33ND INTERNATIONAL COSMIC RAY CONFERENCE, RIO DE JANEIRO 2013
THE ASTROPARTICLE PHYSICS CONFERENCE

Swinson Flow and the Tilt Angle of the Neutral Current Sheet

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Abstract: As the consequence of the Lorentz force and the positive radial density gradient of cosmic rays in the heliosphere, when the interplanetary magnetic field (IMF) near the earth is directed toward the sun, the flow of cosmic rays perpendicular to the ecliptic plane from the north is induced and vice versa. This IMF polarity dependent flow is called Swinson flow after the name of the first proposer of the mechanism. We have investigated the relationships between the Swinson flow and the tilt angle of the neutral current sheet at the solar source surface.

Keywords: Swinson Flow, Interplanetary Magnetic Field, Neutral Current Sheet, Tilt Angle.

1 Introduction

One of the important flows of cosmic rays in the inner solar system, which is perpendicular to both interplanetary magnetic field (IMF) and radial density gradient, is called Swinson flow. To investigate the genuine sidereal daily variations in galactic cosmic rays, one has to remove any effects being caused by other reasons. The Swinson flow is thought to be one of such causes and it would be the main effect on the sidereal daily variations.

The relationship between the sidereal variation of galactic cosmic rays which could be caused by the Swinson flow and the current sheet of the interplanetary magnetic field has been analyzed. The distance between the current sheet and the earth is thought to affect on Swinson flow strongly. The current sheet is formed by the intrinsic boundary structure of the dipole magnetic field that would be pulling out by the solar wind from the surface of the sun. The boundary between positive polarity and negative polarity of the solar surface magnetic field inclines against the solar equator. Typically this slope, which is called "tilt angle", is not so small that the current sheet forms a spiral wave up to the end of the heliosphere. The amplitude of this wave can be determined by the Tilt angle, and it can settle the earth with the typical distance from the current sheet. In this paper, we analyze a relationship between Swinson flow and Tilt angle with the data of the GRAPES-3 muon telescope.

It is known that typically the Swinson flow can occur when Larmor radius of the cosmic rays become longer than the distance between the current sheet and the earth. However, such a condition can not exist regularly. As in the Fig.1, Fig2, Fig3, there can be the case that the Swinson flow never occurs when the earth is on the current sheet. This is because that a longer distance between the current sheet and the earth can't be yielded if the tilt angle is small.

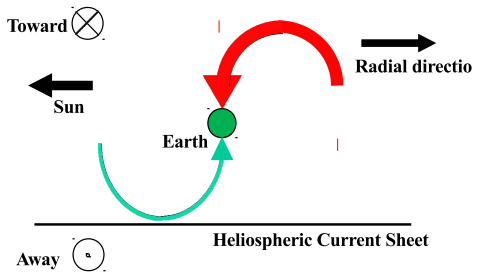

Fig. 1: An isotropy due to the swinson flow is clearly visible.

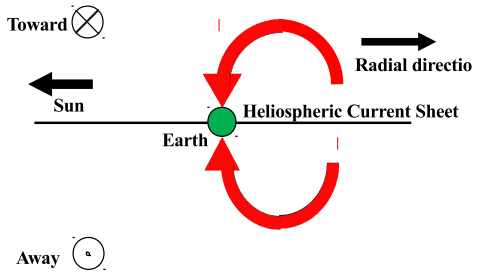

Fig. 2: An isotropy due to the swinson flow is not observable.

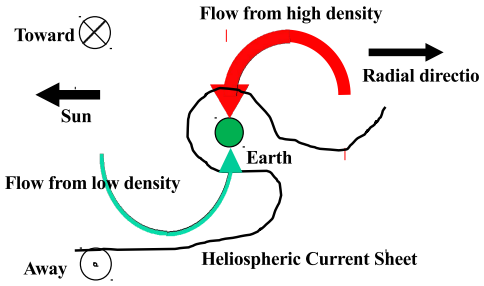

Fig. 3: An isotropy with the inverse phase can be observed.

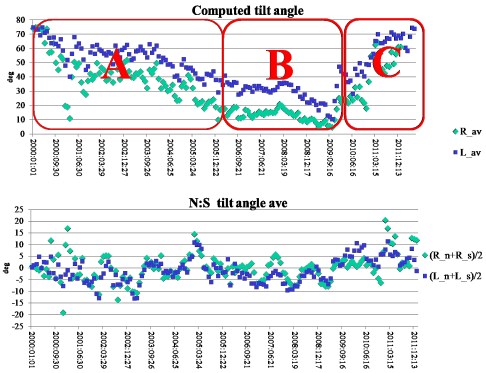

Fig. 4: Computed tilt angle in the period of this analysis.

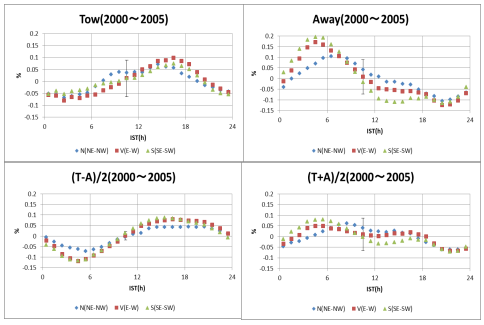

Fig. 5:

2 Analysis

The variation of the tilt angle computed by the Wilcox solar observatory in the period of this analysis is shown in Fig.4. The period has been divided into three periods which have been labeled as A, B and C, respectively.

3 Summary

The tilt angle which is related to an amplitude of the current sheet wave have a variation in time. As from the analysis at both the region of Toward and Away, the relationship between the tilt angle and the Swinson Flow implies that there is a mixture of different flows which have a reverse polarity vice versa. In the analysis of (T-A)/2, where the Away was subtracted from Toward, a component of mixed flows was vanished well and the phase of an anisotropy with expected shape has been obtained. However the amplitude of it is becoming small, possibly. Because the phases of opposite could not be vanished in the analysis (T+A)/2, we have to adopt any step to investigate the genuine sidereal daily variation.

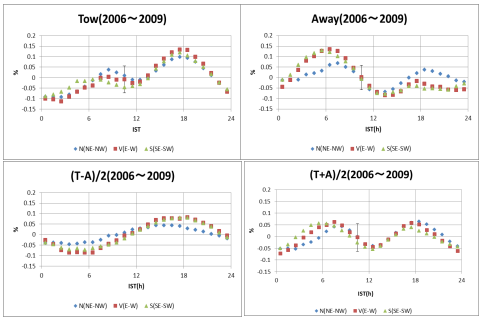

Fig. 6:

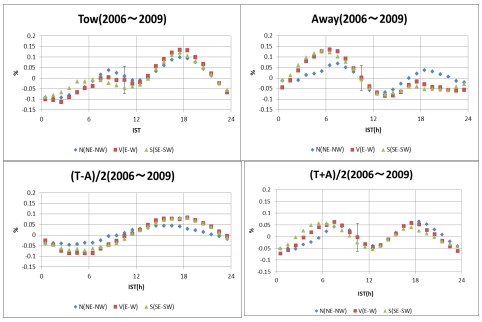

Fig. 7:

Acknowledgment: This work is supported by the grants-in-aid of the Solar-Terrestrial Environment Laboratory of Nagoya University and the Institute for Cosmic Ray Research of University of Tokyo.

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