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Does the Sun work as a nuclear fusion amplifier of planetary tidal forcing? A proposal for a physical mechanism based on the mass-luminosity relation

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Abstract

Numerous empirical evidences suggest that planetary tides may influence solar activity. In particular, it has been shown that: (1) the well-known 11-year Schwabe sunspot number cycle is constrained between the spring tidal period of Jupiter and Saturn, ~ 9.93 year, and the tidal orbital period of Jupiter, ~ 11.86 year, and a model based on these cycles can reconstruct solar dynamics at multiple time scales (Scafetta, in press); (2) a measure of the alignment of Venus, Earth and Jupiter reveals quasi 11.07-year cycles that are well correlated to the 11-year Schwabe solar cycles; and (3) there exists a 11.08 year cyclical recurrence in the solar jerk-shock vector, which is induced mostly by Mercury and Venus. However, Newtonian classical physics has failed to explain the phenomenon. Only by means of a significant nuclear fusion amplification of the tidal gravitational potential energy dissipated in the Sun, may planetary tides produce irradiance output oscillations with a sufficient magnitude to influence solar dynamo processes. Here we explain how a first order magnification factor can be roughly calculated using an adaptation of the well-known *mass-luminosity relation* for main-sequence stars similar to the Sun. This strategy yields a conversion factor between the solar luminosity and the potential gravitational power associated to the mass lost by nuclear fusion: the average estimated amplification factor is $A \approx 4.25 \times 10^6$. We use this magnification factor to evaluate the theoretical luminosity oscillations that planetary tides may potentially stimulate inside the solar core by making its nuclear fusion rate oscillate. By converting the power related to this energy into solar irradiance units at 1 AU we find that the tidal oscillations may be able to theoretically induce an oscillating luminosity increase from 0.05–0.65 W/m^2 to 0.25–1.63 W/m^2, which is a range compatible with the ACRIM satellite observed total solar irradiance fluctuations. In conclusion, the Sun, by means of its nuclear active core, may be working as a great amplifier of the small planetary tidal energy dissipated in it. The amplified signal should be sufficiently energetic to synchronize solar dynamics with the planetary frequencies and activate internal resonance mechanisms, which then generate and interfere with the solar dynamo cycle to shape solar dynamics, as further explained in Scafetta (in press). A section is devoted to explain how the traditional objections to the planetary theory of solar variation can be rebutted.

Highlights

► Empirical evidences that planetary tides may influence solar activity. ► Proposal of a nuclear fusion feedback mechanism to tidal forcing. ► Analysis of the major tidal resonances within the Schwabe frequency band. ► Possible answers to proposed objections to the theory of planetary/solar coupling. ► Synchronization of the solar dynamo to planetary frequency forcing.

Introduction

It is currently believed that solar activity is driven by internal solar dynamics alone. In particular, the observed quasi-periodic 11-year sunspot and total solar irradiance (TSI) cycles are believed to be the result of solar differential rotation, which is modeled in hydromagnetic solar dynamo models (Tobias, 2002). However, the severe incompleteness of the current solar theories assuming that the Sun acts as an *isolated system* is indirectly demonstrated by their inability to reconstruct solar variability occurring at multiple time scales, as also critics of the planetary theory acknowledge (de Jager and Versteegh, 2005). On the contrary, since the 19th century (Wolf, 1859) a theory has been proposed claiming that solar dynamics is partially driven by planetary tides. This theory has never been definitely disproved, although a plausible physical mechanism has not been discovered yet.

Indeed, a planetary theory of solar variation has been criticized for various reasons (Charbonneau, 2002). There are three classical objections. A first objection claims that planetary tides alone would not explain solar variability (Smythe and Eddy, 1977). A second objection based on classical physics claims that the planetary tidal forces are too small to modulate solar activity: for example, tidal accelerations at the tachocline level are about 1000 times smaller than the accelerations of the convective motions (de Jager and Versteegh, 2005; Callebaut et al., 2012). A third objection claims that traditional concepts in the theory of stellar structure such the Kelvin–Helmholtz time scale (Mitalas and Sills, 1992, Stix, 2003) would predict that, because the erratic propagation of the light from the core to the convective zone requires 10^4–10^8 years, changes in the luminosity production would be smoothed out before reaching the convective zone, and the smoothed anomaly signal would not be observable in the final luminosity output. The above three major objections have prevented solar scientists from further investigating the issue taking advantage of the larger and more accurate satellite data about solar activity collected since 1980s, of computer modeling and of theoretical thinking based on modern physics.

