

Magnetic Nature of Coronal loops

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Introduction

- Generally the coronal loops are considered to be isothermal in nature
- 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 systematic observations of coronal emission lines confirm these?

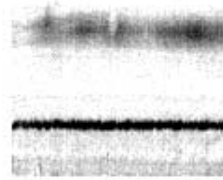
Observations

- Systematic observations of 4 coronal emission lines in the visible wavelengths with 25 cm coronagraph of Norikura observatory were obtained from 1997 to 2004
- Choosing two emission lines simultaneously; 6374 [Fe x] & 7892 [Fe xi] or 6374 [Fe x] & 5303 [Fe xiv] or 6374 [Fe x] & 10747 [Fe xiii]
- Most of the raster scan covered coronal region of about 500 x 200 arc sec. Some covered coronal region of 500 x 500 arc sec.
- Error estimate in FWHM measurements are about 2 mÅ near the limb and about 5 mÅ at 500 arc sec height
- Recently we have obtained observations in 4 emission lines simultaneously; 7892, 10747, 10798 and 5303 lines

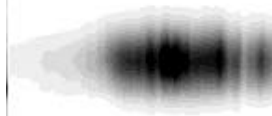
(A)



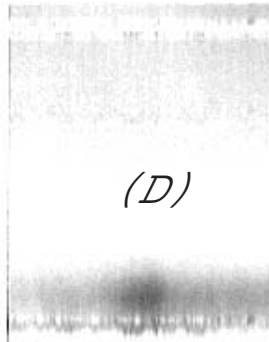
(B)



(C)



(D)



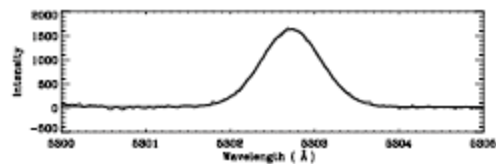
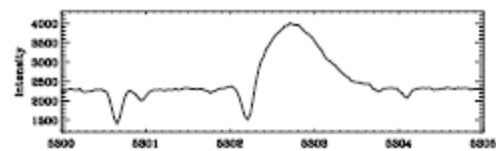


FIG. 1a

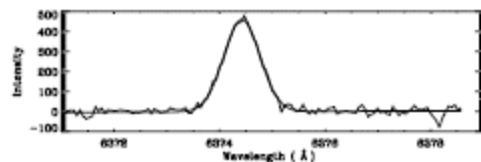
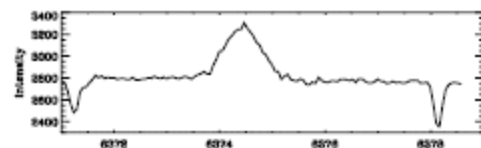


FIG. 1b

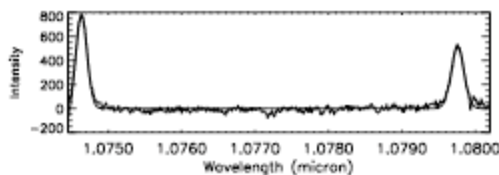
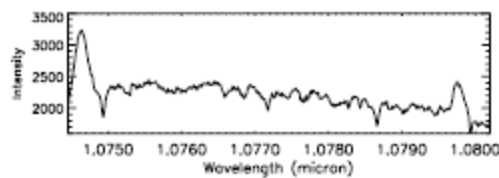
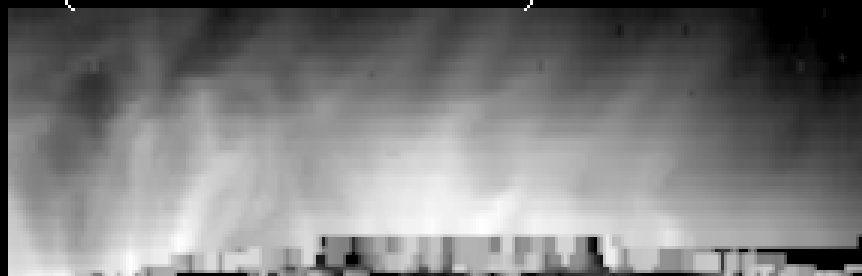


