, to stay away from the neighborhood of absolute zero temperature.

We should ask ourselves if there are other prominent sources of energy other than solar nuclear energy which is mostly lost to space and of which only a minor fraction is caught by Earth's surface, its atmosphere and other celestial bodies in our solar system. Let us just for a moment look into the vast universe; there are both spiral and elliptical galaxies containing billions of stars.

There has to be reasons (physical causes) why some galaxies are three-dimensional rather than two-dimensional. In a similar way there have to be physical processes causing our solar system to become approximately flat and to keep the inner satellites of the giant planets close to the equatorial planes of these planets. A similar situation seems to exist among atoms where the closest electrons are moving in an "equatorial" plane. Apparently, there are forces which act on all scales and which indicate a strong relationship between orbital motions and rotational directions and which might transfer energy between kinetic orbital motion and rotational energy.

The celestial bodies in the solar system are bound together by gravitational energy. Newton's law of gravity can be used to calculate how much energy is needed to separate the planets from the Sun, and the satellites from the planets. Nothing says that the total of this amount of energy has to be constant in the long run. In fact, data from planetary bodies imply that the solar system is contracting, and that potential energy is lost to space. As an example, tidal friction does exist in our atmosphere and oceans. Heat escapes to space sooner or later. It is reasonable to suggest that the rotation rate of the Sun has slowed down and that Venus once rotated as Earth still does. It is known that Earth's rotation is slowing down on a long-term basis (Marsden and Cameron, 1966). The above arguments support the notion that one energy source in our solar system is "friction" energy in a contracting solar system in which rotating bodies also loose rotational energy. However, there is no doubt that there exist physical processes that cause both slowdowns and speedups on Earth's rotational rate. Earth is hardly an exception in this respect.

Processes involving energy transfer can be regarded as reversible and/or irreversible. A pendulum, for example, is switching its total energy between potential energy and kinetic energy. Still, friction exists, and the pendulum is bound to stop its motion sooner or later. Its total energy content is dissipating and lost to the environment and ultimately to space. Any planet that does not move exactly in a circular orbit is constantly switching potential energy with kinetic energy when moving from perihelion to aphelion and vice versa. The idea that these energy pulsations would create friction energy is not farfetched.

In conclusion, the solar nuclear energy provides all celestial bodies in our solar system with average temperatures that can be considered as fairly stable over orbital periods. An approximate steady state situation has evolved for each planet. The system is gradually loosing energy in an irreversible process because of "friction" and is contracting seen in a very long-term perspective.

However, (quasi) reversible energy processes in our solar system do exist and energy is constantly shifting between potential and kinetic energy; a statement valid for any celestial body in the solar system. Reversible energy processes involve both orbital and rotational energy (as further discussed below). A prime topic of this paper deals with the reversible processes causing rotational spin-ups and slowdowns of celestial bodies.

2. Aim of the article

One aim of this article is to show that there is a severe lack of understanding related to energy transfer in our solar system when looking beyond electromagnetic energy transfer. Presented observational evidence and theoretical reasoning are intended to demonstrate that most generally accepted theories relating to the evolution of the solar system and energy transfer between celestial bodies have severe shortcomings. There is a vast pool of observations from a number of sources where the results often seem to be contradictive. Hopefully this article will stimulate to deeper thoughts about such evidence, making it possible to identify dominating subsystems in the solar system and to increase our understanding how celestial bodies interact with each other. Therefore, the present paper is focused on the basic energy transfer processes be-tween celestial bodies. Some statements are made by the author more to stimulate other scientists than to claim them as truths. A controversial hypothesis is formulated (Sect. 8) with the hope that it will be disproved or confirmed by other scientists in the near future.

3. Method

The results are obtained by a combination of

a. gathering information relating to all types of motion in the solar system from adequate scientific papers and data sources;

b. a special investigation of a few key articles dealing with the solar terrestrial interaction and especially the 13.6-days period found in both solar bound and Earth bound data;

c. research on the commensurabilities (Jelbring, 2013);

d. further theoretical considerations.

The combined information under (a) to (d) might persuade the reader that the subject of solar terrestrial interaction is in a severe need of scientific rework. This article is just scanning an ocean of mostly old research results that deserve to be remembered and treated seriously. The results here presented should not be treated on a strict "proof" basis. It is the author's opinion, however, that there exists a number of detailed information that has been published and can be published in the future to defend most of what is stated in this paper.

4 Key sources of information and key variables relating to energy transfer

"It appears that the world scientific community is indeed capable of undertaking a concerted effort to unravel the mysteries of solar activity effects on meteorological phenomena. The success of such an effort ultimately depends on the wisdom of those assigned to assimilate the divers results into predictions schemes for weather and climate. The ultimate beneficiary is mankind" (Herman and Goldberg, 1978). Their book contains 370 references where 170 directly treat solar– Earth correlations and connections. This is just an example indicating that scientific valuable information does exist but that it sometimes has been forgotten or disqualified (for different reasons). In this article, other similar examples will be presented.

After the above statements, irradiation will not be included in the paper. It is well known that it heats celestial bodies in the solar system, and we will concentrate on less known processes. The

energy processes causing the almost constant "quiet" solar wind will also be dismissed. Let me separate the treated types of energy transfer into two categories. One will relate to solar–Earth connections and the other will not depend on earth bound factors. One way to track down energy transfer is to investigate "all" types of motion that occur among celestial bodies in the solar system and describe how they vary.