On the contrary, the argument that solar activity may be linked to planetary motion would be supported by a large number of empirical evidences (Wolf, 1859, Schuster, 1911, Takahashi, 1968, Bigg, 1967, Jose, 1965, Wood and Wood, 1965, Wood, 1972, Dingle et al., 1973, Okal and Anderson, 1975, Fairbridge and Shirley, 1987, Charvátová and Střeštiˇk, 1991, Charvátová, 2000, Charvátová, 2009, Landscheidt, 1988, Landscheidt, 1999, Juckett, 2003, Hung, 2007, Wilson et al., 2008, Scafetta, 2010, Perryman and Schulze-Hartung, 2010, Scafetta, 2012). Recently, Scafetta (in press) has shown that it is possible to reconstruct solar variability with a very good accuracy at the decadal, secular and millennial scale throughout the Holocene using a model based on the tidal cycles of Jupiter and Saturn plus the dynamo cycle. Scafetta's results have strongly rebutted the empirical criticism by Smythe and Eddy (1977), for example, and have reopened the issue.

The geometrical patterns of the motion of the Sun relative to the barycenter of the solar system have been used by some of the above authors to support a planetary modulation of solar activity. The complex wobbling of a star around the barycenter of its solar system is a well-known phenomenon of stellar motion (Perryman and Schulze-Hartung, 2010). Indeed, Wolff and Patrone (2010) have recently proposed that the rotation of the Sun around the barycenter of the solar system could induce small mass exchanges that release potential energy. The mass exchange would also carry fresh fuel to deeper levels and increase solar activity. This phenomenon would cause stars like the Sun with an appropriate planetary system to burn somewhat more brightly and have shorter lifetimes than identical stars without planets. However, the solar barycentric motion should be understood just as an approximate geometrical proxy of the forces acting on the Sun. Tidal forces, torques and jerk shocks act on and inside the Sun, which is not just a point-size body in free fall. Only these forces can potentially influence solar activity according to the laws of mechanics, although additional more complex mechanisms cannot be excluded.

Herein, we observe that the continuous tidal *massaging* of the Sun should be heating the solar core too. Tidal heating, where orbital and rotational energy is dissipated as heat through internal friction processes, is a well-known planetary phenomenon (Goldreich and Soter, 1966, Jackson et al., 2008). Particularly, tidal heating effects are macroscopic in the case of Jupiter's moon Io (Bennett et al., 2010). In the case of a star, we hypothesize that tidal heating modulaes the nuclear fusion rate and, therefore, the star's total solar irradiance (TSI) output. Thus, the planetary gravitational tidal energy dissipated in the core should be greatly amplified by the internal nuclear fusion rate response to it. We propose a rough estimate of both the value of the planetary gravitational tidal heating of the solar core and of the internal nuclear feedback amplification factor that would amplify the released gravitational tidal power into TSI output. Finally, we compare the magnitude of the planetary tidal induced TSI output variation against the observed TSI variation. The theoretical results of this paper, which are based on modern physics, would rebut the second major objection against the planetary-solar theory, which uses arguments based on classical physics alone to claim that planetary tides are too small to influence the Sun (de Jager and Versteegh, 2005). Indeed, the failure of the 19th century Kelvin-Helmholtz timescale theory claiming that the Sun is about 10 million years old instead of the currently accepted age of 4.7 billion years (Carroll and Ostlie, 2007) demonstrates that classical physics alone does not explain how the Sun works by a large factor. Indeed, the well-known fact that stars are not classical physical systems can invalidate any argument that uses classical physics alone to disprove a planetary tidal influence on the Sun.

