

# Correlation between the orbital positions of Pluto/ Neptune and solar activity in the past 8650 years

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## Abstract:

Yearly orbital positions of the four Jovian planets (the gas giants) and Pluto were compared to solar activity proxies: to sunspot numbers (SSN) for the past 8650 years and to radio carbon calibration data of the past 12,000 years. Correlation coefficients were calculated between the angular distance of each planet (or accumulated angular distances of several planets) from 12 different orbital positions and the solar activity of the corresponding year.

Weak but very consistent negative correlations were found between the angular distance of Pluto as well as the accumulated angular distances of Neptune and Pluto from the region of 265° ecliptic longitude and the 40-year moving average of Sunspot Number: Sunspot Number increases when either Pluto or both Pluto and Neptune are closer to the 265° position and is lowest when they are closer to the 85° position, with a gradual transition between these points. The relationship is strongest for Pluto observed independently:  $r = -0.09022$ ,  $p < 10^{-16}$ . Smaller correlations are found for the accumulated angular distances of Pluto and Neptune from this position, and correlation coefficients below  $-0.03$  ( $p < 0.01$ ) were obtained for Neptune when observed independently. No other planet or combination of two or more planets yielded statistically significant correlations  $r > 0.003$ . Possible contributing interactions of the sun and the planets with charged particles and magnetic fields near the orientation of the solar system bow shock are discussed.

## Background

Previous research in the relationship between solar- /geomagnetic activity and solar system object alignments/ geometry has usually included the planets, with focus on the four gas giants. Existing papers investigate the gravitational effects involving the planets' positions in relation to one another and the sun and barycentric perturbations affecting the solar output, whereas the planets' positions in relation to the heliosphere have not been considered.

In the present paper, Pluto was observed with the four gas giants and the positions of the planets were not only analyzed in relation to one another, but in their orientation within the heliosphere.

Early theoretical arguments for the planets as significant outer agents to the Sun go back to the 1970s.<sup>1</sup> Various models have been proposed connecting planetary position geometry and solar activity. One of the presented papers involve the cycles of the four giant planets in the Solar System: Jupiter, Saturn, Uranus and Neptune<sup>2</sup>, another only Uranus and Neptune<sup>3,4</sup>, yet another the alignment of Earth, Venus, and Jupiter<sup>5</sup> (see discussion below).

## Method:

Planetary positions for the past 12,000 years were generated by the Institute of Applied Astronomy of the Russian Academy of Sciences (IAA RAS) using ephemerides EPM2017H (-10106-3036):EPM2017 and EPM2017h:<sup>6</sup> The IAA ephemerides are concurrent with the NASA JPL DE431 with deviations from the latter of up to 1 degree per 10,000 years.

Data from the JPL Horizon online calculator were not included, as they deviate substantially from the JPL DE431 data. SSN values and JPL DE431 data of the orbital positions of Pluto yielded a correlation of 0.26 for the past 450 years, whereas the JPL horizon data yield a correlation of 0.29 for the same time span.<sup>7</sup>

Reconstructed sunspot numbers for the years 6755BC to 1894AD were obtained from Wu et al, 2018 (available in a 10-year resolution).<sup>8,9</sup> The reconstructed SSN and <sup>14</sup>C production are negatively correlated at  $r = -0.56$ .

Detrended <sup>14</sup>C calibration curves (available in a 5-year resolution, Reimer et al, 2013) were also compared with the planetary positions over the past 12,000 years). Further, Southern Hemisphere <sup>14</sup>C calibration data from McCormac FG et al, 2014 were analyzed.<sup>10</sup> The data range for each parameter was defined by the current limited availability of the individual data sets.

For planets and their positions that yielded correlation coefficients  $r > 0.003$ , the accumulated angular distances for each combination of planets from each reference point in the ecliptic were compared to the above proxies of solar activity. All orbital positions are given in °ecliptic longitude.

## Results:

Sunspot Number (40-year moving average of SSN) is overall highest when Pluto is closest to the 265° orientation in the Solar System (from 6755BC to 1894AD). Smaller correlations are found for the accumulated angular distances of Pluto and Neptune from this position ( $r = -0.8480$ ;  $p < 10^{-14}$ ), and lower correlation coefficients of  $r = -0.03025$  ( $p = 0.004$ ) were obtained for Neptune when observed independently. In this paper, the 265° orientation was dubbed the Front End of the Solar System while the 85° orientation was dubbed the Back End. The

relationship gradually increases with increasing proximity to the 265° position, decreases to below  $r = -0.005$ , (not statistically significant,  $p > 0.6$ ) at the 180° and 90° positions and is reversed in the opposite direction, i.e. solar activity is lowest when Pluto and Neptune are closer to the 85° position ( $r = 0.08480$ ;  $p < 10^{-14}$ ), or when Pluto is closest to 85° ( $r = 0.09022$ ;  $p < 10^{-16}$ ).