4.1 Rotation rates

According to NASA the rotation period of the Sun is 25.38 days at 16 degrees latitude. The Sun has a differential rotation with the equatorial period being 25.05 days and the polar being 34.35 days (NASA, 2013). The rotation period (at a specific latitude) can and does change between years. The Carrington synodic period (as seen from Earth) is defined as a constant period of 27.275 days. Rotation rates faster than the Carrington rate usually occur at less than 20 degrees latitude (Gigolashvili et al., 2010). In the same reference it is stated: "The phenomenon of the solar differential rotation has been known for centuries but it is still not properly understood." Notice that an exact rotation rate of the Sun cannot be determined based on observations. It is remarkable that the sidereal rotation period of our Moon is so close to the Carrington period. The latter has been decided as an approximate period for sunspots to move around the Sun as seen from Earth, but very few sunspots live that long. The observed 27-day activity cycle of the Sun can, therefore, not be a result of sunspot groups surviving Sun's rotational period. It is more a question of intermittent revival of sunspots around every fourth week than survival of the same.

All the giant planets have a super rotation at the equatorial region as the Sun has. Estimating a fixed rotation period for the planet is quite hard since the atmosphere moves very differently at various latitudinal bands. On the other hand the true rotation rate for an assumed solid body can be determined by the rotation rate of its magnetic field, which is assumed to be fixed to the solid body below the atmosphere (Glatzmeier, 2009; Drobyshevskij, 1977). Surprisingly enough, the strongest winds in the solar system were found on the very cold planets Uranus and Neptune (Kaspi et al., 2013). On Neptune the equatorial winds move about 250 m s^{-1} faster than the solid body and at higher latitudes the winds move about 250 m s^{-1} slower (Kaspi et al., 2013). The coldest planet (except Pluto) has the fastest mowing winds among planets. It is not probable that these winds are primarily caused by solar irradiation energy variations. Earth absorbs a maximum around 940 W m^2 and Neptune a maximum of 1.1 W m^2 in their equatorial planes. Earth's equatorial winds show little or no super rotation (study the QBO) and Neptune has the most extreme rotation in the solar system.

Comets can be spectacular to watch when, for unknown reasons, their orbits choose to become very elliptical and they closely approach the Sun. What we see is the gas and particle emission from the comet. The mass loss can be substantial and the mass will diminish as time passes on. The comet C/Levy was losing about 4500 kg s^{-1}, mostly water molecules, in the neighborhood of the Sun. The rotation rate of comets is hard to observe but most measured periods are included in the interval of 5–20 h (Jewitt, 1998, Table 1). Jewitt (1998) stated: "The current challenge to cometary astronomers is to quantify the interaction between the spin, the outgassing, and the resultant torque on the nucleus, and to understand the role of rotation in determining the basic physical properties of the nucleus." Experts expect the rotation to be caused by the emitted gas jets, a conclusion which might only be partially true since all "free" celestial bodies do rotate whether they emit gas or not.

The causes of asteroid rotation are hard to understand but there are several physical processes involved. "Asteroids larger than tens of kilometers spin with a mean rotation period around 10 h, with some minor variations with size" and "the distribution is close to normal" (Harris and Pravec, 2005; Pravec et al., 2002). There is an upper limit on spin rate called the "Rubble pile spin barrier" of around 2 h indicating that asteroids would lose mass because of the centrifugal force and disappear if rotating faster. Nowadays a large number of smaller asteroids have been possible to detect and observe, and spin periods down to around 1 min have been measured (Pravec and

Harris, 2000; Ryan and Ryan, 2008). Collisions are believed to be the cause of the fast rotation but it is also recognized that there has to exist one or several "spin-up" processes. One suggestion is that infrared radiation is causing the spin-up but there are also other suggestions.

The inner satellites (up to about 20 planetary radiuses) of the giant planets have their rotation rates bound to its orbital period (NASA, 2013). The rotation period of the planets vary between 9 h (Jupiter) and 243 days (Venus). The rotation period of Venus and Mercury seem to be affected by the orbital period of Earth (Jelbring, 2013).

4.2 Orbital periods

Orbital changes among comets and asteroids are probably caused by other processes than the Newtonian gravitational force. The existence of the Kirkwood gaps in orbital periods of asteroids is a clear indication that energy transfer between celestial bodies does occur. Asteroids, close to resonances with Jupiter's orbital period, have been observed to change their orbital parameters quicker than other asteroids (Sinclair, 1968; Yoshikawa, 1989). Emelyanenko (1985) found that a small number of comets also moved in resonance with Jupiter. Carusi et al. (1988) showed that the most famous comet of all, Halley's comet, has changed its eccentricity from about 0.953 to 0.968 during the last 9 millennia. Most celestial bodies exhibit a decrease in eccentricity with time, which is supported by the fact that all inner satellites move in almost circular orbits close to the equatorial plane of their parent planets. The same tendency is found among planets in the solar system. The possible variability of planetary orbital periods is clearly shown by a rather strange example from another solar system. Two more than Jupiter sized planets orbit the star Kepler-9 in 19.2 and 38.9 days, which is close to a 1 : 2 commensurability. The strange fact is that the inner planet is increasing its orbital period by 4 min/revolution and the other one is decreasing its period by 39 min each revolution (Holman, 2010).

Lately, Nugent et al. (2012) have performed an extensive investigation of semi major axis drift on near-Earth asteroids. They found 54 asteroids "that exhibit some of the most reliable and strongest drift rates" among a larger number of such asteroids. Nugent et al. (2012) attribute this drift to the Yarkowsky effect, which means that solar irradiation pressure should be responsible for the drift. However, this hypothesis cannot explain all the observed drifts quantitatively, which the authors were well aware of.

An amazing work on asteroids named "asteroids harmonics" has been presented on the web by Ross (2013). This work has not been peer reviewed. The results ought to be checked out thoroughly. In short, Ross calculates the "center of mass" for thousands of asteroids by measuring average mass/time unit in each orbit. This center of mass for each individual asteroid is close to the second focal point in the elliptical orbit where the Sun is in the other focal point. He divides the asteroids into 5 groups decided by the Kirkwood gaps. Finally, he shows that each group has their "centers of mass" in different circular "energy states" almost symmetrically spaced around the Sun and the "center of mass" of Jupiter's orbit. Ross (2013) is uncertain about the interpretation. Given that these calculations are correct, they do show that most asteroids are moved into specific energy states that are decided by the Sun and Jupiter. These are not possible to calculate using Newtonian gravity models. If the Ross (2013) calculations are correct, these circular symmetric "energy states" are observational evidence that cannot be refuted.

