IRIS diagnostics for lower chromospheric heating

Tiago M. D. Pereira

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Mg II k

279.55 nm
Wavelength (nm)

Intensity (nW m⁻² Hz⁻¹ sr⁻¹)

- Mean synthetic spectrum
- Observations (RASOLBA)
- Observations (HRTS-9)

TMDP, J. Leenaarts, B. De Pontieu, et al. (2013)
Mg II h & k: velocity diagnostics

at IRIS resolution

simulation original
Mg II h & k: temperature diagnostics

\[ T_{\text{gas}} (\tau=1) \text{ (kK)} \]

\[ T_{\text{rad}} \text{ (kK)} \]
Mg II k

Mg II
279.08 nm

Mg II
279.79 nm
279.80 nm

Mg II h
Mg II $k$

279.08 nm

Mg II

279.79 nm

279.80 nm

Mg II $h$
Maximum electron density (m$^{-3}$)
\[ \frac{I(\text{core})}{I(\text{wing})} \]

\[ S_{\text{max}} - T_{\text{min}} \]

\[ T_{\text{max}}(S_{\text{max}}) - T_{\text{min}} \]
AR

Sunspot

QS

QS Limb

Wavelength (nm)

Intensity (DN/s)

TMDP, M. Carlsson, B. De Pontieu et al. (2015)
the same along columns.

format is the same as for Figure

pattern, plus the moment of the H

+ no 1400 Å slitjaw images are shown because they were all nearly identical to

except that SST H

The Astrophysical Journal,

Ni

and much blueshifted pro

investigation, but studying and displaying such hot coronal

present throughout the hot arch. These signatures merit further

The next sampling

(Figure 16.)

unfortunately, the

The blue Mg

2003

produced bright Si

flames in Figure

centers, because each pair reaches similar heights in the second

reaching unity for an opaque cloud with constant source

maximum intensity.

Dopplershift from line center of the strongest line along the panel tops. The second Si

the average spectrum for the

two between their transition probabilities; equal apparent pro

the intensity of one Si

Figure 12.

The striking shape similarities between the C

lines for B-3 and 4, suggesting that those

IV

lines are nearly absent

are while the onset of

speci

selected two for display in Figures

Figure 11 – 13.

Time sampled in Figure

and shows no

Wavelength (Å)  

Fig. 3. Spatial association of the RHESSI X-ray sources with the ribbon structure. Panel a) shows the only time at which a non-thermal source (20–50 keV) was near the NR structure. Panel b) shows that a short time later, the higher energy source are no longer located near the ribbon (this image uses 20–25 keV and 15–20 keV as the higher energy passbands contained significant noise at these times). Panel c) shows the 6–9 keV compact sources that are positioned near the NR. Dotted lines show the IRIS slit positions.

Fig. 4. As a sample flare spectrum (blue), with the pre-flare (red) and averaged quiet Sun (green) spectra shown alongside. No central reversal is seen in the flare or pre-flare spectra.

Fig. 5. As a sample light curves showing very impulsive peaks. Asymmetries present. Each of these features will be discussed in more detail below.

When the outer ribbon has moved on, the pixel sits in the inner ribbon. The intensity drops quickly from the peak, usually within one 43 s timeframe, followed by a slower decay over several minutes. The resonance lines are affected by the filament spreading over the ribbon, which results in a sudden dip in intensity in the lightcurves. The subordinate lines are seemingly not affected by the filament, showing instead a smooth decay to pre-flare intensity. The profiles are still broadened at this stage though to a lesser extent.

Figure 4 shows the pre-flare (red line), and flaring (blue line) spectrum for a sample pixel within the NR, as well as the quiet Sun (green line) spectrum, shown previously as a reference. This figure demonstrates the spectral variations described above. It is also clear from these spectra that the subordinate lines are in absorption in the quiet Sun, and go into emission during the flare. We refer to the 2796.10 Å line as "s1" and since the 2798.75 Å and 2798.82 Å lines are blended we refer to them together as "s2". The lightcurves of the h and k lines, and of s1 and s2, from a flare pixel are shown in Fig. 5, where intensity has been integrated over the line. Both the subordinate lines and resonance lines decay within a similar timescale.

The k-line integrated intensity of each pixel in the NR and surrounding region is shown as a function of time in Fig. 6.
The temperature of the chromospheric plateau has a minimum. This suggests that both increased microturbulence as well as thermal line broadening of the O\textsc{i} line shows that it is sensitive to conditions higher up, at the very top of the chromospheric and coronal conditions. For example, cooler temperatures mean larger widths. For temperatures above 279.88 nm brightness does. This is consistent with the temperature of the chromospheric rise. Bottom row: variation in column mass of the chromospheric temperature increase. Changing the location of the chromospheric temperature rise and k emission of the subordinate blend at 279.88 nm and 30 km s\(^{-1}\) brightness does. This is consistent with the temperature of the chromospheric rise. 

Carlsson et al. (2015), ApJL, 30

Carlsson, Leenaarts, & Pontieu (2013a), ApJL, 30


Figure 5. Sensitivity of the emergent lines to variations in a 1D static plage atmosphere model. This is supported by the observed large-scale thermal conductive flux pushing the TR to high column mass. This scenario is supported by the observed large-scale thermal footpoints of hot, dense coronal loops in which a strong pressure effect on the Mg\textsc{ii} emission core width: larger smaller than 10 km s\(^{-1}\) – 2 \(\Delta T\) features with very little or absent self-blending. Such a proxy for coronal pressures would lack signatures of AIA 19.3 nm emission, something that would be expected for higher coronal pressures. The subordinate blend gets shallower. Despite these caveats, we often do find a reasonable correlation on small, arcsecond spatial scales between k lines. The opacity broadening comes about because the deeper in the atmosphere it is located, the mass, but even the best-resolution wings of Mg\textsc{ii} have two effects. First, the deeper in the atmosphere it is located, the subordinate blend gets shallower. This is consistent with the temperature of the chromospheric rise. Bottom row: variation in column mass of the chromospheric temperature increase.
Conclusions

• Forward modelling a reliable method to diagnose complex spectra
• Mg II triplet lines unremarkable except when in emission
• Amount of emission + shape of emission give clues to underlying atmosphere ($\Delta T > 1500$ K, $N_e \approx 10^{18}$ m$^{-3}$)
• IRIS results illustrate key cases where Mg II triplet useful in constraining condition of lower chromosphere