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Relation Between Solar Wind Parameters and Sunspot in Recent Solar Maxima

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ABSTRACT

The characterestics of solar wind parameters reveals the solar activity and variations. The relation between solar wind parameters and sunspot during 23 and 24 solar cycle maxima were analyzed in this paper. To determine the relation between of solar wind plasma parameters and sunspot , data from ACE and WIND spacecrafts and NOAA(National Oceanic and Atmospheric Administrtion) were used. The solar wind parameters parameters such as solar wind velocity, density, temperature and magnetic field and sunspot during 23 and 24 solar maximum activity phase were analyzed. Both spacecrafts observe similar interconnection between solar wind parameters and sunspot in 24 and 23 solar cycle.

Keywords: Solar Wind Velocity, Solar Wind Density, Solar Wind Temperature and Solar Wind Magnetic Field

I. INTRODUCTION

The Sun offers a unique laboratory for the study of the fundamental physical process of the interaction between matter and magnetic fields. The combination of vast amounts of ionized gas, strong magnetic fields and enormous interaction length scales constitute physical conditions which are impossible to reproduce on Earth. Applying similarity transformations (Alfvén and Falthammar , 1963), reducing the solar dimensions down to those of terrestrial laboratories, the scaled values of magnetic field strengths and electric current densities are beyond reach of present-day technology [1]. Hale observed that sunspots usually occur in pairs of opposite polarity. These are called bipolar pairs as opposed to the less common unipolar sunspots. [2] write that all bipolar pairs consist of a leading sunspot (in the direction of the suns rotation) of the same polarity as the hemisphere it appeared in as well as a trailing sunspot of the opposite polarity. This is known as Hales polarity law.Various investigators have used these observations to establish statistical relationships between the solar wind parameters and sunspot [4, 7, 8].

Sunspots are one of the interesting aspects of solar cycle and activity phenomena. The progress of the solar cycle is always basically similar, but there are also significant differences between cycles. During periods of solar maximum, the dominant component of the solar wind plasma appears to be slow solar wind.[10].The high variability of the solar wind in space and time reflects the underlying coronal structures[3]. The solar wind is basically determined by the sun's magnetic field and responds in various ways to solar activity and the accompanying changes in the magnetic field, which determines the solar wind parameters and formation of sunspots. The expansion of sunspot and solar wind prameters, and their effect on the interplanetary medium, have great attention for the 24 and 23 solar cycles.[6].

In this study, we have analysed the interdependence of solar wind parameters, namely solar wind velocity, temperature, density and mean magnetic field in the solar wind and sunspot. As the solar wind moves outwards, velocity and temperature remain coherent, whereas density does not [5] Various parameters, such as solar wind velocity, proton density, proton temperature and magnetic field, fluctuate in this scenario.

II. DATA

The data of solar wind parameters and sunspot for consecutive solar maxima in 23 and 24 solar cycles are

taken for the study. Solar cycle 23 began in 1996 and ended in 2007 and the maximum corresponds to the periods, end of 1999 to beginning of 2002. The solar cycle 24 began in the middle of 2008 and still going on and the maximum corresponds to end of 2011 to 2014. These two maximum periods are taken account for the present work. The daily averaged solar wind parameters are taken from the spacecrafts, ACE and WIND and sunspot data is taken from NOAA. The solar wind velocity, temperature and density for ACE is taken from Solar Wind Electron, Proton & Alpha Monitor (SWEPAM) instrument and that for WIND is taken SolarWind Experiment (SWE) instrument. The magnetic field data for ACE is taken from magnetometer (MAG) and for WIND is taken from Magnetic Fields Investigation (MFI).

III. THE RELATION BETWEEN SOLAR WIND PARAMETERS AND SUNSPOT IN RECENT SOLAR MAXIMA

How exactly are the solar maximum tied to the sunspot cycle? To answer this, we compare plots of sunspot number against the various solar wind parameters measured by the spacecraft. Since NOAA only keeps track of monthly sunspot numbers, i.e.the total number of sunspots per month and ACE and WIND observations at 1AU is taken account for solar wind parameters. First, in figure 1,2 there is a plot of sunspot number against temperature and density for solar maxima of 23 and 24 solar cycles.