4.3 Commensurabilities

The tendency of celestial bodies to have orbital periods described by integers, has been known for a long time. As an example of this, it is mentioned in Herman and Goldberg (1978, p. 23) that

– 46 siderial revolutions of Mercury = 11.079 (yr)

– 18 siderial revolutions of Venus = 11.074

– 137 synodic revolutions of Moon = 11.077

Commensurabilities are probably major evidence indicating that celestial bodies exchange energy with each other in a way that cannot be explained by applying the Newtonian gravity model. Boeyenes (2009) gives a limited overview of commensurabilities. Commensurabilities are treated in a separate paper (Jelbring, 2013) where examples of three to four body commensurabilities are presented. Some of these have not been mentioned in the literature before. Jelbring (2013) also claims that a number of strong commensurabilities, like the one mentioned above, hardly can be produced by chance. If so, every celestial body in the solar system has found its recent energy state (orbit) by interacting with other celestial bodies during long time periods.

4.4 Volcanisms on celestial bodies

Active volcanism has only been observed on three celestial bodies in the solar system; viz. on Earth, Jupiter's moon Io and Neptune's moon Triton. Io is close to the size of our own Moon and is the most volcanic celestial body in the solar system. The reason for volcanisms is declared by Hamilton (2013): "As it (Io) gets closer to Jupiter, the Giant planet's powerful gravity deforms the moon towards it, and then, as Io moves further away the gravitational pull decreases and the moon relaxes. The flexing from gravity causes tidal heating." This simple mechanical model is not unchallenged. Recently, Cook (2013) wrote an article with the title "Scientists to Io: Volcanoes are in the wrong spot". He quoted the research-leader Christoffer Hamilton: "... but we found that volcanic activity is located 30–60 degrees east from where we expected it to be." More information from NASA about active volcanism is found in "Triton's volcanic plains" on the web (NASA/JPL, 2008). The title "Cryovolcanism on the icy satellites" (Kargel, 1995) is motived by the fact that the surfaces of several satellites far away from the Sun are more or less lacking scars from meteoritic impacts as seen on the surfaces on our Moon and Mercury, which is indicating a relatively young surface. Kargel (1995) mentions that there is evidence of past volcanic activity on the surfaces of Ganymede, Europa (Jupiter), Enceladus, Tethys, Dione (Saturn), Miranda and Ariel (Uranus). Adding Io and Triton to the list, it should be noted that all of the satellites indicating volcanic activity are orbiting close to the parent planets. In Table 1, the first column shows the ratio between the radius of orbit to the radius of planet, the second the satellite mass relative lunar mass, the third the visual geometric albedo, the fourth the eccentricity of orbit and the last column tells if the satellite at any times moves in a retrograde direction relative to the Sun. The percentage tells how far the satellite is from achieving such a retrograde motion indicated by 100 %.

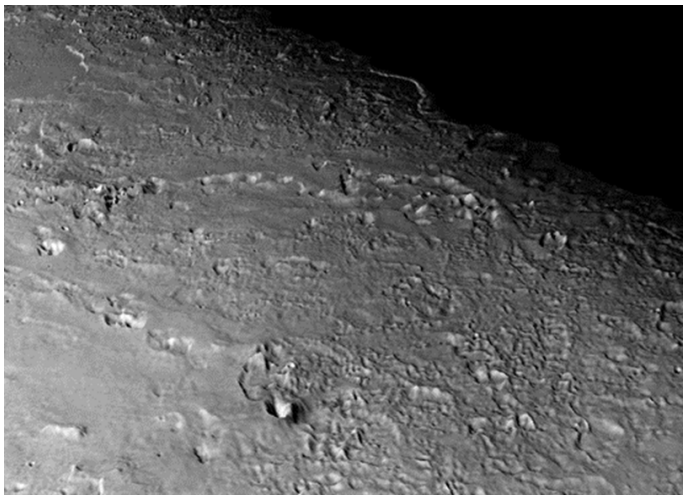

Figure 2: This view of the volcanic plains of Neptune's moon Triton was made from topographic mapping of images obtained by NASA's Voyager spacecraft during its August 1989 flyby. Credit: NASA/JPL/Universities Space Research Association/Lunar & Planetary Institute.

Table 1. Some characteristics of satellites in our solar system

Satellite	Orbital/ equatorial	Lunar mass	Albedo	Eccentricity	Retrograde rotation
Moon	60.27	1.00	0.12	0.026–0.077	No (3.6 %)
Io	5.91	0.82	0.62	0.004	Yes
Europa	9.40	0.65	0.68	0.0101	Yes
Ganymede	14.97	2.02	0.44	0.015	No (83 %)
Enceladus	3.95	0.0015	1.0	0.0045	Yes
Tethys	4.89	0.0084	0.8	0.0000	Yes
Dione	6.26	0.015	0.7	0.0022	Yes
Miranda	5.08	0.00090	0.27	0.0027	Yes
Ariel	7.48	0.018	0.35	0.0034	No (81 %)
Triton	5.88	0.29	0.76	0.000016	No (81 %)

Data according to NASA satellite fact sheets and CRC Handbook of Chemistry and Physics.

Table 1 is quite interesting in that the values in column 1 only vary within a factor of 4, excluding our Moon. The mass of these satellites varies with a factor of 1350. The albedos are extremely high which seems to indicate that "new" satellite surfaces have high albedos. Compare the albedo of the old lunar surface. Our Moon is also special in having an exceptionally variable eccentricity. All the satellites, but our Moon and Ganymede, move very close to circular orbits. All of the volcanic ones can move or do move close to a retrograde direction around the Sun during short periods of their orbits. These factors will be discussed below.