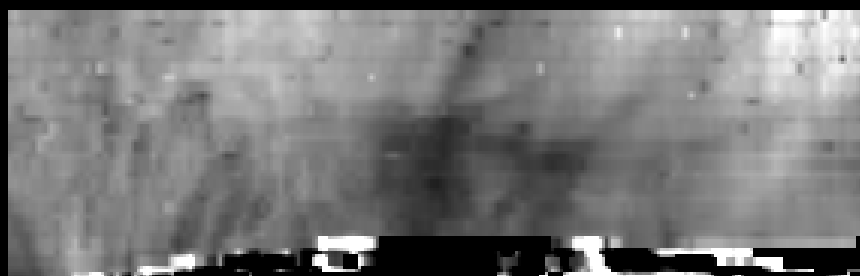
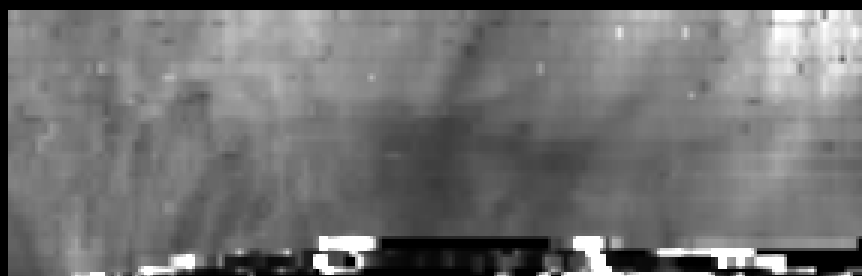
FIG. 1c

FIG. 1.—(a) Top panel shows a typical observed profile for the green coronal emission line (5303 Å). 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 Å). (c) Same as (a), but for the two infrared emission lines at 10747 and 10798 Å.

NKR 25cm:
(FeX 6374A)



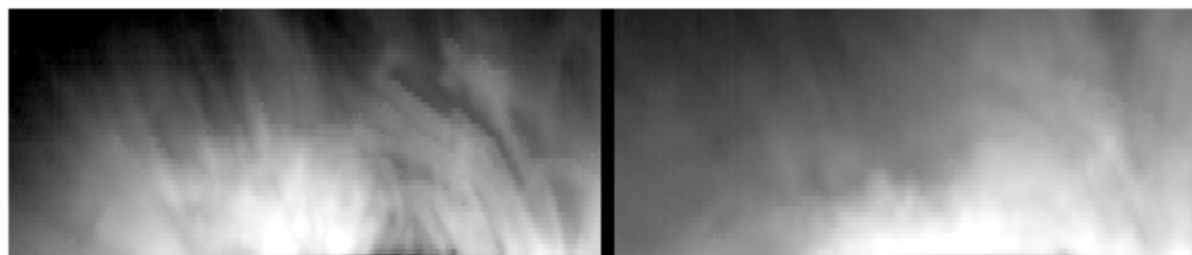
(FeXI 7892A)



