If the coronal loops are magnetically shielded?

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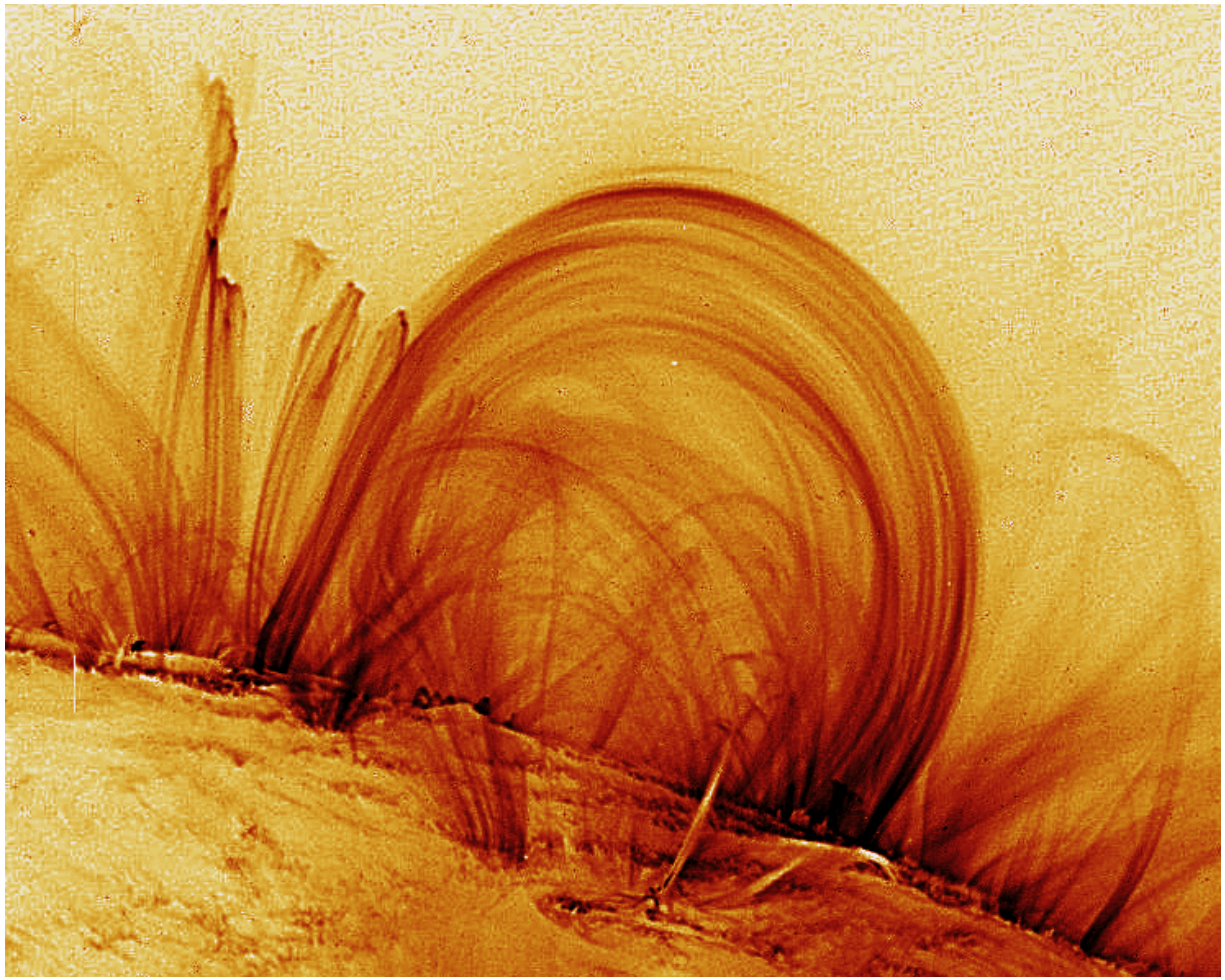
Coronal loops as seen by TRACE



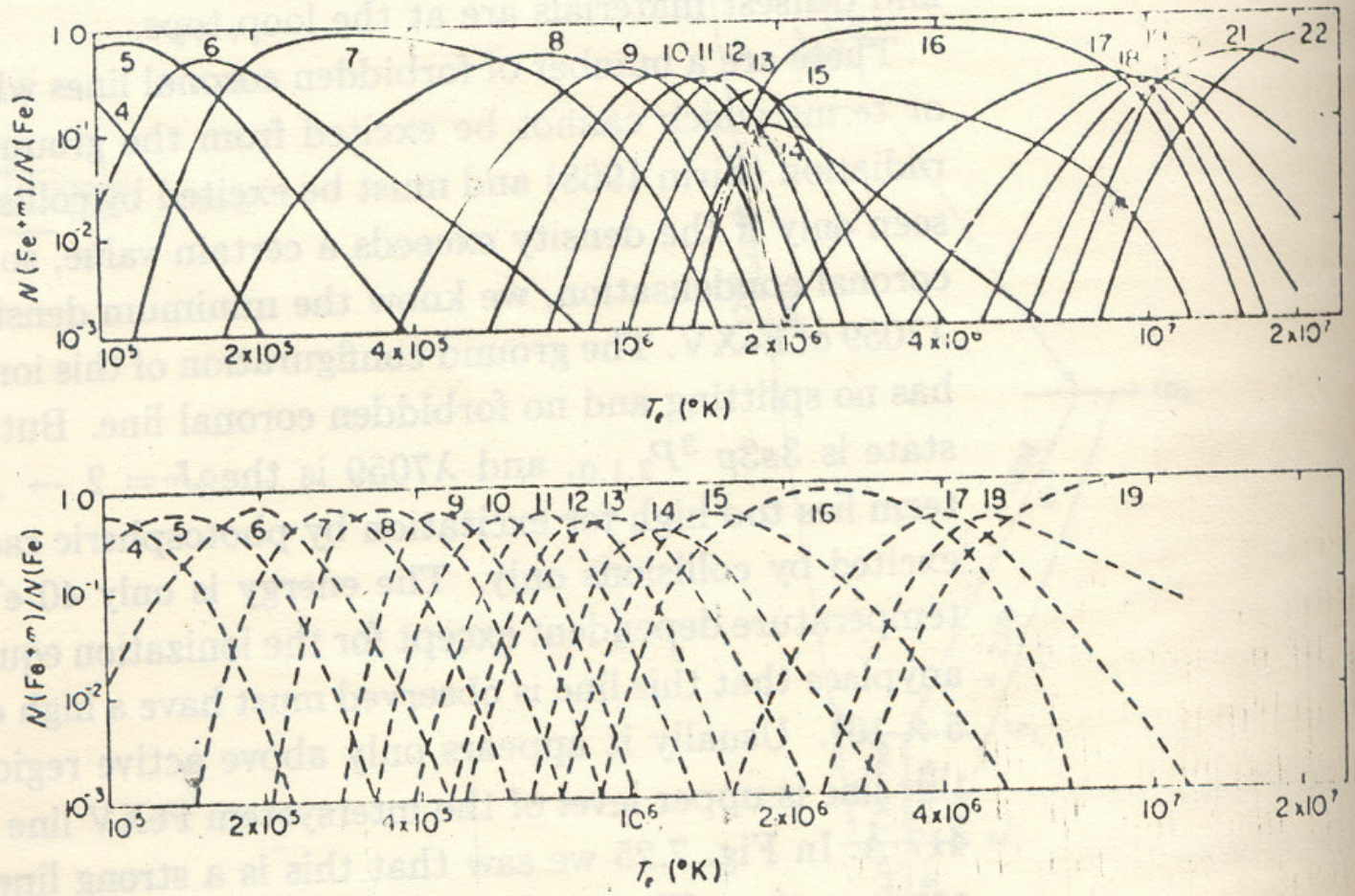
In my talk we shall talk about quiescent loops which are long lived and slowly varying coronal loops. The observed loops are not connected with activity such as flares.