5. Irrefutable evidence from Earth

From Earth itself, we may obtain some "irrefutable evidence" relating to inner planetary energy exchange as discussed below.

5.1 Evidence of storminess and sunspot cycles in sediments

There is no trace left of variable energy states in the atmosphere. Fortunately, such variations will affect wind systems on earth and ultimately, they will show up as secondary effects in sediments, in wind blasted rocks, in glacial drill cores and as below in beach ridges during 9000 years. The combined processes of land uplift and cyclic storminess has produced an impressive testimony of energetic variations in earth´s atmosphere since the end of the last glacial period. No one knows for sure why the cycle, forming the ridges in the image below, is close to 45 yr. Fairbridge and Hillaire-Marcel (1977) suggested that it had to do with the beat period between Saturn and Uranus, which is 45.392 yr.

Fairbridge was a pioneer in trying to gather all types of information relating to solar–Earth connections and was the scientist who pushed attention towards the importance of commensurabilities (Mackey, 2007; Jelbring, 2013). Fairbridge was not the first scientist claiming that celestial bodies are causing sunspots. There is a one hundred year old story waiting to being told about this topic. Physical sunspots–Earth connection impacts have occurred for a long time according to an exceptional research performed by an Australian geologist investigating drill cores in the Elatina formation that was formed about 680 million years ago (Williams et al., 1985). The variations in varve thickness were analyzed and treated by signal processing methods (Williams and Sonett, 1985). The results conclusively indicate that solar–Earth processes have created the observed variations (still, alternative implausible interpretations have been published).

Figure 3. The Hudson Bay "staircase" of 185 successively uplifted shorelines, documented in Richmond Gulf on the eastern side of Hudson Bay, Canada (Hillaire-Marcel and Fairbridge, 1978). The sand gravel beaches recur with great regularity about every 45 yr, representing the cycle of storminess. There are also longer cycles of 111 yr and 317 yr evident in the sequence of beach ridges, which are linked with planetary cycles according to Fairbridge and Hillaire-Marcel (1977) (Credit: Fairbridge).

5.2 Evidence of long-term solar wind influence

The production of the isotopes ^{10}Be and ^{14}C occurs in the atmosphere due to cosmic radiation. These variations do confirm the existence of solar wind variability during the investigated period. The paths of these isotopes into sediments and biological matter vary in complicated ways. Still, it has been possible to extract probable periodicities during a time interval of 9400 yr. Some of these might be coupled to planetary orbital periods even if such a statement is not made by the authors of an interesting article based on advance sig-nal processing methods (McCracken et al., 2013). Another interesting article (Georgieva et al., 2005) shows that there are at least two physical processes affecting solar wind speed (and thus ^{10}Be and ^{14}C isotope production). One of them is correlated with sunspot numbers and the other with coronal holes which do not correlate with sunspot numbers. It is advocated that geomagnetic activity correlates with the sum of these processes. Geomagnetic activity is also claimed to be better correlated with global temperature variations than with sunspot numbers alone (Georgieva et al., 2005).

5.3 Evidence of planetary influence on climate and Earth's axis

A few earthbound physical processes are critical when examining the energy transfer between celestial bodies. One is the quasi-biennial oscillation (QBO), which is an equatorial stratospheric wind that changes direction about every 27 month. There is no plausible physical earthbound process that can generate this type of wind shift so the cause should be looked for from outside Earth itself.

The QBO variations are correlated both with variations in AAM and LOD according to Abarca del Rio et al. (2003) and several other researchers. AAM is the atmospheric angular momentum and LOD is the length of the day on Earth. Much research has shown very strong correlations between LOD and AAM in the decal and interannual ranges (Abarca del Rio et al., 2003; Morgan et al., 1985). The former also claims correlation between solar activity and QBO: "At interannual times scales we present results regarding associations between the decadal cycle in solar activity and

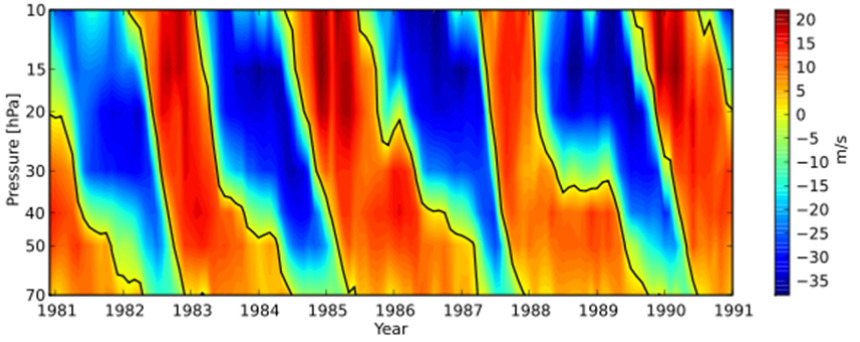

Figure 4: The quasi-biennial oscillation, QBO (Credit: Free University of Berlin).

the amplitude and phase of the stratospheric QBO."

The Earth's axis is wobbling. The polar axis moves about 9 m back and forth. The orbital year of Earth is affecting the wobble and so is another period, which is around 433 days. The interference between these two components produces the approximately 6.5 yr envelope seen in Fig. 5. The physical mechanism providing the excitations energy causing the Chandler wobble is unknown. The existence of the wobble proves that there is an external torque affecting Earth's axis

.