October 26, 2003

6374 Å

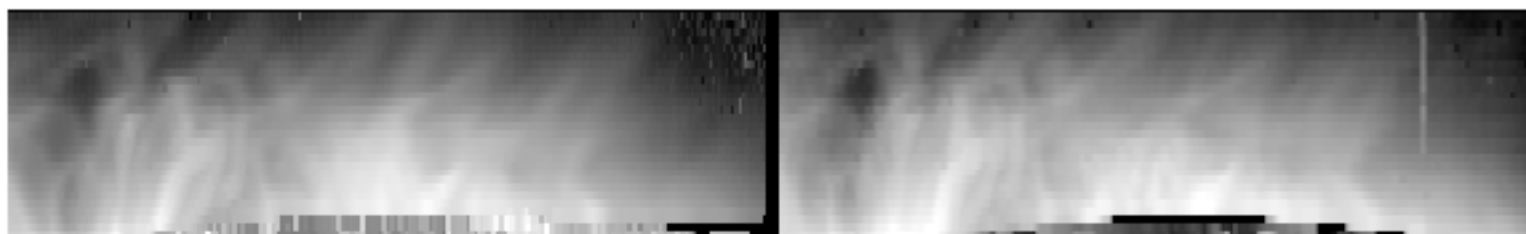
5303 Å



October 27, 2003

6374 Å

7892 Å

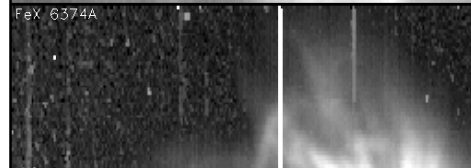


09 Sep.1998: 22:27UT

FeXIII 10747A



FeX 6374A

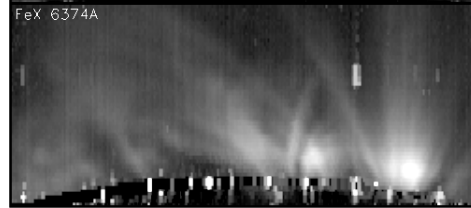


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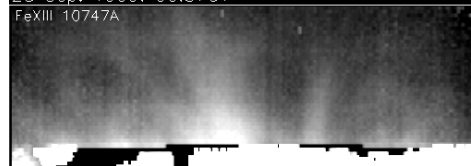


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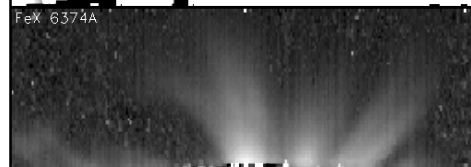


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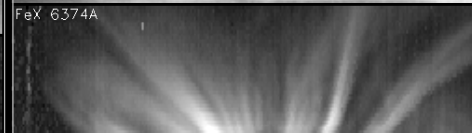


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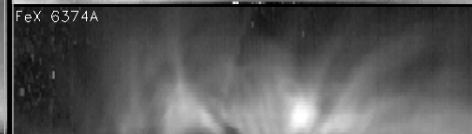


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FeXIII 10747A

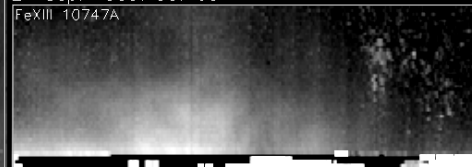


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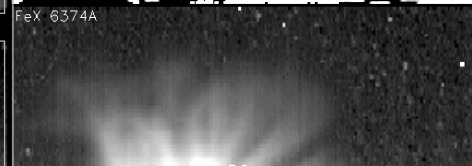