Coronal loops

- Generally the coronal loops are considered to be isothermal in nature with the small increase in temperature with height. Loop tops are hotter as compared to foot points.
- The magnetic pressure is believed to be high as compared to the gas pressure in the coronal loops
- The loops are thin and are magnetically shielded from other temperature loops
- Mostly increase in line-width of coronal emission lines with height has been interpreted in terms of increase in non-thermal velocities with height due to coronal waves
- Do our systematic observations of coronal loops in coronal emission lines confirms these?

Abundances of ions as function of Temperature

8.11. Ionization equilibrium of Fe ions. (Jordan 1969)



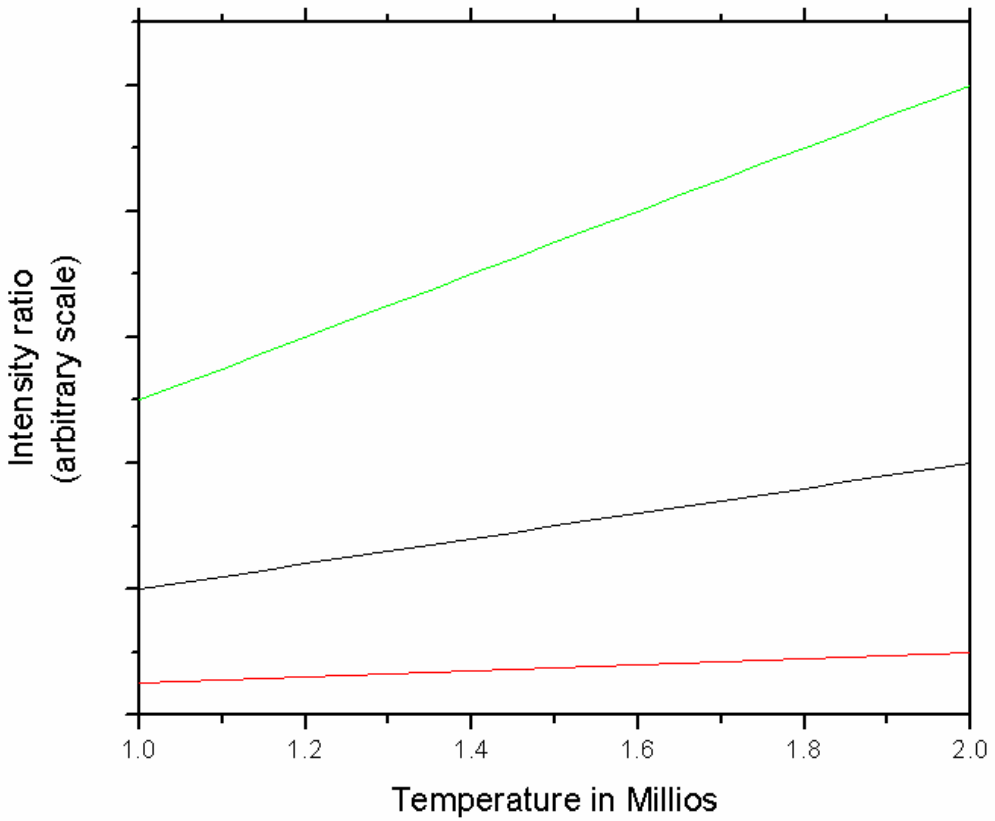
Expected Intensity Ratios

The abundances of Fe ions as function of temperature indicate that

Intensity ratio of [Fe xi] to [Fe x] should increase with temperature

Intensity ratio of [Fe xiii] to [Fe x] should increase steeply

Intensity ratio of [Fe xiv] to [Fe x] should increase more steeply

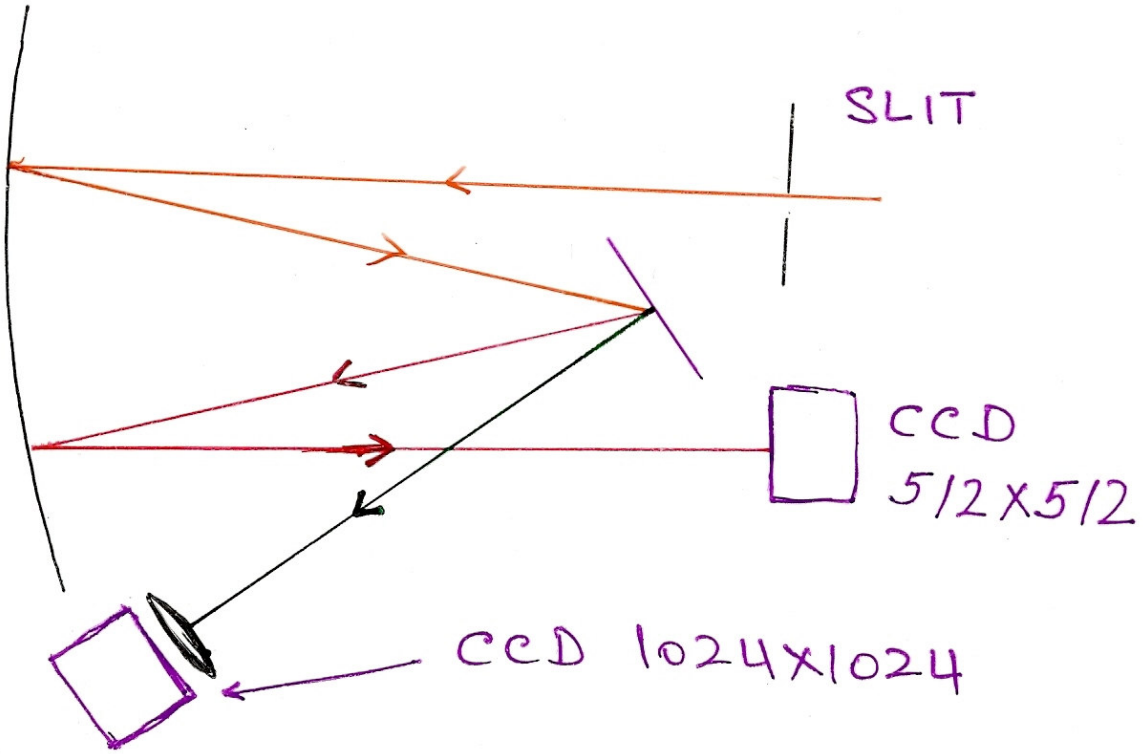


Fe X 1.0 MK

Fe xi 1.2 MK

Fe xiii 1.6 Mk

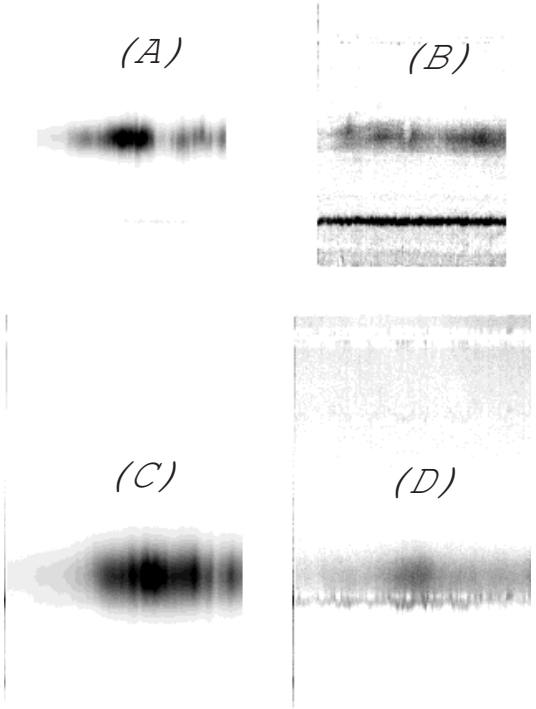
Fe xiv 1.8 MK



Possible combination of emission lines
for observations

S. No.	Littrow focus (Order)	Second focus (Order)
1.	6374 A (III)	5303 A (IV)
2.	6374 A (III)	10747 A (II) 10798 A (II)
3.	7892 A (III)	6374 A (IV)
4.	6374 A (IV)	7892 A (III)

Scattered light corrected spectra in the red and green emission lines at 50 arcsec (C & D) and at 300 arcsec above the solar limb (A & B)



Observed and corrected profiles of green, red and infra-red coronal emission lines