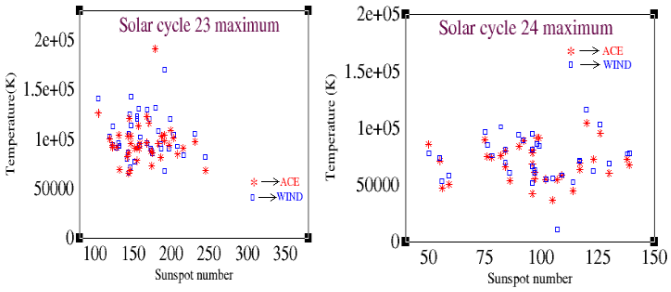

Figure 1: Solar wind temperature Vs. Sunspot number

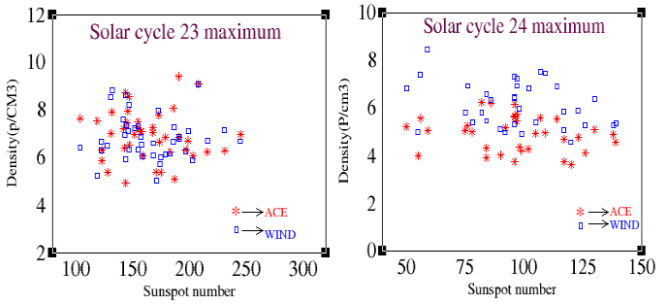

Figure 2: Solar wind density Vs. Sunspot number

In the figures 3 and 4 show velocity and magneticfield Vs. Sunspot for solar cycle 23 and 24 maxima. The solar maximum in 23 SC shows values that were more condensed than the spread of values seen in the solar maximum in 24 SC. The values during the solar maximum are spread out more in both the vertical and horizontal directions. Hence, not only is the extreme behaviour of the solar wind during successive solar maxima shown here, but also the difference between the successive solar maxima in terms of sunspot numbers. The solar minimum sunspot number varies between 100 and 250 sunspots per 23 solar maximum, whereas the sunspot number in 24 solar maximum varies between 50 and 150 sunspots per month.

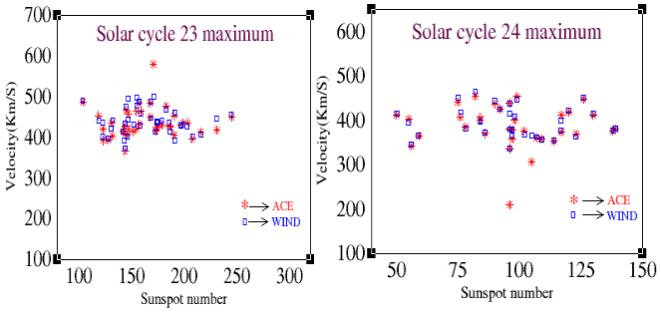

Figure 3: Solar wind velocity Vs. Sunspot number

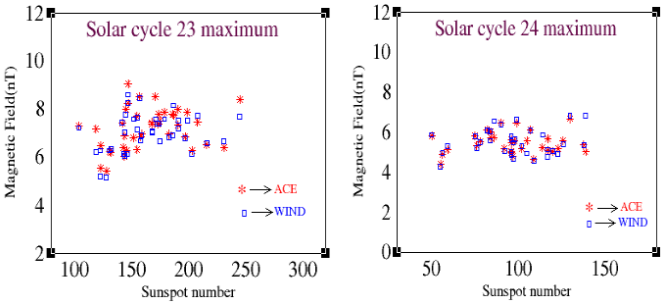

Figure 4: Solar wind magnetic field Vs. Sunspot number

The vertical range in average temperatures during the solar maximum period in23 SC is approximately 20,000 K, whereas the vertical range in average temperatures in 24 SC is approximately 13,000 K. The vertical range in average density during the solar maximum period in 23 SC is approximately 10p/cm 3 , whereas the vertical ange in average temperatures in 24 SC is approximately 9 p/cm 3 . Like this, the vertical range in average velocity during the solar maximum period in 23 SC is approximately 580Km/s, whereas the vertical range in average temperatures in 24 SC is approximately 460 Km/s. Also the vertical range in average temperatures

during the solar maximum period in 23 SC is approximately 9 nT, whereas the vertical range in average temperatures in 24 SC is approximately 7 nT K.

IV. CONCLUSION

The changes in activity on the surface of the Sun cause variations in the solar wind output by the corona. The less number of sunspot are observed s24 solar maxima due to the lower activity of sun, since its a weker solar cycle. The ACE and WIND observed similar solar wind parameters. Since 24 solar cycle is weak, only less number of sunspot found but the intensities of solar wind parameters observed in 23 and 24 solar maxima follows a simular mode.

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