The Width of the Streamer Belt in the Two Successive Solar Minima

(Evidence for “The conservation of the total magnetic flux in the non-streamer belt region during the two solar minima”)

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Outline

- The distribution of the streamer belt and streamer wind relative to the Heliospheric current sheet (HCS) in the two solar minima.
- The low latitude coronal holes.
- The magnetic field outside of streamer belt.
- The total amount of magnetic flux outside of the streamer belt.
- A new magnetic transport model.


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Streamer belt region

- Streamer belt is the large, extended loops under the heliospheric current sheet (HCS). It extends to a few solar radii.

- Since the streamer belt loops are hotter, the solar wind coming from the stalks of the streamer belt should exhibit the highest charge state ratio, i.e. $\text{O}^{7+}/\text{O}^{6+}$. Therefore, we assume streamer wind can be determined by their relatively high charge state ratio, i.e. $\text{O}^{7+}/\text{O}^{6+} > 0.145$. and those high $\text{O}^{7+}/\text{O}^{6+}$ ratio wind comes from the stalks of the streamer belt, around the current sheet.

1. Streamer wind
2. non-streamer wind (some of them are coronal-hole wind and some of them are still low speed wind)
3. ICMEs.
Contribution of the three solar wind types

ICMEs (10%)
Non-streamer Wind (63%)
Streamer Wind (27%)

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Zhao et al. 2009
Map to the 2.5 Rs solar surface


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Different distribution of the streamer wind in the two solar minima

Last Minimum 1995.07-1998.2


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O^{7+}/O^{6+} distribution relative to the HCS

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Coronal holes from the SOHO EIT195 images

• SOHO/EIT 195 image of CR 2033, in which the dark regions are coronal holes.

• We highlight every coronal-hole pixel by white, and calculate the area of those coronal hole regions, especially at low latitude.

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Enlarged low latitude coronal hole area

Last Minimum

|latitude| < 45

Current Minimum

Coronal hole area (arbitrary unit)

0

5.0 \cdot 10^3

1.0 \cdot 10^4

1.5 \cdot 10^4

2.0 \cdot 10^4

1920 1940 1960 1980 2000 2020 2040

Carrington Rotation

380%

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Distribution of coronal pixels during two solar minima

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Magnetic field is lower

\[ B_r^* r^2 \text{ in non-streamer belt} \]

- Current min
- Last min

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Fisk and Zhao. 2008
Total amount of magnetic flux outside of streamer belt

<table>
<thead>
<tr>
<th></th>
<th>Streamer half-width (degree)</th>
<th>Non-streamer solid angle</th>
<th>Br*r²</th>
<th>Total Magnetic flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last minimum</td>
<td>25</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Current Minimum</td>
<td>7.5~10</td>
<td>1.43</td>
<td>0.7</td>
<td>~1</td>
</tr>
</tbody>
</table>

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Compared with the previous solar minimum, in the current solar minimum:

--- The width of the streamer belt region relative to HCS is narrower.
--- The area outside of the streamer belt (non-streamer region) is larger.
--- The low latitude coronal hole area is larger.
--- The magnetic field in non-streamer region is lower.
--- The total magnetic flux in the non-streamer region is the same.
Thank you!
Three Categories: CME, coronal hole wind and non-coronal-hole wind,

<table>
<thead>
<tr>
<th>Condition</th>
<th>Category</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{O}^7+/\text{O}^6+ \geq 6.008 \exp(-0.00578V_{sw})$ ICMEs</td>
<td>CME</td>
<td>Yellow</td>
</tr>
<tr>
<td>$0.145 &lt; \text{O}^7+/\text{O}^6+ &lt; 6.008 \exp(-0.00578V_{sw})$</td>
<td>Non-coronal-hole wind</td>
<td>Orange</td>
</tr>
<tr>
<td>$\text{O}^7+/\text{O}^6+ \leq 0.145$</td>
<td>Coronal hole wind</td>
<td>Green</td>
</tr>
</tbody>
</table>
Solar Cycle 23 (V-MAP)