Long-term variation of the corona in the quiet region

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Outline

• Daily calibration of Hinode/EIS
• Correcting the EIS sensitivity change
• Averaged properties of the corona
  • Variation with the solar activity cycle
  • Temperature analysis (DEM)
  • Coronal density
• Discussion
EIS calibration program

- Intended to determine the degradation of EIS.
- 90 sec exposure at the Sun center
- Performed on daily basis since Dec 2006
- Also useful to study averaged properties of the corona.

Slit 1” x 256”
EIS sensitivity correction

- He II radiance in quiet Sun is assumed to be constant.
- EIS sensitivity is reproduced by combination of two exponentials (Mariska et al. 2012)

\[ e = \frac{\exp(t/\tau_1) + \exp(t/\tau_2)}{2} \]

\[ t : \text{time since Hinode launch} \]
\[ T_1 = 467 \text{ day, } T_2 = 11311 \text{ day} \]
Radiance variation

Fe XIV 264
Fe XIII 202
Fe XII 193
Si X 258
Fe XI 180
Fe X 184
Si VII 275
Fe VIII 185
He II 256

1000 100 10 [erg cm\(^{-2}\) s\(^{-1}\) sr\(^{-1}\)]

Year 07 08 09 10 11

x3.2

[Image of graphs showing radiance variation for different elements and years]
Radiance variation ratio

<table>
<thead>
<tr>
<th>Ion</th>
<th>$\lambda$ [Å]</th>
<th>$\log T_e$ [K]</th>
<th>Dec [erg cm(^{-2}) s(^{-1}) sr(^{-1})]</th>
<th>Feb 2009</th>
<th>Ratio</th>
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</thead>
<tbody>
<tr>
<td>Fe XIV</td>
<td>264.79</td>
<td>6.25</td>
<td>38</td>
<td>7.8</td>
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<tr>
<td>Fe XIII</td>
<td>202.04</td>
<td>6.20</td>
<td>207</td>
<td>33</td>
<td>6.2</td>
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<tr>
<td>Fe XII</td>
<td>193.51</td>
<td>6.15</td>
<td>225</td>
<td>70</td>
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<td>Si X</td>
<td>258.37</td>
<td>6.15</td>
<td>75</td>
<td>35</td>
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<td>Fe XI</td>
<td>180.40</td>
<td>6.10</td>
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<td>282</td>
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<td>Fe X</td>
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<td>Si VII</td>
<td>275.36</td>
<td>5.80</td>
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<td>Fe VIII</td>
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<td>31</td>
<td>44</td>
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<td>He II</td>
<td>256.32</td>
<td>4.85</td>
<td>256</td>
<td>229</td>
<td>1.1</td>
</tr>
</tbody>
</table>

\(^1\)With a blending Fe XI 264.77Å

- Temperature dependent variation:
  The hotter, the greater variation

2006
DEM analysis

- DEM in a range
  \[ \log T = 5.8 - 6.3 \]

- High temperature region at 6.2 indicates a large variation

- Nearly constant at 6.0 (~ Fe X)

- Hot component of the corona changes with solar activity cycle
Coronal density

- Deduced from the line ratio Si X $258.37/261.04$
- Coronal emission:
  \[ I = f d n_e^2 g(T, n_e) \]
- Dashed curve: square root of the radiance
- Density variation can not reproduce the observed radiance variation
Discussion

- Coronal emission shows temperature dependent variation.
- Density variation is not likely the cause.
- High temperature component in the corona changes with solar activity cycle.
- Remaining questions
  - What will happen at the solar activity maximum?
  - How does the solar activity cycle effect quiet Sun?
  - Relationship with magnetic field properties?
  - Latitude dependence of the variation?
Radiance Histogram

- Deduced from one-month data of Fe XII 193