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FeXIII 10747A



FeX 6374A

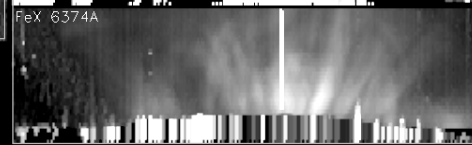


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FeXIII 10747A

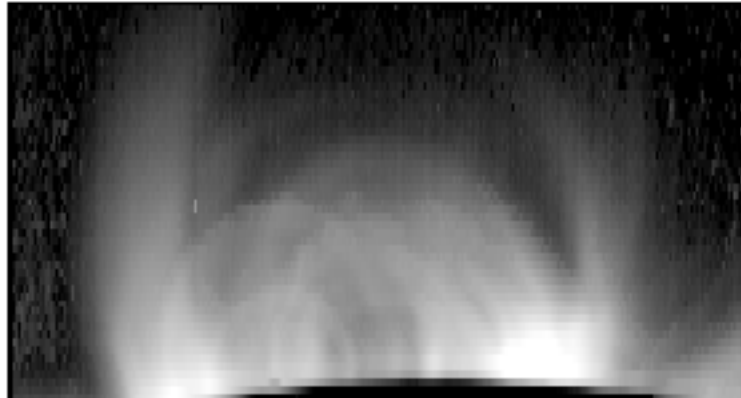


FeX 6374A

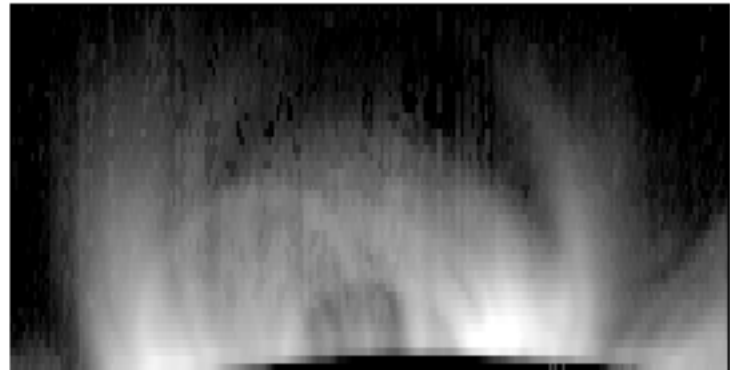


October 9, 2003

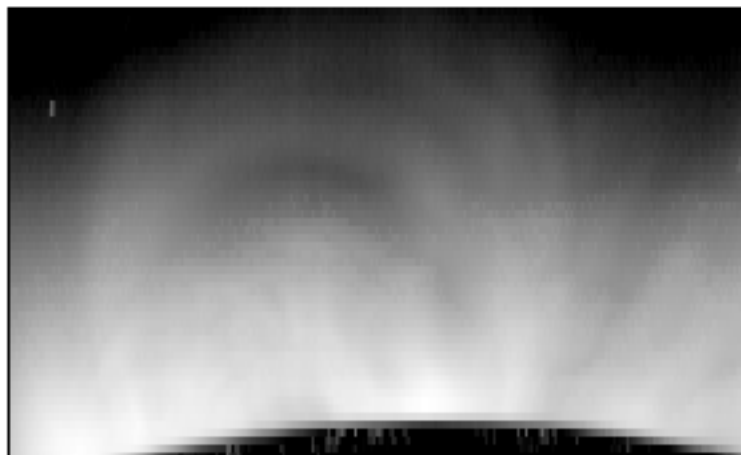
6374 Å



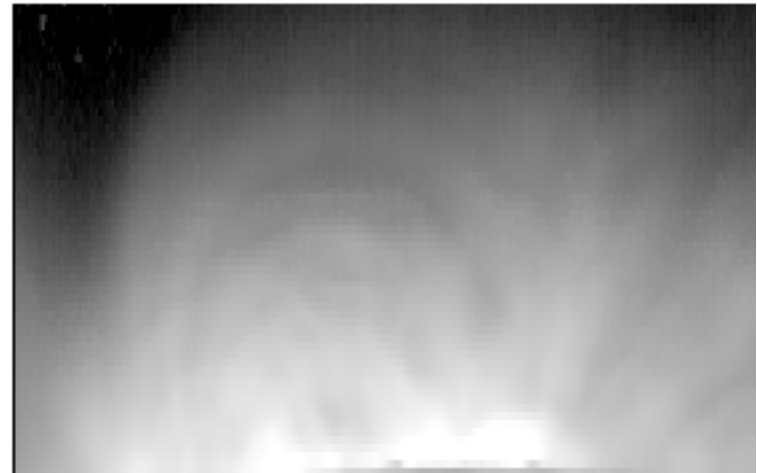
7892 Å



10747 Å



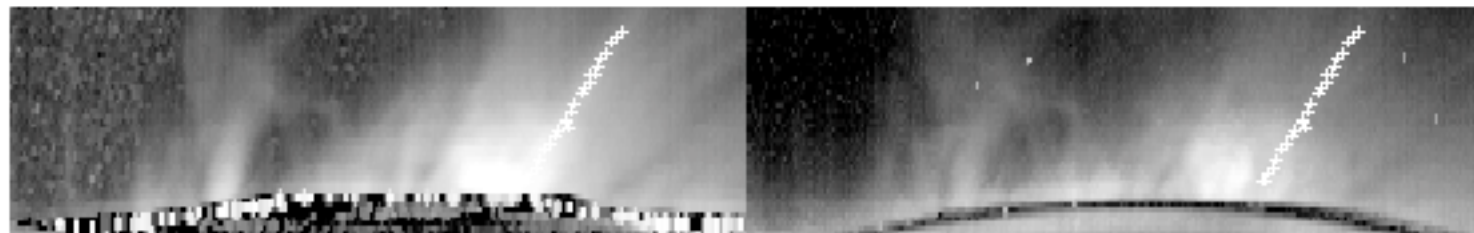