The correlation of the angular distance of Pluto from the 265° orientation, when observed independently, and SSN is:  $r = -0.09022$ ,  $p < 10^{-16}$  for the past 8650 years.

No other planets or combination of two or more planets yielded statistically significant correlations with either SSN or any of the other proxies of solar activity of  $r > 0.003$ .

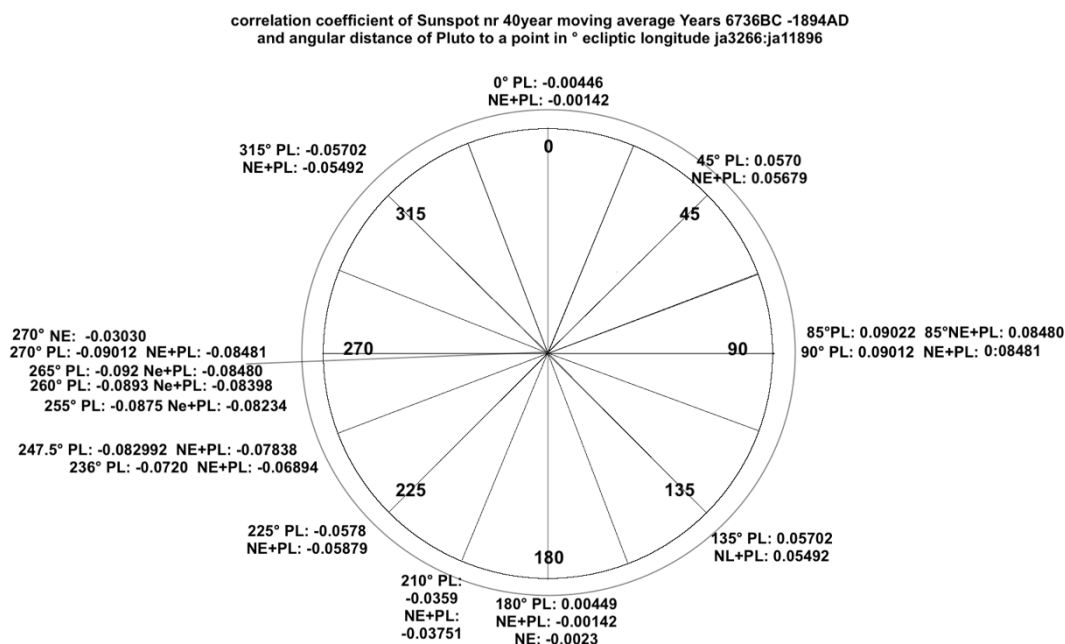


Figure 1 Correlation coefficients of Sunspot Number (40-year moving average) and angular distance from the orbital positions of the same year for: NE =Neptune; PL= Pluto, NE+PL= added angular distances of the two bodies. The 265° ecliptic longitude orientation indicates the "Front End of the Solar System", 0° indicates the orientation of the vernal equinox.

#### Radio Carbon production:

When detrended  $^{14}\text{C}$  calibration data (Reimer et al, 2013 <sup>11</sup>, and McCormac et al 2014 <sup>12</sup>) were compared with planetary positions over the past 12,000 years, the position of the four giant planets or Pluto showed no statistically significant relationships with radiocarbon production.

The fluctuations in atmospheric  $^{14}\text{C}$  are caused by three major factors:

- 1) changes in the intensity of the geo- magnetic dipole moment, 2) heliomagnetic modulation, i.e., modulation by the magnetic field imbedded in the solar wind, and 3) changes in the carbon cycle. A prescient article by Lingenfelter and Ramaty (1970) also included the production of  $^{14}\text{C}$  by solar flares and supernova. <sup>13</sup>

#### Conclusion:

The Planets' (and Pluto's) positions in respect to the heliosphere may be used to predict long-term fluctuations in the amplitude of solar cycles and especially the non-periodical grand solar cycles. Further investigations on the interaction of Pluto and Neptune with the sun may help to achieve better predictability not only of solar and geomagnetic activity, but of the associated changes in climate and social mood.