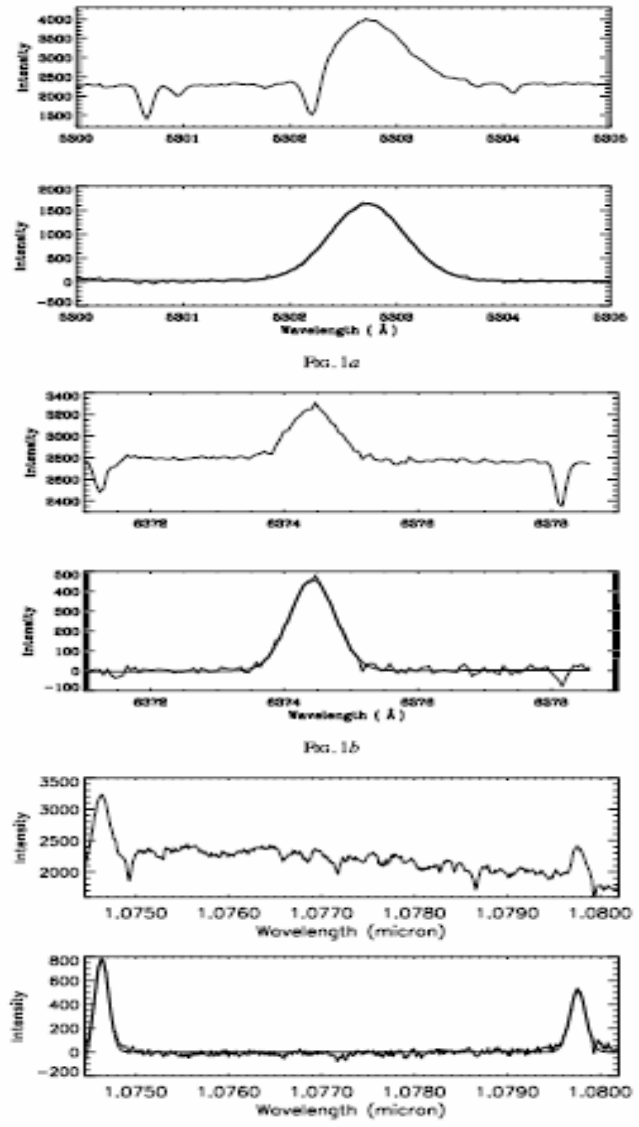
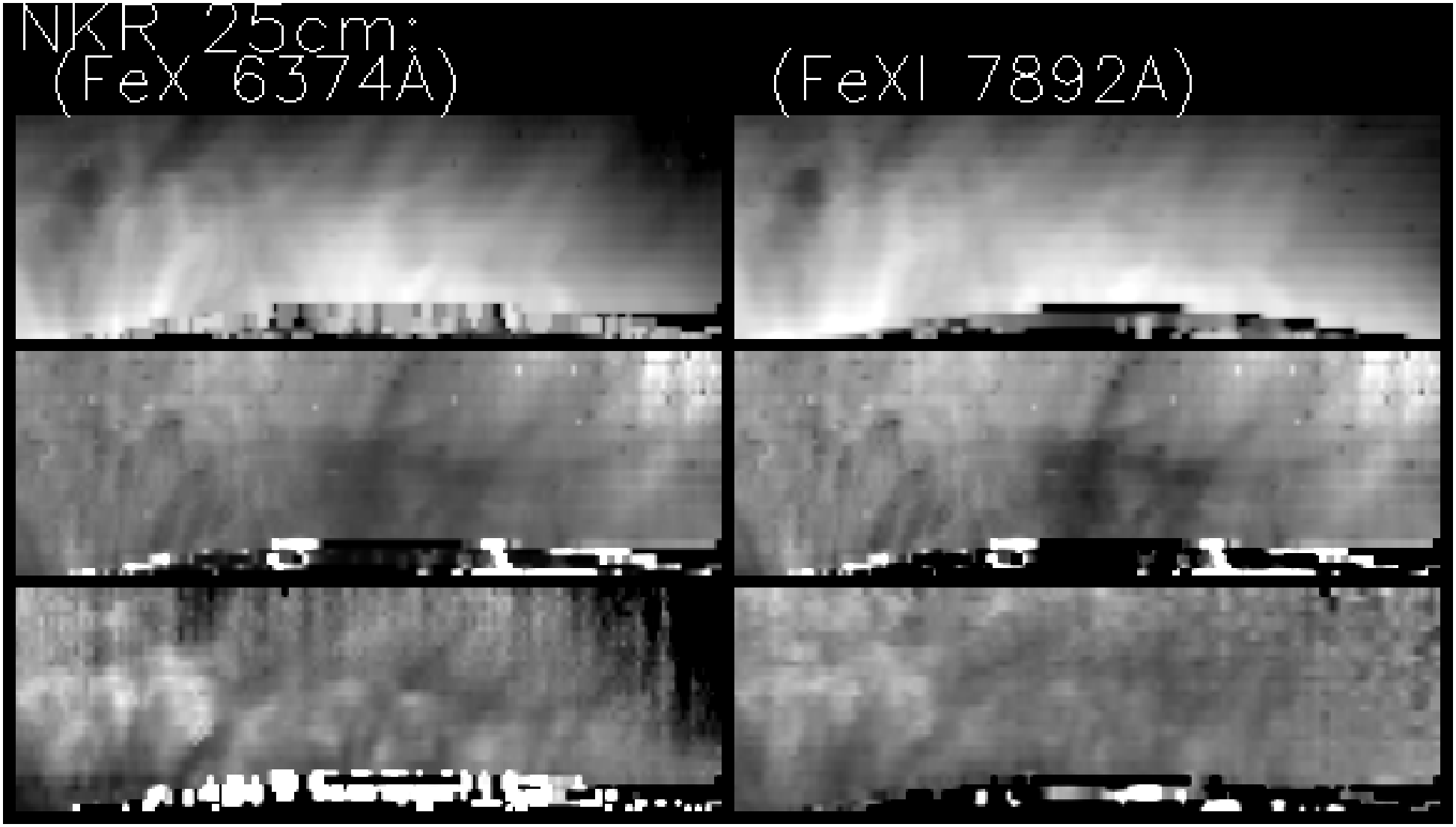