5303 Å



September 20, 1998

6374 Å

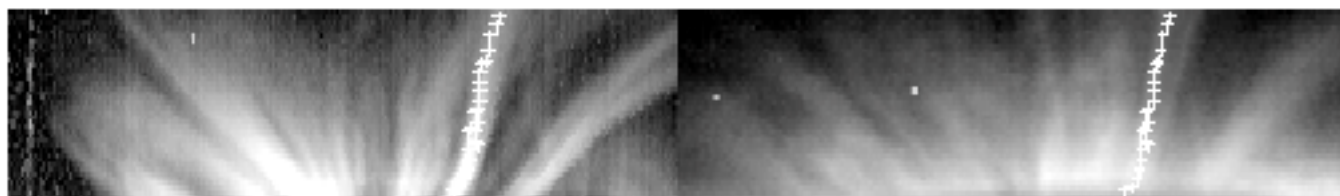
7892 Å



September 10, 1998

6374 Å

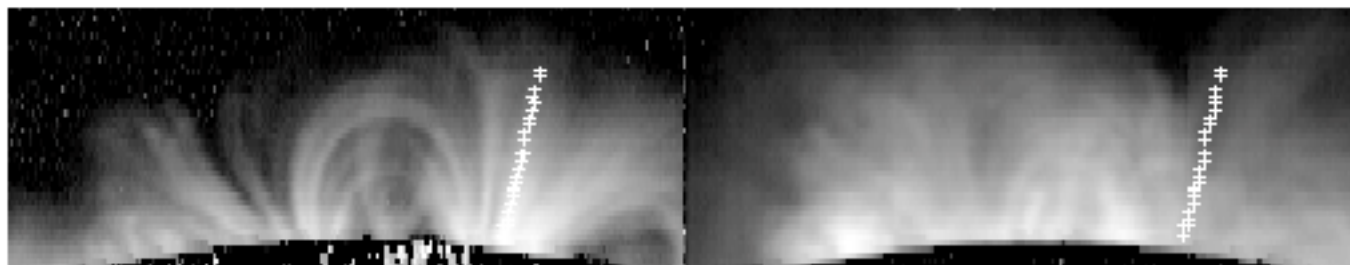
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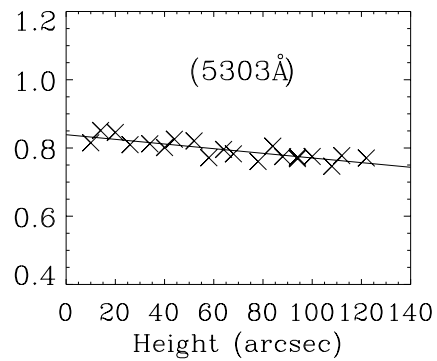
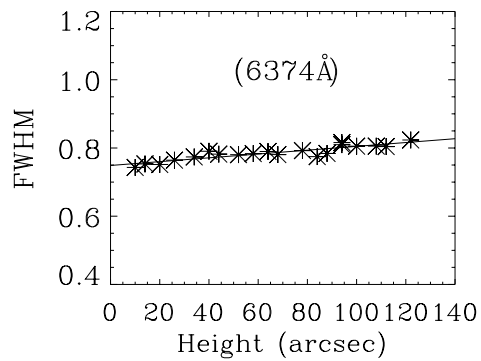
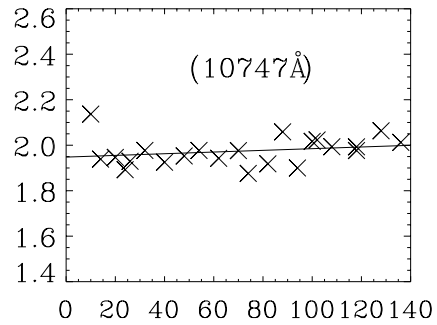
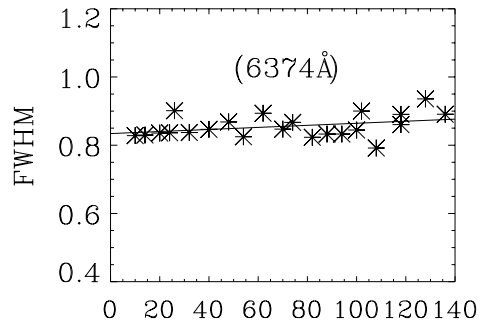
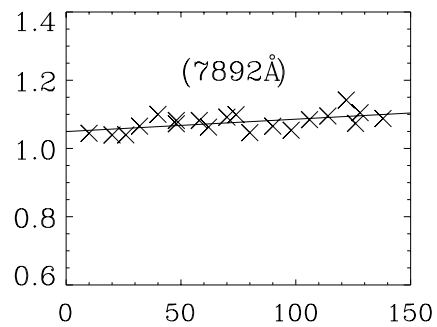
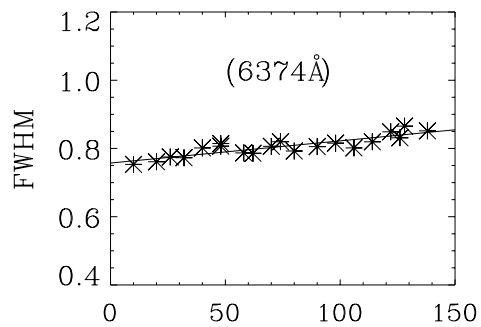