The Pluto/Neptune - solar activity connection may contribute to further understanding of physical processes in solar system models involving charged particles and electromagnetic exchanges between the sun, the outer heliosphere and the interstellar wind, possibly involving planets as conductors or capacitors.

The termination shock is twice as far from the sun as Pluto and Neptune and the region within is believed to be affected only in an insignificant way by the interstellar medium and magnetic field.

However, a cloud of entering interstellar dust with particle size of  $0.0316 \mu\text{m}$  concentrates at the termination shock centering around 260°, reaching well into the orbits of Neptune and Pluto, with much higher densities than the ambient interstellar dust outside the heliopause (Slavin et al 2012, see fig. 2).<sup>14</sup> The grains tend to be positively charged by the solar UV radiation once they get within  $\sim 100$  AU of the sun.

#### Discussion:

If future research should find the relationship to have a causal aspect, it is highly probable that Pluto's mass is not sufficient to influence solar activity by gravitational mechanisms/ perturbations of the solar system barycenter.

The observation of Neptune's position independently from Pluto yielded considerably lower correlations as compared to Pluto, even though they also point towards the *Front End*. Neptune and Pluto are tidally locked in a 2:3 synchronization and never come closer than 2600 million km to each other.<sup>15</sup> The angular separation of Pluto's perihelion to the orbit of Neptune is always greater than 52°. <sup>16</sup> Whether this synchronization plays a role in the observed patterns, is subject of further research.

Pluto has a mass 500 times smaller than the Earth's, 9000 times smaller than that of Neptune. <sup>17</sup> It had been suggested that Pluto's mass is theoretically not sufficient to have caused the perturbations of Neptune's orbit, which had led to Pluto's discovery.

The prediction that Pluto must be a large object was in part the result of a miscalculation of the mass of Neptune. When Neptune was visited by Voyager II in 1982, it was found to be smaller in mass than previously suspected.

The sun is traveling through a magnetized, low-density, partially ionized interstellar cloud (Frisch et al. 2011). <sup>18</sup> The *Nose of the Heliosphere* <sup>19</sup> overlaps with the "Front End" of the solar system around 265°. This is the orientation of the solar system bow shock i.e. the direction from where the interstellar plasma arrives at the outer heliosphere and also the solar apex (the direction of motion of the solar system, right ascension ~ 271°).

Further, this is the orientation of the Centre of the Milky Way Galaxy, which is located next to the constellation Tea Pot, left of Scorpio as seen from Earth. The Galactic Center is defined at 17h 45m 40.04 s <sup>20</sup>, equivalent to 266.42° ecliptic longitude. <sup>21</sup>

The 265° region is also close to the perihelion of Pluto (224.06676° ecl. long. <sup>22</sup> See also Fig. 2).

The nearest star Alpha Centauri is located at 4h 39m 41s right ascension = 219.9° ecl. longitude.

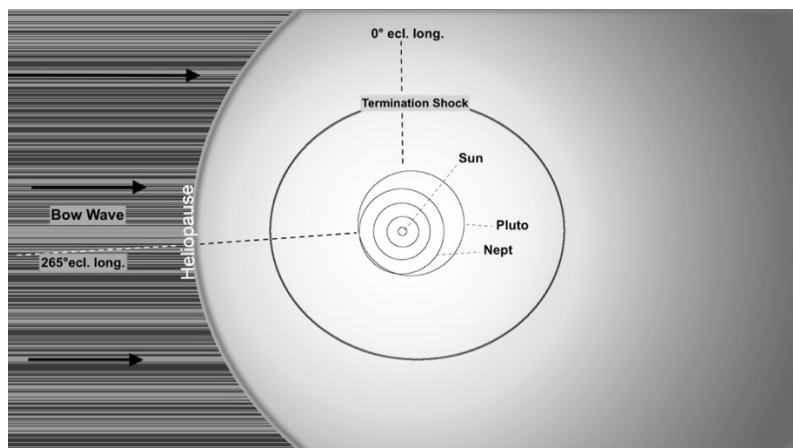


Figure 2: Orientation of the bow shock and heliopause of the solar system around the 252-271° ecliptic longitude region, the direction from where the interstellar wind and the interstellar dust particles encounter the solar wind as they arrive at the outer solar system. Solar wind and the interstellar medium interact to create the inner heliosheath, bounded on the inside by the termination shock, and on the outside by the heliopause. Image: Sacha Dobler, reiteration of NASA illustration. NASA / IBEX / Adler Planetarium; NASA Jun 6, 2018 nasasibexobs As Solar Wind Blows, Our Heliosphere Balloons <https://www.nasa.gov/feature/goddard/2018/as-solar-wind-blows-our-heliosphere-balloons>