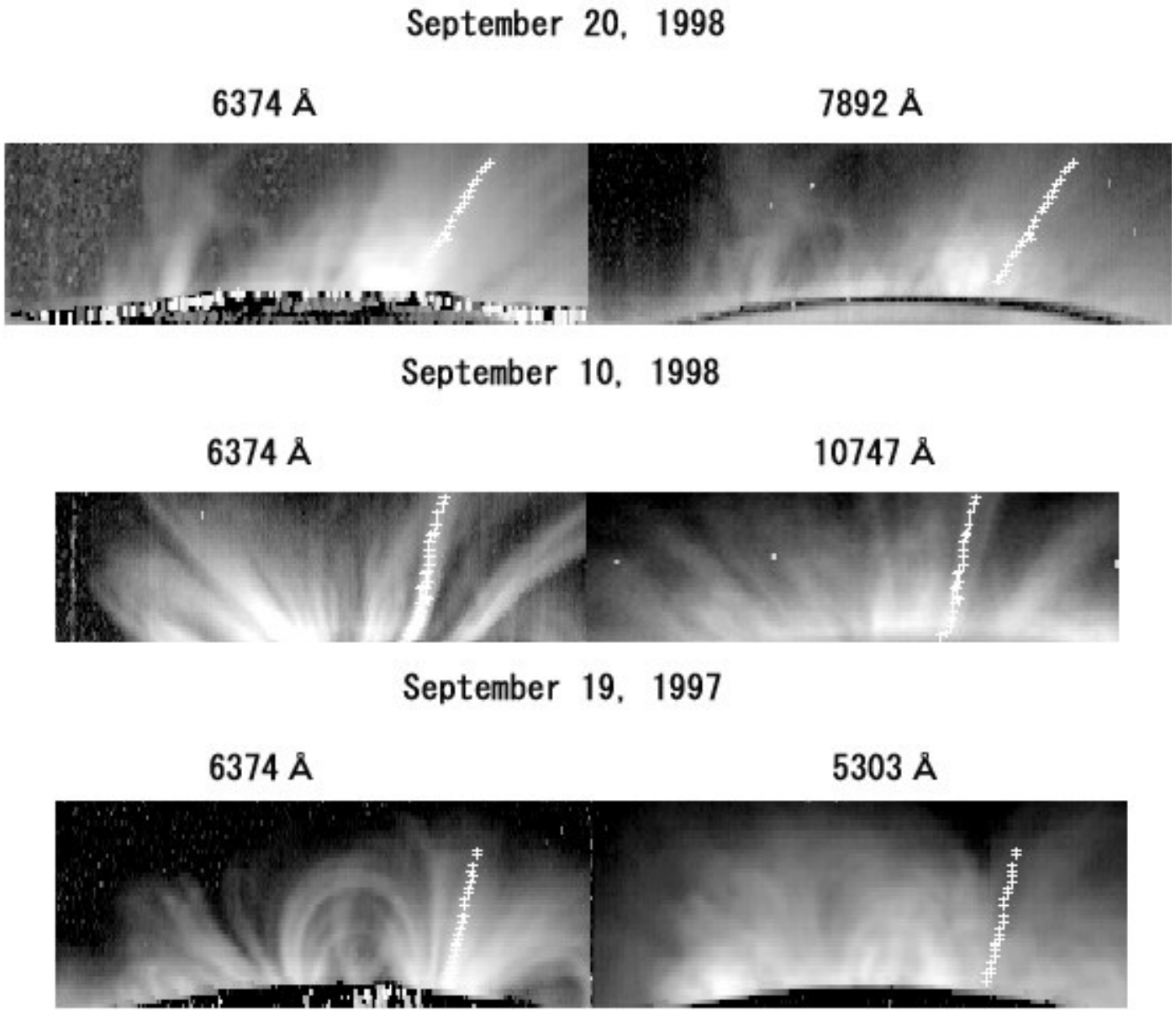