6. Evidence of solar terrestrial connections

ENSO, LOD, QBO, SOI, AAM, Chandler wobble, 11 yr Sunspot cycle, 27- and 13.6-day sunspot cycles all describe energy states on Earth or parts of Earth. Much research effort has been made to find correlations between these variables (e.g., Herman and Goldberg, 1978) and these efforts have continued. The coupling between sunspots cycles and the stratospheric Aleutian High is described by Soukarev and Labitzke (2001) as an example also including the 27-day sunspot cycle. A similar message is given by Fioletov (2009) and Shapiro et al. (2012). The former recognizes, besides the 27-day cycle, a 13.5-day cycle, which is found in the tropical upper stratospheric ozon concentration. Generally, authors are persuaded that the 27-day sunspot cycle is caused by the solar rotation period. Fioletov (2009) states that "the analyses shows that during the periods of high solar activity, about half of the variance for periods of 13.5 and 27 days near 40 km can be attributed to the fluctuation of the Mg II index", which is a solar index originating from the solar chromosphere.

In an analysis focusing on outgoing long-wave radiation (OLR), where it is considered as a proxy for cloudiness, Takahashi et al. (2010) showed that there is a distinct 27-day periodicity over the warm pool of water in the Western Pacific during the period 1980 to 2003. An intriguing fact is that the 27-day periodicity was only found during sunspot maxima periods (1979–1982, 1990–1992, 2000–2002). The 27-day period was also compared with the $F10.7$ index from the solar surface. The authors state: "Identification of the physical mechanism for physical 27-day periodicity is not an easy ask since most solar parameters, including total solar irradiance, solar UV, and galactic cosmic ray (GCR) intensity, vary with the period of solar rotation and are modulated by the 11 yr solar cycle." The result proves that Earth's atmospheric system has filtered OLR power (Wm^{-2}) geographically and temporally to match sunspot data in the solar atmosphere. Similar processes must have been at work producing the sunspot bound data in the Elatina formation reported by Williams (1985).

It is of a special interest that LOD is a true global variable. The same can only be claimed for the Chandler Wobble among the solar terrestrial variables mentioned above. The amplitude of LOD is around 1 ms in most of the treated time ranges. Several articles inform us that (1) LOD is slowly decreasing due to tidal friction, (2) LOD is correlated with ENSO events in the decadal range of periods (Fong Chao, 1988), (3) LOD is strongly correlated with AAM on the interannual range

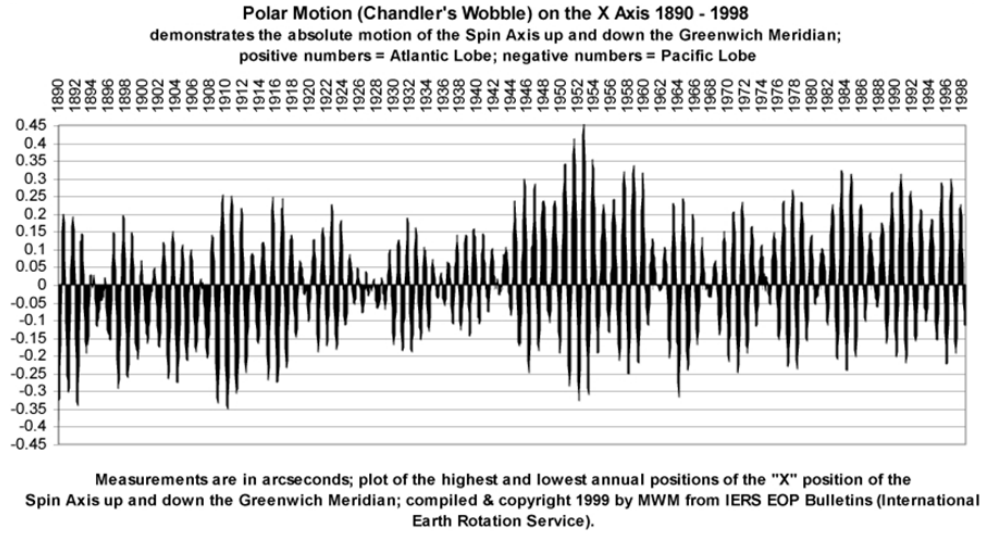

Figure 5: Chandler's Wobble 1890–1998 (Credit: MWM from IERFigure 5. Chandler's Wobble 1890–1998 (Credit: MWM from IERS EOP Bullentins, 1999

(Abarca del Rio et al., 2003) and (4) LOD is strongly correlated with lunar declination and atmospheric geopotential height (Gouqing, 2004). Gouqing (2004) states: "It is found that there are a 27.3 and a 13.6-day east-west oscillation in the atmosphere circulation following the lunar phase change. The lunar revolution around the Earth strongly influences the atmospheric circulation. During each lunar cycle... (change in)... atmospheric zonal wind, atmospheric angular momentum and LOD. The dominant factor producing such an oscillation in atmospheric circulation is the period change of lunar declination during the lunar revolution around the Earth. The 27.3- and 13.6-day atmospheric oscillatory phenomenon is akin to a strong atmospheric tide, which is different from the weak atmospheric tides, diurnal and semidiurnal, previously documented in the literature. Also, it is different from the tides in the ocean in accordance with their frequency and date of occurrences."

These are indeed strong statements written in 2004, but is seems to have had little impact on climate scientists. Gouqing's (2004) work proves that the 27.3-day and 13.6-day oscillations in wind circulation emanate from the Earth – Moon system and that the critical parameter is the declination of the Moon (27.321 days period) and not the synodic month (29.53-days period). Mursula and Zieger (1996) are analyzing the 13.5-day and 27-day periodicity of a number of mostly solar variable using advanced signal processing during 3 solar cycles. All variables were normalized to make quantitative comparisons between them possible. The variables are the near-Earth solar wind speed, solar wind temperature, ion density, geomagnetic activity (*Kp* index), sunspot number, IMF radial component, IMF direction, IMF *z* component, IMF radial magnitude, CA-plage index, X-ray intensity.