The third objection is not explicitly addressed herein. However, the interior of the Sun is not in a pure hydrostatic equilibrium, but it is likely crossed by buoyancy gravitation-waves known as g-mode waves (García et al., 2007). Wolff and Patrone (2010) proposed that g-mode waves may activate extremely fast upward transport mechanisms of luminosity variation from the core to the surface. Fast wave propagation mechanisms would solve the theoretical problems related to the theorized extremely slow luminosity diffusion movement occurring in the radiative zone (Mitalas and Sills, 1992, Stix, 2003).

In Section 2 we summarize some empirical findings suggesting that planetary tides may influence solar activity. In Section 3 we develop a simple energetic model argument to demonstrate that such a theory may be physically plausible. We conclude that the empirical and theoretical evidences in favor of a planetary influence on solar activity are too strong to be ignored: in the future there is the need to study them extensively and include these mechanisms in future solar models. This would be greatly beneficial to solar physics and climate science as well.

Section snippets

Empirical evidences for a planetary forcing on the Sun

The possibility that solar cycles are partially modulated by planetary tidal cycles has been frequently suggested since the 19th century (Wolf, 1859, Brown, 1900, Bendandi, 1931, Schuster, 1911). For example, in a short letter to Carrington, Wolf (1859) proposed that the variations of sunspot-frequency depend on the influences of Venus, Earth, Jupiter and Saturn. Brown (1900) noted that the 11-year sunspot cycle and its multi-decadal variation could be linked to the combined influence of…

Estimation of the planetary tidal heating and its nuclear fusion amplification factor in the solar core

In this section we attempt to roughly estimate the luminosity variation that planetary tides can hypothetically induce, and we compare our estimate against the observed roughly 1 W/m^2 11-year TSI cycle variation at 1 AU, as seen in Fig. 1.

As explained in the Introduction, the idea that we propose is that nuclear fusion mechanisms in the solar core greatly amplify the gravitational energy released by tidal forcings. Only by means of a huge nuclear fusion amplification mechanism may planetary…

Combination of all planetary tides and their ∼10–11–12–61 year TSI induced oscillations

Herein, we assume that all tides are linearly superimposed and re-write Eq. (33) as

$$I_P(t) = \frac{3GR_S^5}{2Q\Delta t}\int_0^1 K(\chi)\chi^4\rho(\chi)\,\mathrm{d}\chi \times \int_{\theta=0}^{\pi}\int_{\phi=0}^{2\pi}\left|\sum_{P=1}^{8} m_P\frac{\cos^2(\alpha_{P,t})-\frac{1}{3}}{R_{SP}^3(t)} - m_P\frac{\cos^2(\alpha_{P,t-\Delta t})-\frac{1}{3}}{R_{SP}^3(t-\Delta t)}\right|\sin(\theta)\,\mathrm{d}\theta\,\mathrm{d}\phi,$$

where the internal sum is extended to all eight planets. Eq. (36) is numerically integrated, and the output is depicted in Fig. 10. The figure shows very rapid oscillations due to the inner planets. The average is about 0.35 W/m^2, which is about 250 ppm of the TSI output. The fast oscillations have a…

Rebutting possible objections

As explained in the Introduction, at least three major objections exist against a planetary influence on the Sun, and we believe that they can be rebutted.

The first objection (Smythe and Eddy, 1977) claims that Jupiter and Saturn planetary tidal patterns would be inconsistent with the periods of prolonged solar minima such as the Maunder grand solar minimum. This objection is explicitly addressed and rebutted in Scafetta (in press). There it is shown how the three frequencies detected in Fig. 2 …

Conclusion

Numerous empirical evidences indicate that planetary tides can influence solar dynamics. High resolution power spectrum analysis reveals that the sunspot number record presents three frequencies at about Jupiter/Saturn's spring tidal period of 9.93 years, at 10.87±0.1 and at Jupiter period 11.86 years. In addition, the alignment patterns of the sub-systems of Venus–Earth–Jupiter and Mercury–Venus produce major resonance cycles at about 11.05–11.10 years, which coincides with the average length…

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