INJECTION OF SCATTERED DISC OBJECTS INTO THE INNER SOLAR SYSTEM IN RESPONSE TO SHRINKAGE OF THE HELIOSPHERE

STEVEN FOSTER
Consultant at FT Group, Charlotte, North Carolina Area, USA

SHAHINAZ YOUSEF
Astronomy and Meteorology Department, Faculty of Science, Cairo University
habibat_arrahman@yahoo.com

The heliosphere is the cocoon which engulfs the solar system within. It includes the planets, dwarf planets, the asteroid belt and finally the icy fragments of Kuiper belt objects and the scattered disk objects.

The Kuiper belt is rather a thick donut extending from 30 AU inclined by about 0-10 degrees to the ecliptic. Beyond the Kuiper belt. Extend the scattered disc objects, SDOs to perhaps 100 AU and beyond. Most important, the SDOs are the source of periodic comets lasting less than 200 years which is of the order of the De Verie solar cycle.

The boundary of the heliosphere is determined by the balance between the solar wind pressure and the stellar wind pressure. At times of reduced solar wind, the heliosphere is pushed inward. Right now we are at the bottom of the 80-120 years Solar Wolf-Gleissberg cycle where weak solar cycle series persists. During the period 1890-2010, the heliosphere oscillated between 75-125 AU.

This paper proposes a “pump mechanism” in which scattered disc objects are injected into the inner solar system during times of low solar cycles and the conjunction of Neptune with the Hydrogen wall. We suggest that the inward movement of the heliosphere inject short period comets into the inner solar system. A possible orbital relationship exists between Neptune (164.3 years) and two Wolf-Gleissberg cycles (165 years).

As the solar wind has been reduced at present, we suggest an increased frequency of these short period comets after allowing for delay times.

Introduction

The scattered disc is a sparsely populated region beyond the Kuiper belt, extending as far as 100 AU and farther. Scattered disc objects (SDOs) travel in highly elliptical orbits, usually also highly inclined to the ecliptic. Most models of solar system formation show both KBOs and SDOs first forming in a primordial comet belt, while later gravitational interactions, particularly with Neptune, sent the objects spiraling outward; some into stable orbits (the KBOs) and some into unstable orbits, becoming the scattered disc. Due to its unstable nature, the scattered disc is believed to be the point of origin for many of the Solar System's short-period comets. Their dynamic orbits occasionally force them into the inner Solar System, becoming first centaurs, and then short-period comets, (Wikipedia and references therein).

In this paper we address ourselves to a perturbation mechanism of the heliosphere in which the variability of the solar wind at reduced solar activity via the collapse of the heliosphere triggers the inward push of the scattered disc objects into the inner solar system thus forming short period comets.

The Solar Wolf- Gleissberg Cycles

The strength of the magnetic solar cycles vary in a wavy pattern of 80-120 years as shown in Fig 1. This cycle is termed the Wolf-Gleissberg cycle.
Weak solar cycles of 12 years duration occur at the bottom of these cycles. Cycles 23 and 24 are weak solar cycles (Yosef2006).

THE DYNAMIC HELIOSPHERE

The heliosphere is the cavity curved by stellar wind inside which the whole family of the sun resides (Fig 2). It is engulfed by the Oort cloud which is the source of long period comets.

The extent of the heliosphere is governed by the equality of the inward pressure of the solar wind and the outward pressure of stellar wind (Lang 2001).

\[ P_1 = P_{SW} = P_{1AU} \times \left( \frac{1AU}{R_s} \right) = (m_p \times N_{1AU} \times v_{1AU}^2) \times \left( \frac{1AU}{R_s} \right) \]

(1)

Where \( P_1 \) and \( P_{SW} \) are the interstellar and solar wind pressures respectively. We can use the solar wind properties at the Earth's distance of 1 AU to infer the pressure, \( P_{SW} \), at the stagnation point distance, \( R_s \). The proton's mass is \( m_p \), \( N_{1AU} \) is the number density of the solar wind near the Earth and \( V \) is the solar wind velocity.

At the time of reduced solar activity, its boundary is pushed inward by the stellar wind pressure while it expands at times of intense solar activity. Yousef et al. (2010) found that the dynamic heliosphere oscillated between 75 and 125 AU during the period 1890-2010 as shown in Fig 3.
Fig 2. The solar System embed inside the heliosphere.