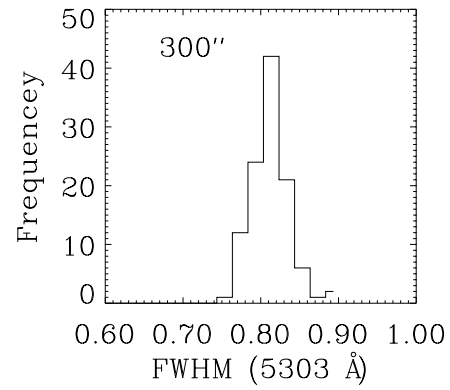
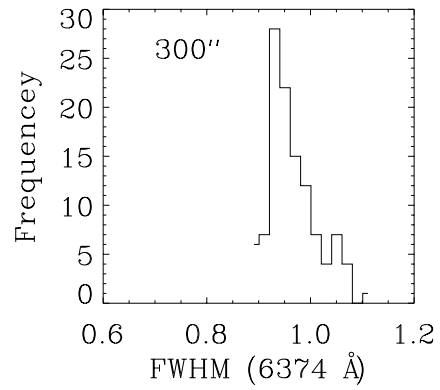
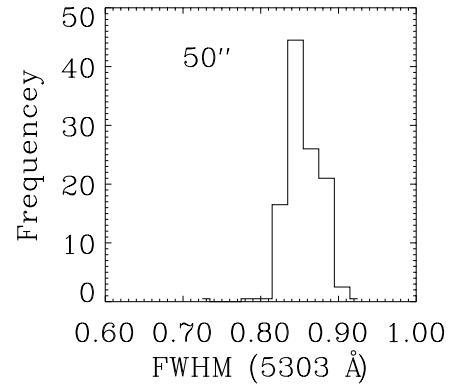
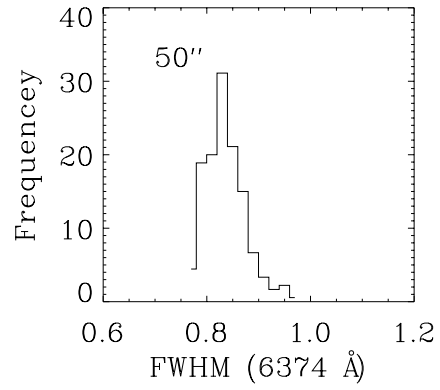
September 19, 1997

