Summary

We examine galactic cosmic ray (GCR) behaviour across the heliospheric current sheet (HCS). To do this we take mean profiles of all heliospheric parameters around all HCS crossings throughout the OMNI2 dataset.

HCS crossings are categorised in 3 ways:

a) By the sense of change in local magnetic field polarity.

b) By the strength of the compression associated with the HCS.

c) By the Sun’s prevailing magnetic field polarity to observe particle drift effects.

We find that the effect of the polarity reversal across the HCS is a significant contribution to GCR modulation in addition to the compression of the solar wind attributable to the association of corotating interaction regions (CIRs) with the HCS.

1. The Catalogue of Current Sheet Crossings

The HCS separates opposing polarity magnetic field lines in the heliosphere and passes over Earth on average once every 9 days. The change in magnetic polarity can be either a change in magnetic field orientation from away-to-towards the Sun (AT crossings), or from towards-to-away from the Sun (TA crossings). Here we compile a catalogue of HCS crossings to examine the effect the HCS has on GCRs. A superposed epoch analysis of various heliospheric parameters around all 402 HCS crossings is shown in Figure 1.

Figure 1 - Superposed epoch analyses of; (a) neutron monitor count rates, (b) plasma density, (c) HMF strength and (d) solar wind speed. Grey regions show Monte-Carlo analysis of 90% of 1,000 randomly selected fake crossing times (results are significant to 95% above/below shaded region).

We do not include HCS crossings in which the hourly resolved heliospheric magnetic field (HMF) components do not rotate smoothly or fluctuate between HMF sectors on time-scales of more than 3 hours. Rather, we limit event selection to those that display a sharp transition between the two most frequent Parker Spiral regimes. Although this reduces the size of the catalogue, it also reduces uncertainty in the time of the HCS crossing and in the mean GCR variation. Hence, we have a conservative selection of 402 HCS crossings between 1965-2013. This is a more conservative catalogue than others (such as El Borie et al. [2001]), but covers the full length of the OMNI-2 dataset, rather than a few years of data.

2. GCR Behaviour Due to Local Magnetic Polarity Changes

Firstly, we consider how GCR flux varies with the sense of the change in the local magnetic field polarity. All HCS crossings are thus separated by whether the magnetic field at the HCS varies from away-from-Sun to towards-the-Sun (AT) or vice-versa (TA). Throughout the GCR data there are 271 AT crossings and 131 TA crossings. Superposed epoch analyses of each crossing are displayed in figure 2.

Figure 2 - Superposed epoch analyses of neutron monitor count rates across away-to-toward Sun HCS crossings (top) and toward-to-away from Sun crossings (bottom). The number of events are given for each plot. Monte-Carlo analysis of random events is again shown in grey.

By dividing the HCS crossings in this way, we can uncover changes between the two polarities. The peak in GCR flux occurs approximately 1 day before the HCS for AT crossings and at the time of the HCS for TA crossings.

The decline in GCR flux also occurs more steeply for AT crossings and is significantly lower (at the 95% level) 2 days after the HCS. For TA crossings, this level is reached 4 days after the HCS crossing.

However, to analyse the cause of these differences it is useful to split the data further for this crossings with a large solar wind compression and those without.

3. GCR Behaviour Due to “Strong” and “Weak” Compressions

The HCS is often embedded within the streamer belt (associated with the slow solar wind) which is followed by fast solar wind which compresses the slow wind. Thus, HCS crossings often occur very close to or at the same time as a compression region (CIR). Here we separate the CIRs to those crossings with just a change in the magnetic polarity to find changes associated with this effect. We label those with significant CIRs “strong” compression crossings and those with small or no CIR “weak” compression crossings. The solar wind density is used to split events using those with peaks of +3 times the background or -3 times the background. This gives similar event numbers in each category.

No studies have yet investigated HCS crossings where the effect of the solar wind compression is minimal. Previous work has focused on just the average behaviour of GCRs across all HCS crossings. We thus included the effects of a large number of CIRs within their samples. With this further analysis, we are able to investigate whether the change in magnetic field polarity influences GCR flux or whether the sole modulating factor is the solar wind compression.

4. Effect of Solar Polarity

As the local magnetic polarity change across the HCS varies the flux of GCRs at Earth, it is reasonable to expect that the direction of cosmic ray particle drifts through the heliosphere is important in modulating the flux of GCRs reaching Earth. During years of A-positive solar polarity particle polarities predominantly drift down to Earth from over the solar poles, whereas in A-negative years, GCR arrive at Earth down the solar ecliptic plane.

Therefore we further split HCS crossings by the prevailing polarity of the Sun to examine GCR differences caused by particle drifts through the heliosphere. It is clear that the results for the two heliospheric polarities are very different and GCR flux is enhanced independent of solar polarity in the away-from-Sun magnetic field sector. The results are not shown on this poster but can be found on the supplied papers next to the poster.

Conclusions

1. HCS crossings with strong compressions on average have more GCRs ahead of HCS and depletion of cosmic rays behind.

2. HCS crossings with weak compressions also have significant changes in GCR flux. This pattern is different between AT and TA crossings.

3. There is a trend towards GCR flux peaking within away-from-Sun magnetic field sectors.

4. These differences are likely to be due to the ease at which GCR access magnetic field lines in each polarity.

References & Acknowledgements:

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