Correlation between the solar wind speed and four other variables (solar wind temperature, ion density, IMF radial component and Kp index) were carried out using raw data and data filtered around 13.5 days to find out the time lag between these variables. The authors show that existing data gaps in solar wind data and IMF field variables can be handled in a satisfactory way. The analysis is a high quality investigation. It is hard to imagine an analysis that involves more relevant variables and which is more suitable as a foundation for deductions.

Background information is given by Mursula and Zieger (1996) in the introduction: "First evidence or the fact that geomagnetic activity and auroral occurrence reflect the solar rotation period of approximately 27 days were obtained already more than a century ago" and "in most early and

even some later studies, these peaks at the second harmonic of the fundamental solar rotational period were not considered to correspond to a real physical periodicity related to certain specific heliospheric conditions but rather to be due to mathematical artifacts related, for example, to numerical effects when calculating power spectra." With these words in mind, it is quite a scientific feat to find out that the 13.5-day period is for real in all the variables mentioned above.

The 13.5-day period is only lacking for the IMF *z* component and is rather weak for sunspot numbers and X-rays. On the other hand, the amplitude of the 13.5-day cycle beats the amplitude of its "fundamental" 27-day cycle for solar wind velocity, solar wind temperature, ion density and IMF radial magnitude (Fig. 1 of Mursula and Zieger, 1996). Regarding the chromosphere variables Ca plage index and Mg ratio, the 27-day cycle is dominating, but the 13.5-day period is clearly recognized. It is reasonable to suggest that both these periods should emanate from the same physical process.

The autocorrelation function tells how "persistent" a specific period is. This persistence can be counted in days based on Fig. 2 of Mursula and Zieger (1996), which covers a year. A persistence during 1 yr means that the 13.5-period amplitude has been well detected about 27 times during that year. The most persistent variables (> 1 yr or close to 1 yr) are the IMF radial component in the average IMF direction, Ca plage index, solar wind speed, Mg ratio, solar wind temperature and ion density. The variables are ordered relating to amplitude by the present author based on Fig. 2 of Mursula and Ziegler (1996). The persistence of other variables is shorter such as sunspot numbers (250 days) and Kp index (100 days). A very interesting fact is that all the chromo-sphere variables show a secondary period around 290 days. After that time the X-ray amplitude is 180 degrees phase shifted compared to the Ca plage index and the Mg ratio which is an interesting result.

The cross-correlation calculations on filtered data show phase shifts between variables (Fig. 3, Mursula and Zieger, 1996). It should be noticed that both the Kp index and solar wind temperature peaks 1 day before the maximum value of solar wind speed. The correlations between both these vari-ables and solar wind speed are above 0.8, which is highly significant.

Mursula and Zieger (1996) have demonstrated very strong connections between the Earth bound geomagnetic Kp index and a number of solar variables relating both to the 13.5-day period and to the 27.5 period in a scientifically qualified manner. Gouqing (2004) has, in an equally qualified manner, showed that periods of 13.6 days and 27.3 days are found in major atmospheric air oscillations and that these are caused by the dynamics of our Moon when rotating around Earth.

7. Theoretical considerations

The aim of all disciplines in natural sciences is to increase our knowledge about what happens and what could happen in our environment, atmosphere, solar system, galaxy and in the Universe. When we believe that we know enough of a subsystem, we can make models aimed for predictions or better understanding. However, there is a golden rule in natural sciences: If there exists undeniable observational evidence these will always beat the result of any model whatever its output is. Models always have to be adjusted to nature since nature can never adjust to a model output. Models are and will always be incomplete copies of a partial piece of nature.

Regarding knowledge related to the creation and functioning of the solar system, human knowledge is far from complete. The unknown and "unsolvable" problems are often left aside or forgotten since there is little reward for pointing out limitations in scientific research and contemporary understanding. This article deals with this problem by trying to locate types of energy transfer in our solar system which shows up in observational evidence, but which may seem unexpected (and therefore often are neglected).

The models predicting positions of celestial objects in the solar system are very effective and precise. Solar and lunar eclipses can be predicted within minutes many years in advance. Still,

that model might have been constructed without a real understanding of what causes energy transfer between celestial bodies. It may rely on Newton's gravity force model in an average sense and Kepler's observations that the momentum of planets orbiting the Sun is approximately constant. But a number of "perturbation terms" have been added to each planet to increase the accuracy of the model to fit observational evidence gathered for hundreds of years, demonstrating how the orbits of planets actually deviate from the theoretical exact elliptical paths.

To be more specific some additional examples will be treated below. Earth moves in an approximate elliptical path. Its closest distance from the Sun is called perihelion and its longest is called aphelion. Newton's gravity law only describes where the average distance between the Earth and the Sun should be located. It can be used to calculate the energy required to move Earth away from Sun. It can, however, not be directly used to calculate the energy needed to move the Earth away from the Sun when Earth is in the perihelion and aphelion positions. The orbital velocities in these positions are 30.29, 29.78 (average value) and 29.29 km s^{-1} according to NASA fact sheet where the velocity at average position is added. The corresponding distances are 1.4707, 1.4957 and 1.5207E11 m (according to West, 1960). At aphelion Earth has gained potential energy and lost kinetic energy but it has lost more kinetic energy than it has gained in potential energy according to Newton's law. To understand this statement, the gravitational binding energy of Earth and Sun is expressed by Eq. (1) where the subscript "a" means average value over an orbital period:

$$1/2M_j \times M_s \times G/R_a = 1/2M_j \times V_a^2, \quad (1)$$

where M denotes masses, G is the gravitational constant and V is velocity. Now assume that the distances mentioned above are all average distances and put them into Eq. (1). The resulting velocities (Va) are then: 30.03, 29.78 and 29.05 km s^{-1}. Thus, applying the approximate formula that kinetic energy is $E_{kin} = 0.5 \times M \times V^2$ the following statement and questions seem proper. When Earth is at perihelion it has gained more kinetic energy than the potential energy it has lost. The question arises, where is the part of excess or missing kinetic energy physically located when Earth is in its aphelion or perihelion positions? We assume that the law of conservation of energy is valid, implying that energy cannot be created from nothing and not disappear without a trace of it.