M. Opher et al give a direction of the interstellar wind of 5° latitude above the ecliptic plane and 255° (longitude in the solar ecliptic coordinate system) and a variation of intensity of BISM from 1.8nT to 2.5nT. <sup>23</sup>

Likewise, values for the direction of interstellar hydrogen inside the heliosphere are given between 252.2°, 9° <sup>24</sup> and 255.4°, 5.2°) <sup>25</sup> in ecliptic coordinates. The flow of the interstellar medium (ISM) into the heliosphere has been measured by at least 11 different spacecrafts as of 2013. <sup>26</sup> The flow, coming from Earth's perspective from the constellation Scorpius, "has probably changed direction by several degrees since the 1970s". <sup>27</sup>

Further, a broad belt of energetic protons with a nonthermal pressure comparable to that of the local interstellar magnetic field, is centered at approximately 260 degrees ecliptic longitude extending from north to south and looping back through approximately 80 degrees. "The belt appears to be ordered by the local interstellar magnetic field." <sup>28</sup>

W. I. Axford and S. T. Suess, 1994 stated; "It is natural to assume that the relative velocity [of the Sun and the heliosphere] might be parallel to the motion of the Sun with respect to the nearer stars, namely from the solar apex (right ascension ~ 271 degrees, declination ~ 30 degrees) with a speed of ~ 20 km/s. However, typical interstellar clouds have random (line of sight) velocities of ~ 10 km/s or more and the direction could easily be 30 degrees or more from the solar apex - which turns out to be the case." <sup>29</sup>

The solar wind pressure - a combined measure of its speed and density - increased by approximately 50 percent in 2014 (at the peak of the last solar maximum) and remained that way for several years thereafter. <sup>30</sup>

Voyager I is travelling in the almost exact direction (longitude) against the interstellar wind (the direction of the Front End) but at a steeper ascension in respect to the solar system plain.

The spacecraft crossed the heliopause, or the edge of the heliosphere, in August 2012. Heading in a different direction, Voyager 2 crossed another part of the heliopause in November 2018. <sup>31</sup>

The heliosphere itself is thought to reside in the Local Interstellar Cloud inside the Local Bubble, which is a region in the Orion Arm of the Milky Way Galaxy.

Outside the heliosphere there is a forty-fold increase in plasma density.<sup>32</sup>

The local interstellar medium (LISM), which is partly ionized plasma, interacts with the solar wind (SW) plasma and forms the heliospheric interface. At the heliospheric interface, solar wind and interstellar plasma, interplanetary and interstellar magnetic fields, interstellar atoms, galactic and anomalous cosmic rays (GCRs and ACRs) and pickup ions play prominent roles.”<sup>33</sup>

Previous publications on planetary positions and solar activity

Early theoretical arguments for the planets as significant outer agents to the Sun go back to the 1970s.<sup>34</sup>

Relevant models “are supported by observations showing that planetary tides follow a pattern correlating with the solar cycle in the last three and a half centuries”.<sup>35</sup>

Geoff J. Sharp 2013 - who proposed the Angular Momentum perturbation and modulation of solar activity is a direct product of the **outer gas giants (Uranus & Neptune)** - predicted in 2013 solar cycle 24 [peaked in 2014] & 25 [started 2020] will be heavily reduced in sunspot activity resembling a similar pattern to solar cycles 5 & 6 during the Dalton Minimum (1790-1830).<sup>36</sup> SC 24 has already turned out to be the lowest in a century and has been considered as a precursor of a new extended solar minimum.<sup>37</sup> Lockwood, 2013 *estimated solar activity is “falling faster than at any time in the last 9300 years.”*<sup>38</sup>

McCracken et al, 2014 confirmed: Low cosmic-ray intensity (higher solar activity) occurred when Uranus and Neptune were in superior conjunction (mutual cancellation), while high intensities occurred when Uranus–Neptune were in inferior conjunction (additive effects).<sup>39</sup>

During the period 1874 – 2017, the Morlet wavelet power spectrum of the north–south asymmetry of sunspot-group area and that of the mean absolute difference of the orbital positions of **the [4] giant planets** are found to be similar.<sup>40</sup>

A team of researchers from the HZDR found that between 1000 and 2009 AD, the tidal forces [of the Synchronized Solar Dynamo] are strongest when **Earth, Venus, and Jupiter** align, and that this alignment occurs every 11.07 years - falling at the same time as the solar minimum.<sup>41</sup>