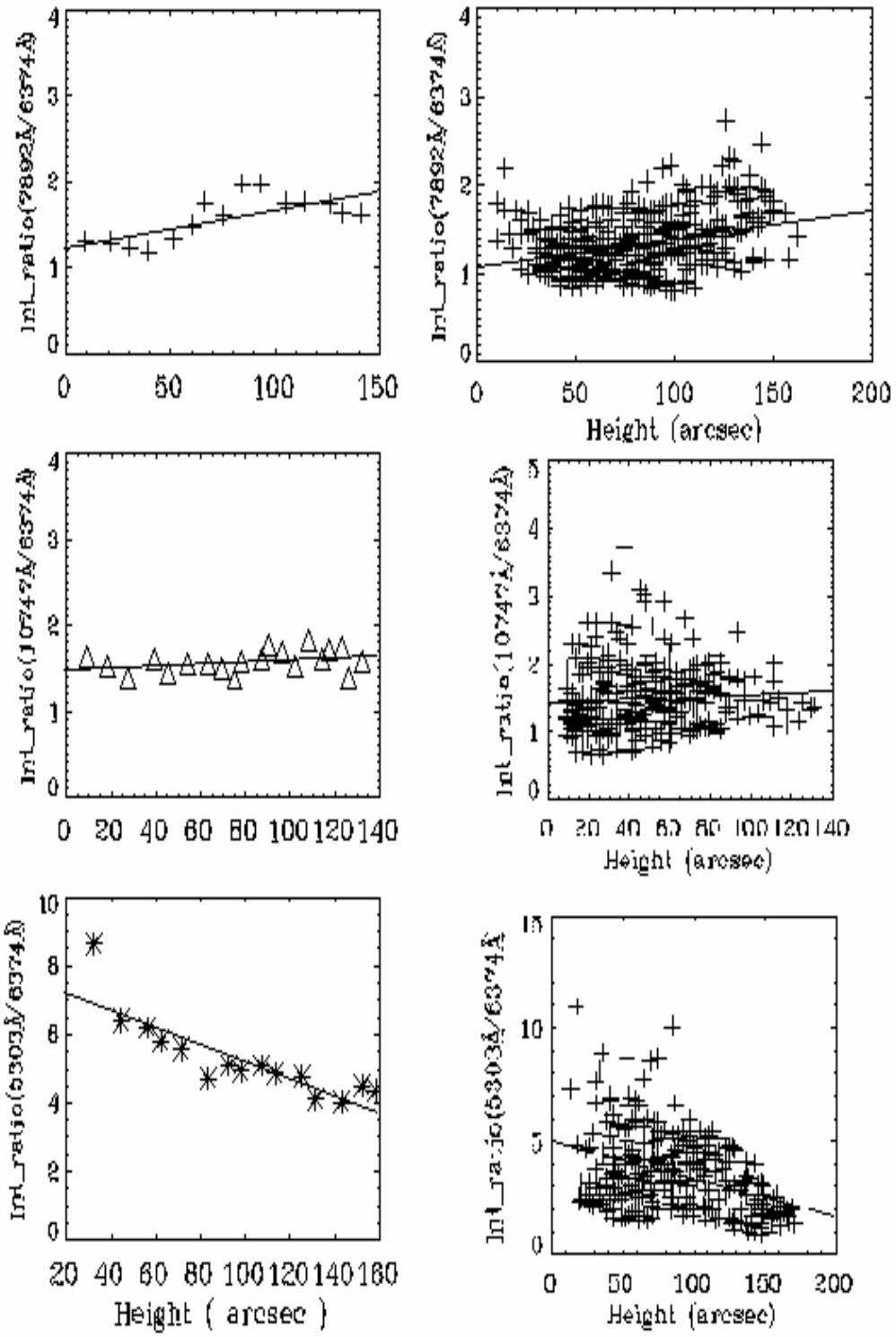
Fig. 1.—(*a*) Top panel shows a typical observed profile for the green coronal emission line (5303 A). The residual profile after corrections for the dark frame, flat field, and scattered light due to sky brightness, and a Gaussian fit to the profile are shown in the bottom panel. (*b*) Same as (*a*), but for the red coronal emission line (6374 A). (*c*) Same as (*a*), but for the two infrared emission lines at 10747 and 10798 A.

Distribution of intensity, line-of-sight velocity and line-width in a coronal region observed on Oct 27, 2003 simultaneously in [Fe x] and [Fe xi] coronal emission lines



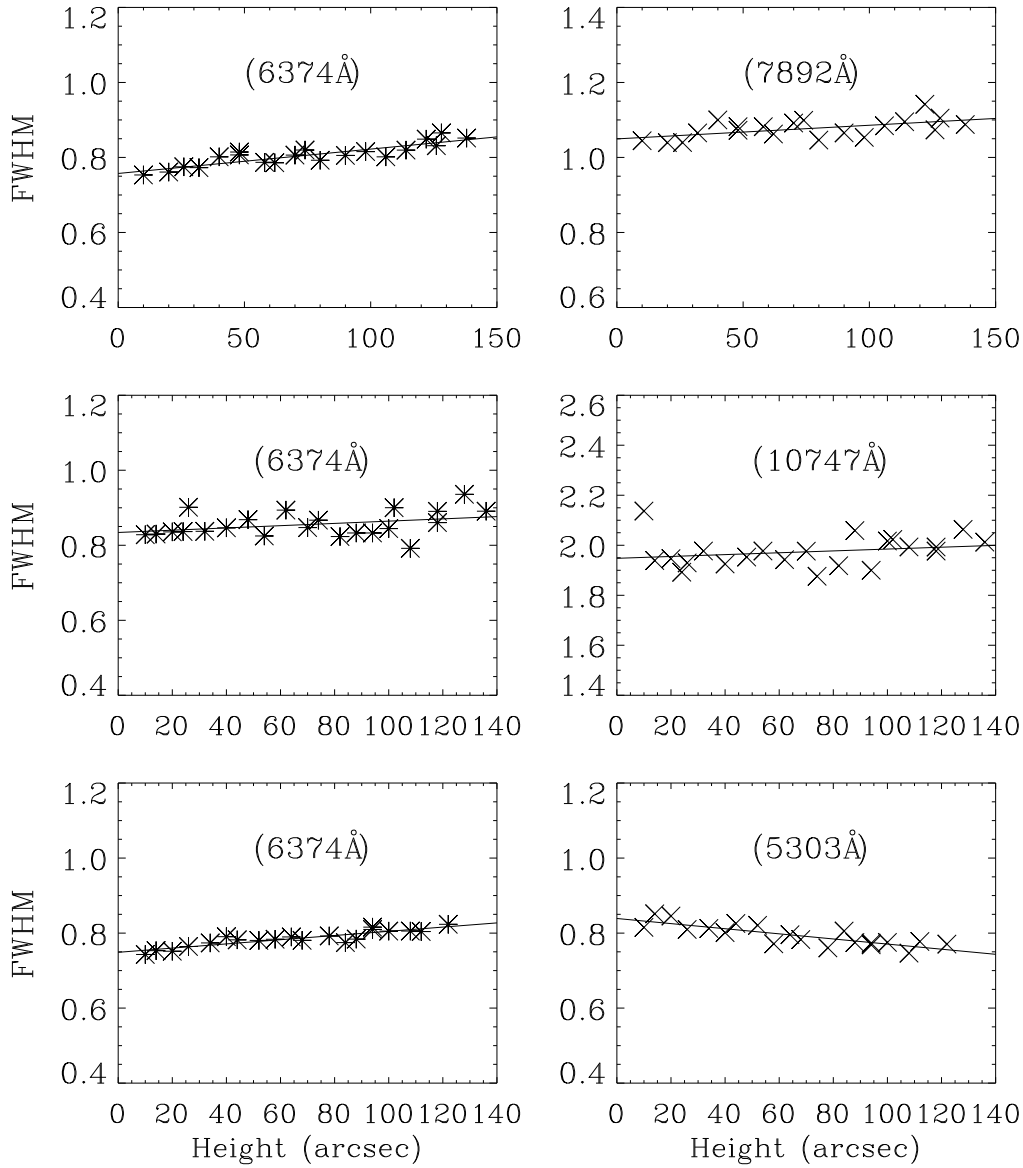
Three typical coronal loops selected by + marks to study the variation of line-widths with height above the limb