Hence, the missing energy has to be found at some physical place especially since it disappears and reappears once every orbital period and has done so for billions of years. The answer ought to be either inside the Earth (and the Sun) or in space between these bodies. Space seems to be a good guess. In that case, there should be some type of field in space where amplitude depends on how much Earth deviates from its average energy state, which can be calculated by Newton's gravity formula. Such a field should act as a gravity field, which can change signs and should be responsible for an attraction when Earth is further from the Sun than its average distance and repulsion when Earth is closer than its average distance. The resultant orbit is the one Kepler observed and which he assumed to be an ellipse. Such a field should be called a dynamic gravity field.

If variable energy fields in our solar system constantly interfere with each other there is no wonder that celestial bodies will be trapped in commensurabilities with each other (Jelbring, 2013) meaning that one specific body has found a "lowest" energy level in relation to several other celestial bodies. If so, commensurabilities should be found between all the celestial bodies, if enough time has passed for their binding energies to adjust to each other. This would also mean that individual celestial bodies can both loose or gain binding energy to their parent body although there would always exist a "friction" loss due to tidal action between bodies in any "energy cycle".

The Chandler wobble has two prominent components, which have been estimated as 1.000 yr and 433 days. Few persons seem to have asked why the 1-yr component exists. They take for granted that Earth should be the reason but do not investigate the case further. Is Earth most affected when it is at perihelion or aphelion or at some other longitudinal position? In that case what physical situation would excite the 1 yr wobble component? The interaction when Earth is exactly at

perihelion based on the Newtonian gravity formula might be one reason. Another option is to investigate when Earth's and Sun's axis point "most" towards each other. It should be noticed that 3 times the beat period of Mercury and Venus is very close to the observed Chandler period. It is 433.57 days according to the orbital periods preferred by Jelbring (2013) and 433.70 days according to NASA fact sheets (2013). It is the opinion of the author that there is an energetic coupling between Mercury, Venus and Earth causing the 433-day Chandler component and causing Earth's axis to wobble. This is a novel finding proposed here.

8. Location of sunspot generator

The major issue relating to the sunspot's generating process is whether it is located inside or outside the surface of the Sun. The view held by the established experts favors the former view. The sunspot period is generally known as the 11 yr cycle. A long-term analysis of its length based on Schove's (1955) data indicates a cycle length of 11.11–11.12 yr. The 27-day period is much less recognized, but has been known for a long time. Carrington determined the solar rotation period from low latitude sunspots in the 1850s and found it to be 25.38 days. Looking from Earth, a spot rotating at that period would cross our line of sight every 27.275 days. This is why this period has been termed Carrington Rotation. Since then the Sun has been hypothesized to harbor the physical mechanism generating sunspots.

There are several objections to why the cause of sunspots should be situated inside the surface of the Sun. Consider the hypothetical situation that the Sun would have no planets or other objects circling it. Would 11-yr, 27.3-day and 13.5-day sunspot periods still be present if seen from a non-existing imaginary Earth? How would the Sun be aware of the length of its rotation period? How would the Sun know about its own 25.5-day rotation period when its closest reference point in space is 4 light years away (the closest star)? There is no way it could sense its own rotation rate in such a hypothetical situation and that argument alone places the physical mechanism generating sunspots outside the Sun itself.

Consider the following alternatives if the conclusion above is not persuading. If the answer is yes, it would imply that the inner part of the Sun would have a clock administrating (1) the start of the activity, (2) the stop of activity, (3) distribute this activity over an immense surface area and (4) control the intensity of these periodicities of which the longest one is of a very quasi-periodic nature and the two others are relatively stable. If the answer is no, planets have to be involved in the sunspot generating process and they have to be responsible for the forces producing the described actions.

This paper has listed a number of observational evidence and analytical results that do diminish the probability that there is a sunspot generating process hidden in the interior of the Sun. There is another advantage with a sunspot generating process coupled to planetary dynamics and it is that any hypothesis can be checked since measurements can be made outside the surface of the Sun. The latter is essential if we want to apply scientific methods. A hypothesis that cannot be tested has little or no scientific value. The following hypothesis can be checked in the future and hopefully it will turn into a verified theory.

9. A hypothesis *suggesting that Earth–Moon is modulating sunspot activity*

The 13.6-day and 27.3-day periodicity in a number of variables that have been observed in the atmosphere of the Sun and in the atmosphere of the Earth are all caused by our Moon due to its motion back and forth to high declinations above and below the equatorial plane of the Earth.

If so, it follows that the Earth–Moon system modulates other sunspot generating processes caused by the action of the great planets, preferentially Jupiter and Saturn. When the action from these big planets are strong, the 27.3-day variations gets stronger and when the action of the bigger planets reduces, the 13.6-day period gets stronger. When the big planets are in energetic balance

with the Sun (sunspot minimum), the 13.6 and 27.3-day periods are hardly detectable except in LOD. When the energetic balance prevails for longer times Earth gets cold and we will experience both Little Ice Ages and larger glaciations.

The period of the Moon crossing the equatorial plane of the Earth varies between 12–15 days because of the Moon's variable orbital motion. The forcing period thus varies in the interval 13.6±1.5 days. The dates for minimum LOD (at highest absolute declination) follow the actual lunar variations but the variations increases to 13.6 ± 2.5 days (during 2012). The advocated forcing mechanism is thus phase stable and there are no phase shifts even if the variation occasionally gets bigger than what is mentioned above during solar maxima. The solar activity variables can show phase shifts depending on the influence from the bigger planets. The most spectacular phenomenon might be that the 13.6-day periodicity gets almost eliminated in sunspot numbers and to a large extent in the Ca plage index and in the Mg II ratio (Mursula and Zieger, 1996), the reason being that the amplitude of the 11 yr sunspot period is bigger than the amplitude of the 13.6-day period. The 13.6-day signal during moderate solar activity turns into a 27.3-day modulating signal during maximum solar activity.

