E108-007 **Room: 101A** **Time: May 23 15:30-15:45**

Solar cycle variation of the solar wind at all heliolatitudes

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The Sun and the solar system move through a part of the galaxy referred to as the local interstellar cloud (LIC). The LIC consists of material originated from the stars of our galaxy through stellar winds, novae, and supernovae. The interaction between the solar wind plasma expanding into the LIC and the interstellar plasma forms heliosphere (the region influenced by our Sun and its magnetic field). The solar wind at the vicinity of the Earth has been observed for several decades, mostly from spacecraft. However, the solar cycle variation of the solar wind out of ecliptic plane has not yet been obtained because of difficulty in observing continuously from the spacecraft. In this regard, combination between the backscattered solar Lyman alpha emission of the interplanetary neutral hydrogen and interplanetary scintillation observations enables us to monitor the long-term variations in the solar wind out of ecliptic plane. The purpose of this study is to elucidate the solar cycle variation of the solar wind over the entire range of heliographic latitudes. In this study, we have developed a remote sensing method to elucidate the solar cycle variation of the solar wind at all heliographic latitudes. Firstly, in order to elucidate the solar cycle variation of the solar wind at all heliographic latitudes during the solar maximum period from 1999 to 2002, we have analyzed data obtained from the ground-based interplanetary scintillation observations by the STEL, Nagoya University and the interplanetary Lyman alpha emission observations with the Nozomi spacecraft. The basic characteristics and important processes for the solar cycle variation of the solar wind revealed by the remote sensing method are summarized as follows.

The solar wind density and mass flux at high latitude show increases and become substantially larger than those at low latitude in the period from 2000 to 2001. These enhancements are associated with the disappearance of the fast solar wind in the polar region. The solar wind with high-mass flux from the polar region of the northern hemisphere is depleted when the fast solar wind in the northern hemisphere reappears. The mass flux reaches almost the same value at low latitude. That of the southern hemisphere is also depleted at later time. Different behavior of the solar wind between the two hemispheres leads to the global north-south asymmetric structure. By comparing the solar wind variation mentioned above with the coronal maps obtained from the SOHO observations and the maps of the source surface magnetic field provided by Wilcox Solar Observatory (WSO), the heliospheric current sheet (HCS) configuration has been investigated. The HCS is located around the pole in 2000, mostly perpendicular to the equator. This means that an enhancement of the solar wind mass flux in the polar region in 2000 is associated with the streamer structure extending to the high latitude region. By comparing the solar wind variation mentioned above with the polar magnetic field strength derived from the magnetograms at WSO, it has been shown that the polar reversal occurs just before the depletions of the solar wind mass flux in the polar region in each hemisphere. As Durrant and Wilson [2003] showed, the polar reversal is seen in the observed magnetic field in February 2001 in the northern hemisphere and in September 2001 in the southern hemisphere. The period when the solar wind mass flux stops its enhancement in the polar region corresponds to the period when the polar reversal is achieved. The results presented here demonstrate an important relationship between the solar wind and the solar magnetic activities for each hemisphere in cycle 23. It is concluded that the north-south asymmetry of the solar wind variation is accompanied with the solar magnetic field activity.