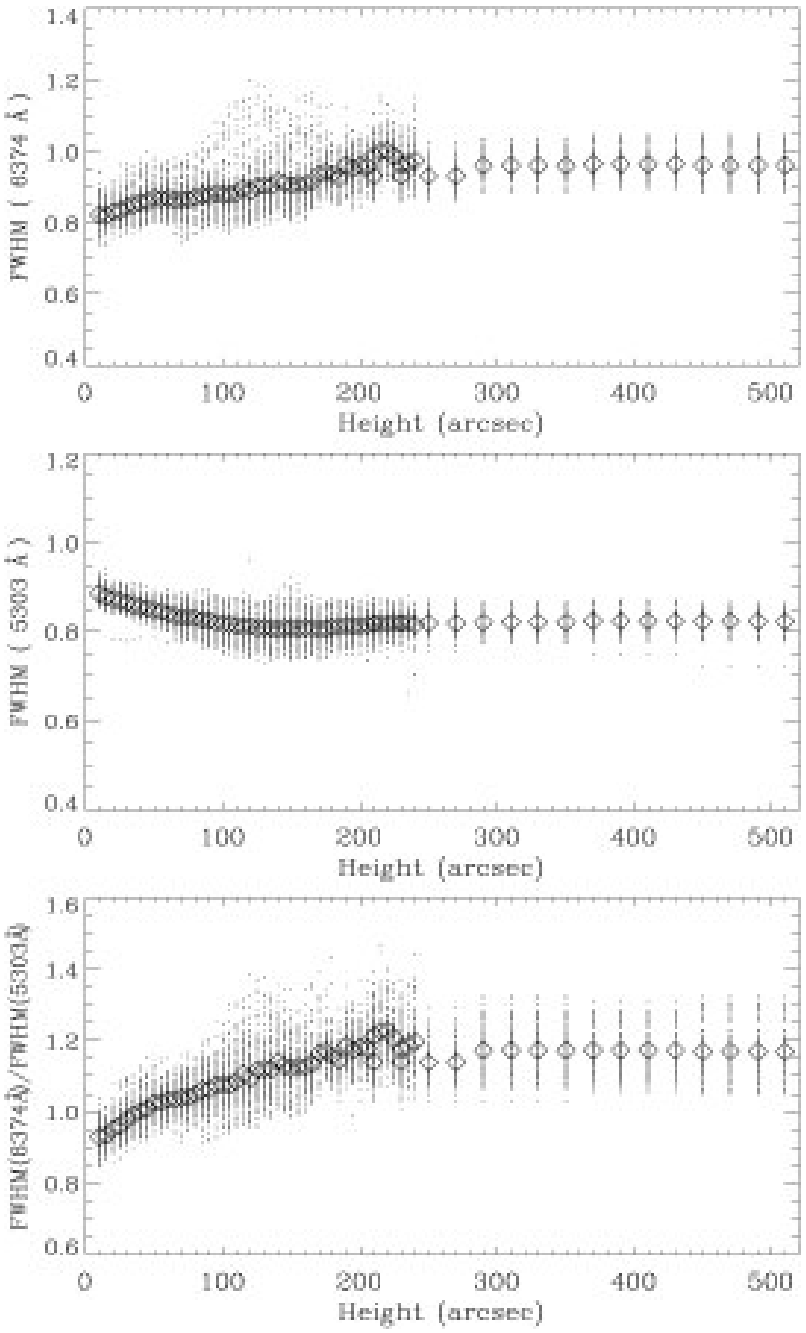




Left panels show the variation of intensity ratios for single loop and right side panels for all loops in the observed coronal region.

Typical variation of line width of emission lines with height for individual coronal loop