The 27.3-day signal can almost always be found in the Mg II ratio except at sunspot minima. It is harder to find it in the sunspot number signal as Mursula and Ziger (1996) have demonstrated. H. Jelbring (unpublished data) found the strongest long-lasting sunspot 27.3-day signal component during the 1937 solar maximum (during 9 consecutive months). A similar phenomenon can be found in the Earth's atmosphere according to Takahashi et al. (2010), who state: "Based on FFT analysis for OLR (Outgoing Longwave Radiation) compared with the F10.7 index, we clearly demonstrate a 27-day variation in the cloud amount in the region of the Western Pacific warm pool, which is only seen in the maximum years of 11-year solar activity."

These findings are also consistent with the following statement relating to the 13.5 day-period: "For each of the three solar cycles studied, the largest two-stream structures were found in the late declining phase of the cycle" (Mursula and Zieger, 1996). It is hard to avoid the conclusion that the 13.6-day period and 27.3-day period in both solar variables and in Earth bound climate variables have the same identical cause and that that cause is the motion of our Moon in relation to the Earth's equatorial plane. LOD is for sure a function of lunar declination and the same seems to be true regarding a part of Earth's climate variations.

10. Discussion and conclusions

This article has focused on surveying non-thermal energy transfer in our solar system. It has raised questions as to what such energy transfer means for the geometry of galaxies, solar system and planetary systems. It makes it probable that such energy transfer affects solid celestial bodies and the atmospheres of planets and that it also is the reason for all observed commensurabilities. There exists an undeniable reversible exchange of energy between Earth's rotation energy and our Moon with 13.6-day and 27.3-day periodicities. Non-thermal energy exchange could be called tidal energy exchange, but it covers more than the normal concept of tidal action. The lunar impact on LOD is quite independent of the distance between the Earth and the Moon and it does correlate well with the atmospheric angular momentum. This type of energy exchange has the potential to explain why meteorological predictions are limited to an absolute maximum of about one week and why glacials and interglacials exist. It also explains why climate models are hopelessly wrong since the influence of our Moon on atmospheric and oceanic mass motion is ignored in these models.

The transfer of energy to and from Earth's rotation energy is a fact. It happens on a number of timescales. One timescale is definitely locked to the orbital sidereal period of the Moon and the cause has to be coupled to physical processes related to the maximum absolute declination the

Table A1. List of acronyms.

AAM	Atmospheric angular momentum (Global wind index)
Ca pla. index	Calcium plage index (solar activity index)
ENSO	El Niño–Southern Oscillation
GCR	Galactic cosmic rays (Semantic ambiguous concept)
IERS–EOP	International Earth Rotation Service – Earth Orientation Parameters
IMF	Interplanetary magnetic field
JPL	Jet Propulsion Laboratory
Kp-index	3 h global geomagnetic activity index
LOD	Length of day
Mg II	Magnesium II wing index (solar activity index)
NASA	National Aeronautics and Space Administration
OLR	Outgoing long wave radiation
QBO	Quasi-biennial oscillation (stratospheric wind variations)
SOI	Southern Oscillation index (atmospheric mass variations)
X-ray	Electromagnetic radiation within a specified frequency range

Moon reaches above or below the equatorial plane twice each rotation. Earth rotation slows down when the Moon passes the equator plane and speeds up when it is at high or low absolute declinations. This has occurred at every rotation since consistent LOD measurement started in 1973 (H. Jelbring, unpublished data). The Moon is very special as a big satellite because it is not orbiting in the equatorial plane of its mother planet. In fact the Moon is more like a planet than a satellite just for this reason, which is also why we do observe a strong 13.6-day period in LOD variations. These variations would not be there if the Moon was orbiting Earth close to Earth's equatorial plane. Still, there would be long-term, interannual and decadal variations of LOD even if our Moon was equator bound. The 13.6-day variation in LOD constitutes a key factor when investigating energy transfer in the solar system and is to a great help for an improved understanding of many of its subsystems.

All the satellites showing active or former volcanic activity are moving very fast close to their mother planet in orbits with eccentricities close to zero. What might be even more important is that they move faster than or almost as fast as the orbital motion of their mother parent planets. All these satellites move very close to the equatorial plane of its parent planet except Triton, which shares this property with Earth's moon. Our Moon is active in influencing the Earth's jet wind system. Neptune has the fastest super rotation in its equatorial wind system among all great planets despite the fact that it is the coldest one; which is remarkable. Is this feature connected with Triton passing at high absolute declinations just as Moon does? Information in Table 1 opens the question if there is friction between "space" and celestial objects. Another way to look at it is to ask if a dynamical gravity field is created when celestial bodies are energetically unbalanced. In that case there would always be an interaction between celestial bodies and such a field would create forces, torques and friction. Unexplained observational evidence such as QBO and the Chandler Wobble would be seen in a new light together with a number of other observational evidence if such a dynamical gravity field really exists. Solar system dynamics is a scientific field of great importance which involves a number of scientific disciplines.

Let us never forget the impressive uplifted shorelines in Hudson Bay (Fig. 3) or the sedimentary layers in the Elatina formation mimicking solar sunspots variations 680 million years ago. These and other evidence have written down the history of Earth for billions of years. It would be a waste of scientific talent and opportunity to ignore this history "book". It seems that we are just scratching at the surface of a sea of potential knowledge related to our solar system, our planets and all other celestial bodies it consists of.

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