Magnetic flux losses from an active region and related coronal activity

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1. Context and Caveats

- AR Magnetic flux losses + Sunspot Decay
  - Spectacular emergence
  - $\Omega$-loop rooted at the bottom of c.z.
  - Active Regions must disappear
  - Compatible with flux transport models
  - Missing spectacular submergence!
  - Reconnection+subtle submergence+ CME?
  - Toroidal flux repaired??
  - Toroidal flux must go away too
2. Sunspot decay: photosphere

- Sunspot decay as seen by TRACE:
  - Most of the sunspot decays in-place
  - A few small fragments break apart
  - Remnant facular regions
  - Decay rate is fast (-20 MSH/day)
  - Sunspot is unipolar
  - How about the other polarity?
  - What happens in upper layers?

Global AR Decay

### Sunspot Set

<table>
<thead>
<tr>
<th>Sunspot Set</th>
<th>N</th>
<th>Mean (MSH/day)</th>
<th>Std. Deviation (MSH/day)</th>
<th>Median (MSH/day)</th>
<th>Mode (MSH/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT</td>
<td>157</td>
<td>-12.1</td>
<td>12.4</td>
<td>-8.2</td>
<td>-9.3/-7.0</td>
</tr>
<tr>
<td>nRT</td>
<td>59</td>
<td>-19.7</td>
<td>15.1</td>
<td>-17.1</td>
<td>-16.7/-18.4</td>
</tr>
<tr>
<td>T</td>
<td>216</td>
<td>-14.2</td>
<td>13.6</td>
<td>-9.3</td>
<td>-9.3/-7.0</td>
</tr>
<tr>
<td>RU</td>
<td>157</td>
<td>-2.0</td>
<td>1.7</td>
<td>-1.7</td>
<td>-1.6/-1.0</td>
</tr>
<tr>
<td>nRU</td>
<td>59</td>
<td>-3.7</td>
<td>2.0</td>
<td>-3.3</td>
<td>-1.8/-1.9</td>
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<tr>
<td>U</td>
<td>216</td>
<td>-2.50</td>
<td>1.95</td>
<td>-2.0</td>
<td>-1.6/-1.0</td>
</tr>
</tbody>
</table>

1. R = recurrent, nR = non-recurrent, T = total decay, U = umbral decay
2. Binning independent value/binning dependent value
3. Sunspot Decay: Chromosphere & Corona

- Other TRACE wavelengths:

1600 Å

171 Å+WL

5 coronal events including:

- 1 global flare
- 1(3) filament eruptions (CMEs)
- post-flare loop
3. Sunspot Decay: Chromosphere & Corona

- Other TRACE wavelengths:
  - $171 \AA$

Sunspot Decay: Chromosphere & Corona

CCMAG 2005
4. AR magnetic flux losses

• But, what happened to the magnetic flux?
  
  • Linear flux decay (69 %!)
  • Reaches a plateau
  • Coronal events localized right & before the plateau

SOHO/MDI

Flare

Filament eruptions
4. AR magnetic flux losses

- Other cases

3 out of 3 show the linear decay+plateau
4. AR magnetic flux losses

• What physical process makes the flux disappear?

Filament eruptions + cancellation
4. AR magnetic flux losses

- Questions about magnetic field cancellation:
  - Found everywhere (QS, Network, ARs, Poles)
  - Related to coronal energetic phenomena
  - It happens at small scales (resistive)
  - Always reconnection?
  - Simple submergence/emergence? (2D)
  - Flux rope expulsion (3D)

Innes, 97

Priest, 87

Low, 01
4. AR magnetic flux losses

- Summary of AR decay:

  - ARs enter a linear flux decay shortly after emergence
  - 70 % of the original flux is wiped-out “in-situ”
  - 30 % (only !) available for transport to the poles
  - Coronal activity concentrated before flux plateau
  - Filament eruptions (CMEs) occur during flux decay
  - Cancellation (U-loop emergence?) as a key player
THANKS