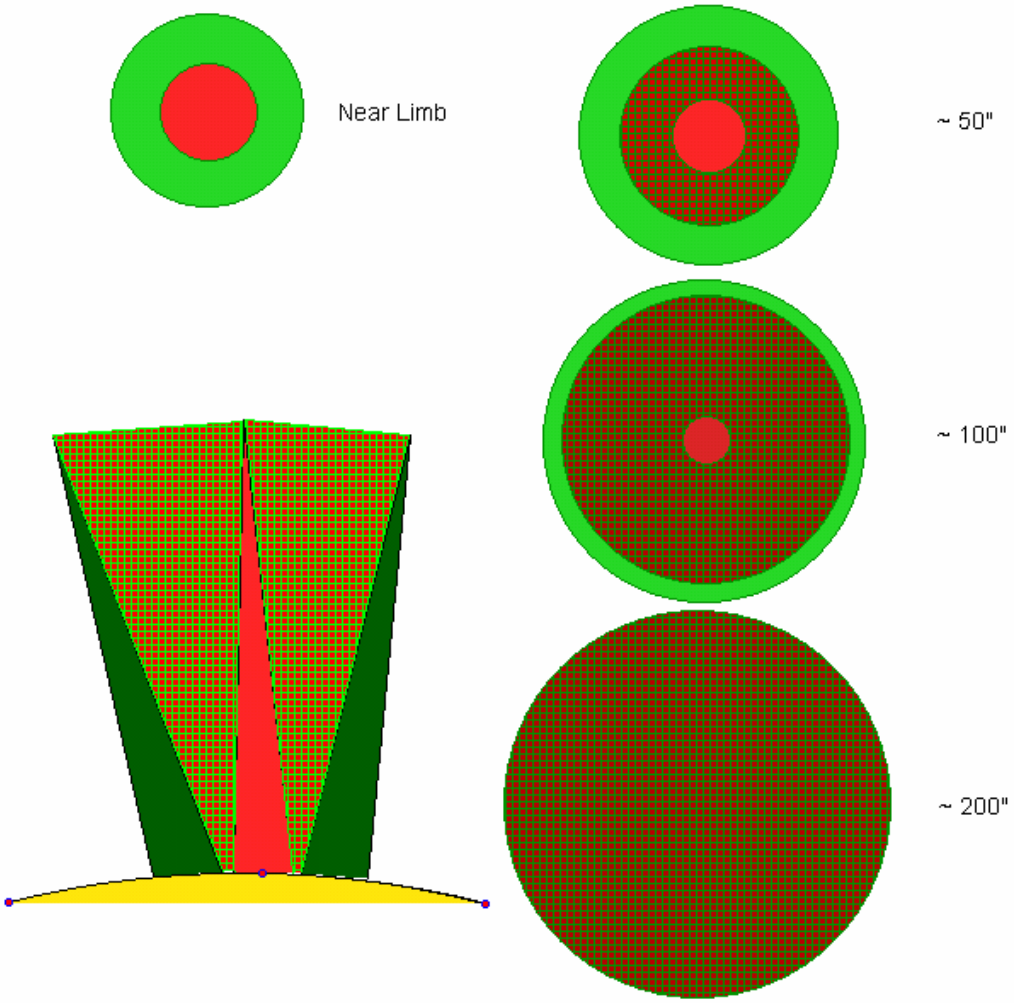


Variation of line widths of red and green coronal emission lines with height above the limb up to 500 arcsec. The line widths do not show any increase or decrease with height after about 250 arcsec

Discussions

- The observed variations considering one line at a time can be explained
- The increase in line width of [Fe x] line can be explained in terms of increase in the non-thermal velocity due to the existence of waves as has been done most of the time in case of this and similar other EUV emission lines.
- Similarly the decrease in line width of [Fe xiv] with height can be explained in terms of dissipation of waves
- The assumption here is that the different type of plasma behave differently but we have found that the different temperature plasmas are correlated.

- The monotonic increase in temperature or non-thermal velocity with height above the limb can not explain the observed variations in line widths and intensity ratios with height in all the lines simultaneously. The observed variations can be explained if we assume that the thin coronal loops are not magnetically shielded. The different temperature plasma interact with each other, probably due to collision and the whole of plasma attains uniform temperature and non-thermal velocity at larger heights.



The cartoon suggests mixing of plasma with increasing height. It explains all these observational results. It may raise many questions considering the present day theoretical scenario

Summary

- All these observational results can be explained by assuming that the coronal loops are not magnetically shielded and multi-temperature plasma coexists.

THANK YOU

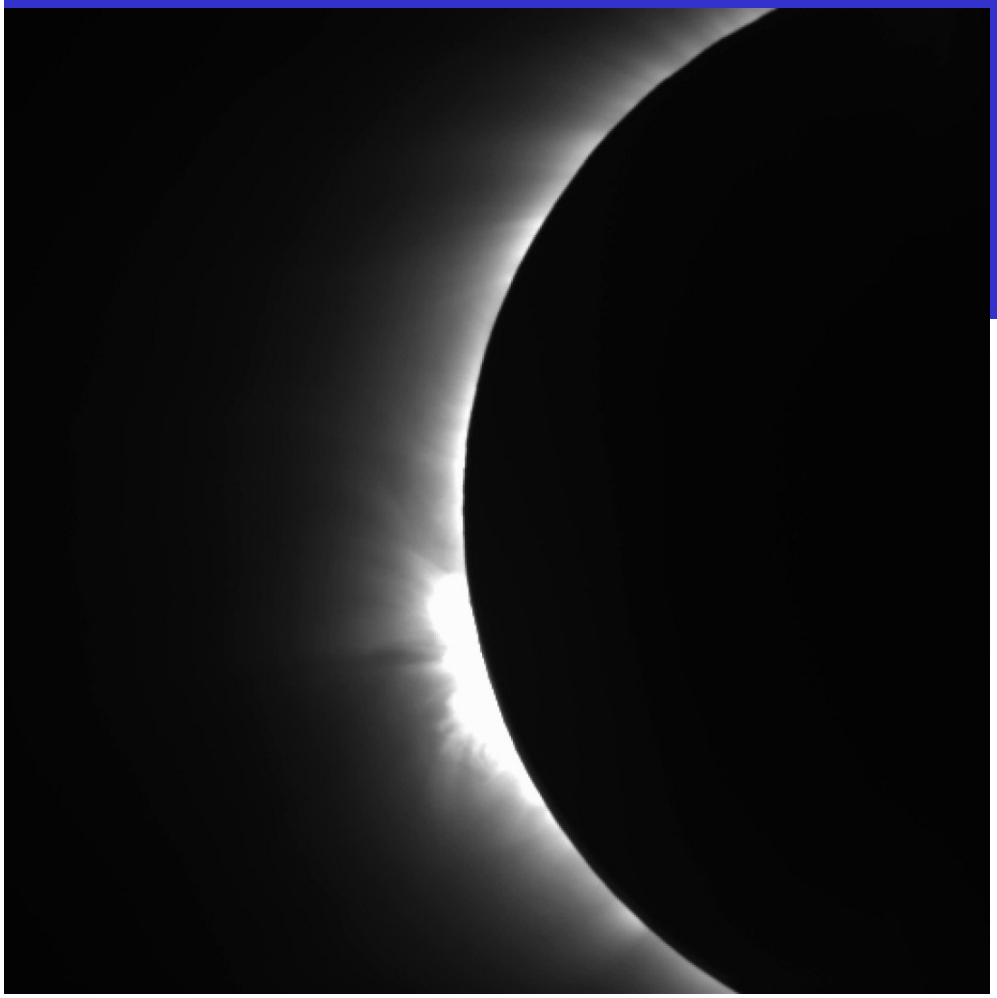


IMAGE TAKEN WITH RED FILTER, 2K X 2K CCD, 4 X 4 BINNING,EXPOSURE TIME 300ms DURING THE TOTAL SOLAR ECLIPSE OF MARCH 29, 2006

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Do the line-widths of emission lines increase with height above the limb?

