Type IV discontinuities are those with large field magnitude changes and large field components along the normal. Such discontinuities are found to comprise a significant fraction of all discontinuities detected at high heliographic latitudes. These Type IV and tangential (Type II) discontinuities often bound large field decrease (MD) regions which can affect energetic charged particle trajectories. We determine the statistical properties of the MDs and develop a Monte Carlo model to determine the cross-field diffusion rate of ~MeV protons.
<table>
<thead>
<tr>
<th>TYPE OF DISCONTINUITY</th>
<th>MASS FLUX $\rho v_n$</th>
<th>CHANGE IN MAGNETIC FIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROTATIONAL DISCONTINUITY</td>
<td>$\neq 0$</td>
<td>$[H_t] = 0$</td>
</tr>
<tr>
<td>TANGENTIAL DISCONTINUITY</td>
<td>$0$</td>
<td>$[\overrightarrow{H}_t] \neq 0$</td>
</tr>
<tr>
<td>SHOCK</td>
<td>$\neq 0$</td>
<td>$[\overrightarrow{H}_t] \neq 0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$[H_t] \neq 0$</td>
</tr>
<tr>
<td>CONTACT DISCONTINUITY</td>
<td>$0$</td>
<td>$[\overrightarrow{H}_t] = 0$</td>
</tr>
</tbody>
</table>
Discontinuity Selection Criterion

Tsurutani and Smith (TS) Criterion of Interplanetary Magnetic Field Discontinuity (JGR, 1979):

\[ \frac{|\Delta B|}{B} \geq 0.5, \]

\[ |\Delta B| \geq 2\delta = 2\sqrt{N^{-1} \sum_{i=1}^{N} |B_{i+1} - B_i|^2} \]

where \( N=14 \). Applied to one minute average data, where the two one-minute vectors that are compared are separated by three minutes.

The thickness of discontinuities varies with radial distance. An empirical factor of \( \exp (r-1)/5 \) has been determined.
Rotational Discontinuity

\[ \vec{B}_1 \cdot \hat{n} = \vec{B}_2 \cdot \hat{n} \neq 0 \]
\[ |\vec{B}_1| = |\vec{B}_2| \]

Tangential Discontinuity

\[ \vec{B}_1 \cdot \hat{n} = \vec{B}_2 \cdot \hat{n} = 0 \]
Ulysses
Trajectory

Orbital Data as of 1 July 1999

<table>
<thead>
<tr>
<th>Distance from Earth</th>
<th>794 million km (5.31 AU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from Sun</td>
<td>718 million km (4.80 AU)</td>
</tr>
<tr>
<td>Velocity Relative to Earth</td>
<td>88,200 km/hr</td>
</tr>
<tr>
<td>Velocity Relative to Sun</td>
<td>37,200 km/hr</td>
</tr>
<tr>
<td>Ecliptic Latitude</td>
<td>22.0° South, descending</td>
</tr>
<tr>
<td>Solar Latitude</td>
<td>29.2° South</td>
</tr>
</tbody>
</table>
Ulysses South Pole
Days 242-268, 1994

$0.3 \leq \Delta |B|/B_\perp < 0.4$

$0.2 \leq \Delta |B|/B_\perp < 0.3$

$0.4 \leq \Delta |B|/B_\perp < 0.6$

$0.6 \leq \Delta |B|/B_\perp < 1.0$

Time Interval (seconds)
Ulysses South Pole
Days 242-268 1994

Tsurutani-Smith Criteria
(129 discontinuities)

\[ \Delta |B|/B_L \]

% Total Number of Events

\[ y = 91e \quad R = 0.98 \]

\[ (-3.6 \ B_n / B_l) \]

\[ B_n / B_L \]
Ulysses South Pole
Days 242-268, 1994

\[ y = 129 \ e^{-4 \Delta |B|/B_L} \]

\[ R = 0.96 \]

\[ \Delta |B|/B_L \geq 0.2 \]
Ulysses South Pole
Days 242-268 1994

Tsurutani-Smith Criteria
(129 discontinuities)

61%

39%
Ulysses: Days 154-155, 1994

Number of Discontinuities

$\Delta t$

Number of Discontinuities

Thickness $\Delta d$ (km)
Ulysses Magnetic Field Data  R=5.22AU, Lat=-6.0, Long=175.1

Bx (nT)

By (nT)

Bz (nT)

Bt (nT)

TIME (TIC=1HR)

92 017 JAN 17
Planar Waves

Circular Polarization

Elliptical Polarization

Linear Polarization
Spherical Waves

Circular Polarization

Elliptical Polarization

Arc Polarization
Figure 4
Ulysses at Solar South Pole 1994

\[ B_x \text{ (nT)} \]
\[ B_y \text{ (nT)} \]
\[ B_z \text{ (nT)} \]
\[ |B| \text{ (nT)} \]

Day of Year
Ulysses VHM

September 7, 1994 (Day 250)

September 11, 1994 (Day 254)

September 3, 1994 (Day 246)

Time, UT
Ulysses VHM

September 14, 1994 (Day 257)

<table>
<thead>
<tr>
<th>Time, UT</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00</td>
</tr>
<tr>
<td>11:02</td>
</tr>
<tr>
<td>11:04</td>
</tr>
<tr>
<td>11:06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time, UT</th>
</tr>
</thead>
<tbody>
<tr>
<td>17:50</td>
</tr>
<tr>
<td>17:51</td>
</tr>
<tr>
<td>17:52</td>
</tr>
<tr>
<td>17:53</td>
</tr>
</tbody>
</table>
Fig. 3