Fig. 3. The oscillations of the extent of the heliosphere after Yousef et al. (2010) based on Svalgaard.
Heliospheric Collapses During Low Solar Activity

A mechanism perhaps exists in which the combined solar oscillation created by the 22-year solar cycle and the orbit of Neptune are related. Every 164.3 years, Neptune approaches the conjunction of the Termination Shock and Hydrogen Wall. There is a possible correlation between two Wolf-Gleissberg cycles of 165 years, and the orbital relationship between Neptune and it’s conjunction with the Hydrogen Wall (Fig 4). During times of solar minimum, the Hydrogen Wall is pulled closer to the Sun, moving through the dust and debris of the Kuiper Belt. At times of solar inactivity, the Heliosphere undergoes a collapse, allowing increased interaction of the Solar System with both the Local Interstellar Medium and Cosmic Rays. The “bubble” surrounding the Solar system contracts and exposes the planetary system with the “local fluff.” One result is an increased influx of KBO/TNO objects i.e. (Trance Neptune Objects) to spiral inward into the inner system. Another result is changes in planetary weather brought on by increased exposure to energetic cosmic rays, including increased cloud cover and global cooling.

Fig 4. Schematic diagram of the solar system.

The interaction of Neptune’s gravity on KBO during times when the planet is in vicinity of the hydrogen wall kicks Centaur bodies into a spiral which bring them to the inner solar system represents one scenario. This may be looked on as a “pumping” mechanism which occurs with cyclic regularity as Neptune finds itself in conjunction of the Hydrogen Wall. During times of solar minimum, the Interstellar Wind (ISW) drives the hydrogen wall through the Kuiper Belt. When Neptune is in conjunction of such an event, the combined gravitational pull and push by the ISW could provide minute energy to push objects into intersection orbits. When Neptune is at opposition of the hydrogen wall and during solar maximums, then
the influx of objects into the solar system is negligible. The combined cycle and relationship of Neptune, solar minimum and conjunction with the bow shock/hydrogen wall is a complex interaction. As the sun passes through the Local Interstellar Medium (LISM), increased interaction of the heliosheath and dust/gas within the Local “fluff” would shrink the surrounding Heliospheric “cavity” in which our Solar System exists.

Fig 5. A perturbation Model of the interaction of solar cycle, gravity and KBO/Centaur’s.

**Conjecture of Relationships to Influx of KB/TN Objects**

As part of this mechanism, the orbit of Neptune has a possible correlation with the hydrogen wall at the heliosphere bow shock. When solar activity is low, the hydrogen wall is closer to the sun. When a
conjunction occurs between Neptune and the Hydrogen Wall, one could see a possible higher number of KBO/TNO objects being injected into the inner Solar System. What needs to be investigated is the possibility of a relationship between the conjunction of Neptune and the Hydrogen Wall at an interval of 164.3 years (with a possible correlation to two Wolf-Gleissberg cycles of 165 years).

![Conjunction Diagram](image)

Fig 6. Possible correlation between 22 yr. solar cycle, Neptune’s orbit and conjunction with hydrogen wall.

**Conclusions**

There appears to be three mechanisms which are the driving force behind an injection method of transporting KBO’s with special reference to scattered disc objects, from the Kuiper Belt into the inner solar system. These are the effect of Neptune’s gravity on TNO/KBO’s and Centaurs, the 22-year solar cycle and the interactions of the Interstellar Medium with the heliosheath which surrounds the sun. The pressure changes in the solar wind results in the oscillation of the Heliosphere. This not only provides a mechanism for an increase of Cosmic Rays entering the inner Solar System, but also results in changes in planetary weather. The fluctuation of the Heliosphere with the Local Interstellar Medium (ISM) also affects the Hydrogen Wall at the termination Shock. In looking at the outer regions beyond Neptune for an explanation of periodic influx of comets, all three of these forces must be integrated into one possible explanation that defines the overall mechanism (Fig 7).
The cyclic expansion and contraction of the outer solar heliosheath as part of the Sun spot cycle is a major driving force. During periods of low solar activity, the outer heliosheath contracts, and the interaction between the local interstellar media (LISM) could “pull” objects in the Oort cloud inward, setting them inbound to the inner Solar system? The pressure at the outer boundary of the Heliosphere where the solar wind meets the interstellar media fluctuates in a rhythm those cycles between periods of 20 to 100 years. The solar wind fluctuates during the 22-year solar cycle and during peak, pushes outward from the center of the solar system, and in the process moves the termination/bow shock front further out into the LISM and Kuiper Belt. During times of minimal activity, the termination/bow shock front would be “pulled” inward, through the Kuiper Belt. This could be visualized as a tide coming in and out at a beach, dragging sand and shells in and out. The regular ebb and flow of the Heliosphere and along with it’s the interaction between the LISM is something that needs to be monitored closely.
An objective search of this relationship between Neptune, and the motion of the Hydrogen Wall/Bow Shock during weak solar cycles is suggested as part of this hypothesis. This would require an examination of historic data with focus upon the Wolf-Gleissberg cycle/Hydrogen Wall and Neptune’s conjunction during low solar activity and influx of objects into the inner solar system.

References

5. Wikipedia, the free encyclopedia.