Andreu et al, 2012 found an excellent agreement between the long-term cycles in proxies of solar activity and the periodicities in the planetary torque and also that some periodicities remain phase-locked over 9400 years. Based on these observations, the authors proposed that the long-term solar magnetic activity is modulated by planetary effects.<sup>42</sup>

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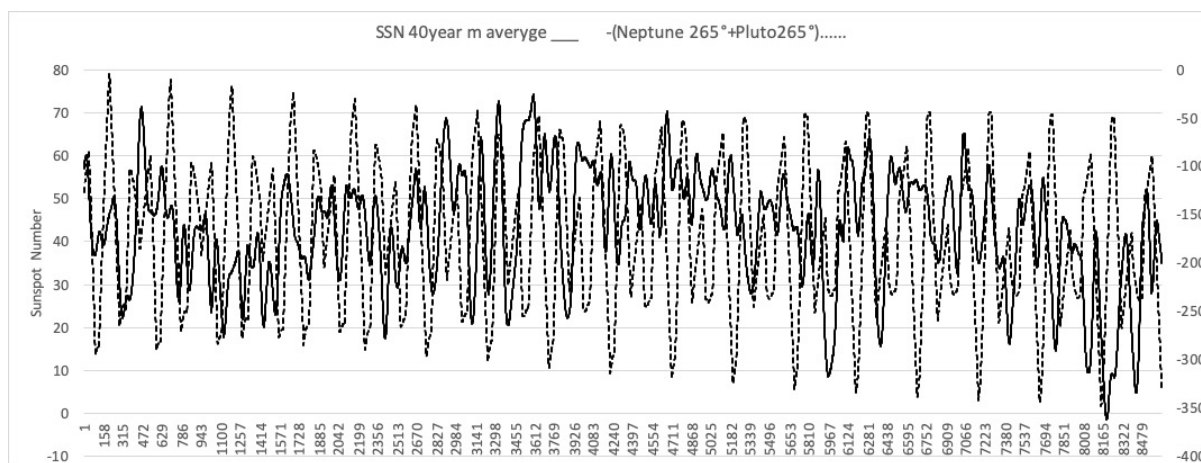


Figure 3: Inverted accumulated angular distances of Pluto and Neptune from the 265 ° position and SSN (40-year moving average) 6755BC to 1894AD (dates labeled as year after 6755BC).

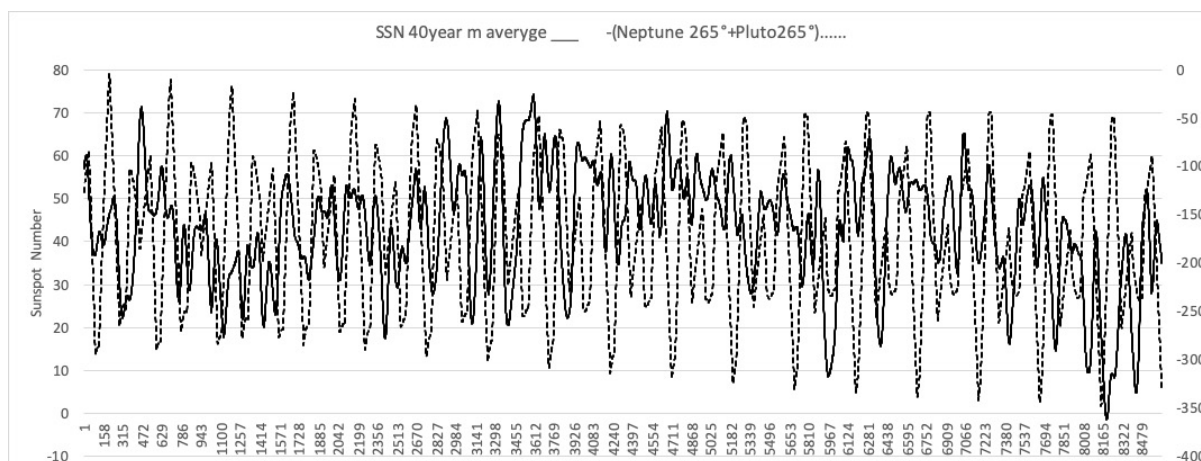


Figure 4: Inverted angular distance of Pluto from the 265 ° position and SSN (40-year moving average) 6755BC to 1894AD (dates labeled as year after 6755BC).

## Notes:

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