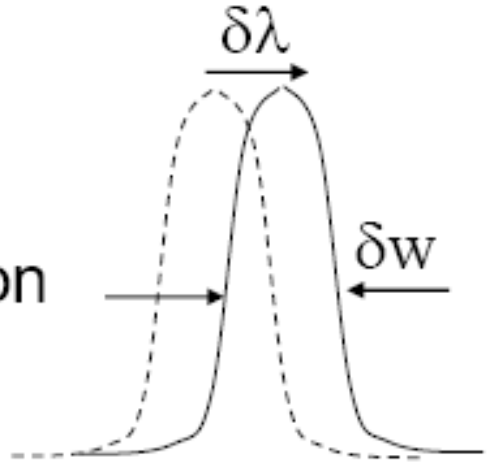
Observables

Information from a single emission line

Line intensity

Line shift by Doppler motion

Line width: temperature, non-thermal motion



Information from selected two line ratio

Temperature

Density

Spectroscopic observations:

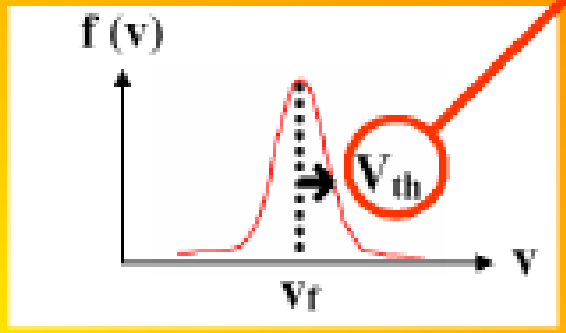
The line width : a mix of 2 informations

Gaussian width :
(optically thin)

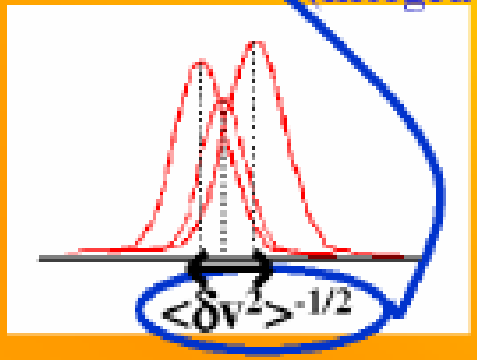
$$\sigma^2 = \frac{\lambda^2}{2c^2}\left(\frac{2kT}{M} + \xi^2\right) + \sigma_I^2.$$

Instrumental width

Thermal Doppler effect
(one volume element) :



« non-thermal » velocity
(integration effect)



- **Temperature** : thermal Doppler effect in one volume element
- « **non-thermal velocity** », or « unresolved velocity » : results from the integration over a lot of volume elements driven by fluid velocity fluctuations :
  - → on the line of sight
  - → on spatial and temporal scales smaller than the resolution scale

Source of velocity fluctuations : Alfvén waves, turbulence ?

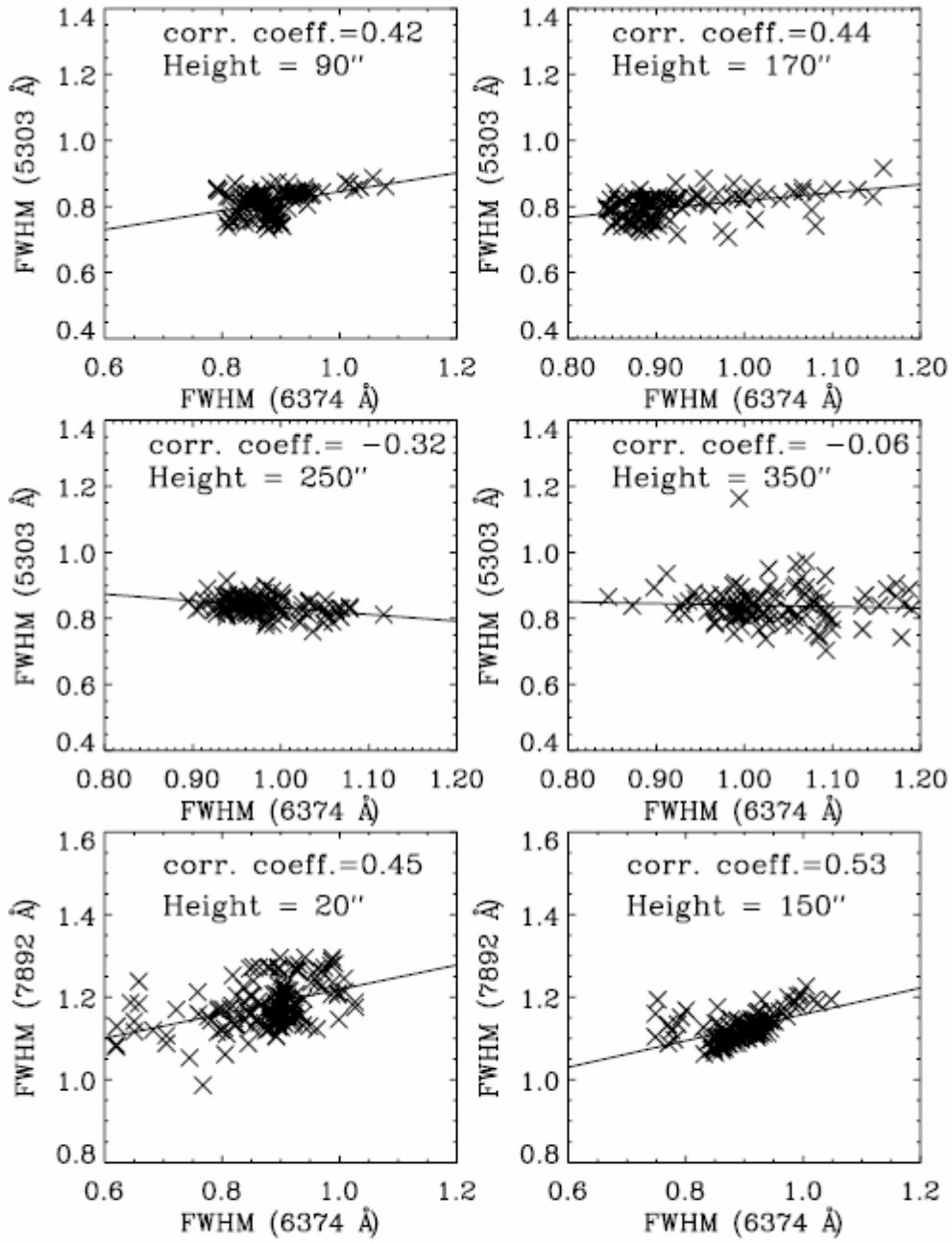


FIG. 6.—*Top and middle:* FWHM of the 5303 Å line against the FWHM of the 6374 Å emission line at the four heights, namely, 90″, 170″, 250″, and 350″, for the observations made on 2003 October 26. *Bottom:* FWHM of the 7892 Å vs. FWHM of the 6374 Å line at 20″ and 150″ for the observations made on 2003 October 27.

Considering the abundances of ions as a function of temperature, the intensity ratios of FeXI, FeXIII and FeXIV with respect to FeX are expected to show the trend shown in figure, Fe X, Fe xi, Fe xiii and FeXIV represents plasma at temperatures of 1.0, 1.2, 1.6 and 1.8 MK