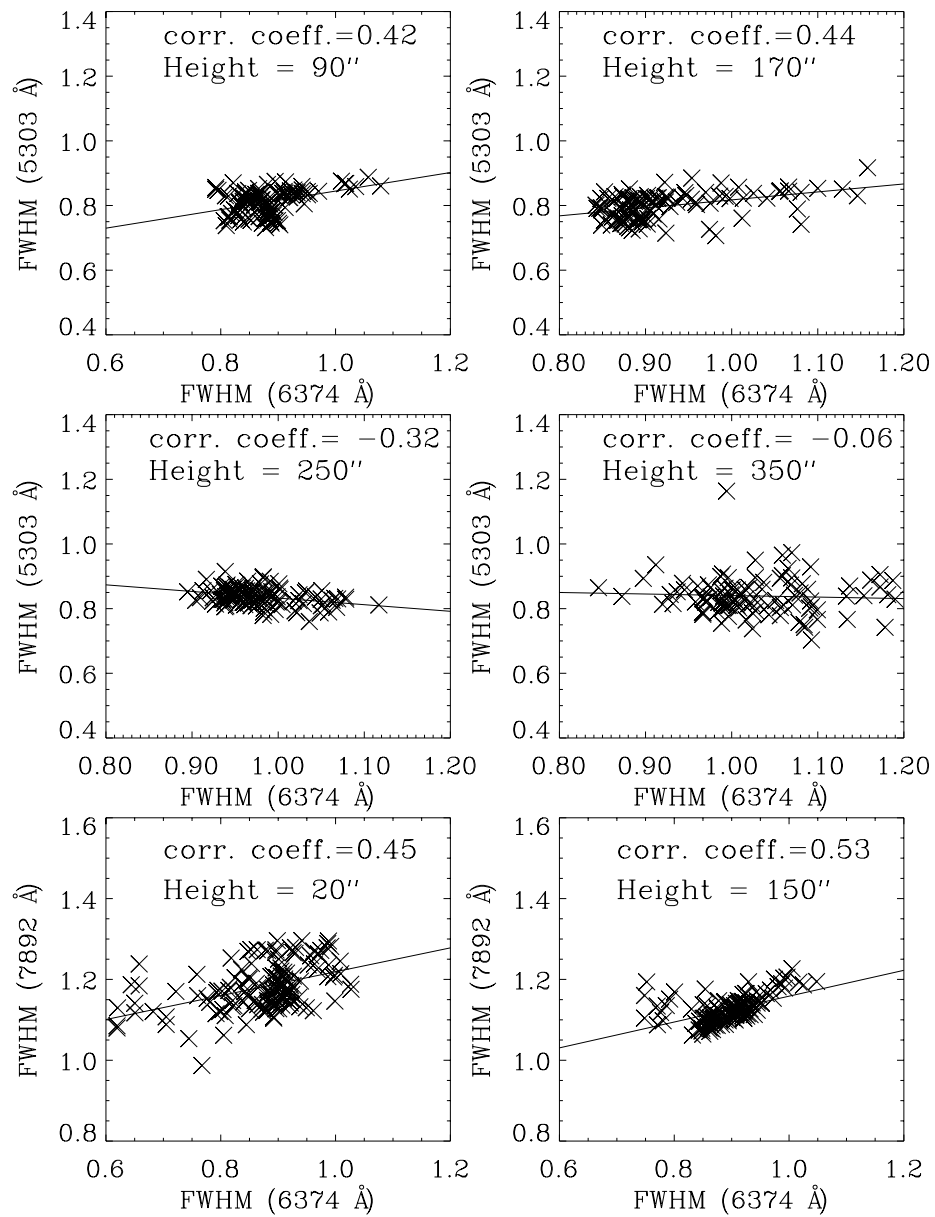
6374 Å

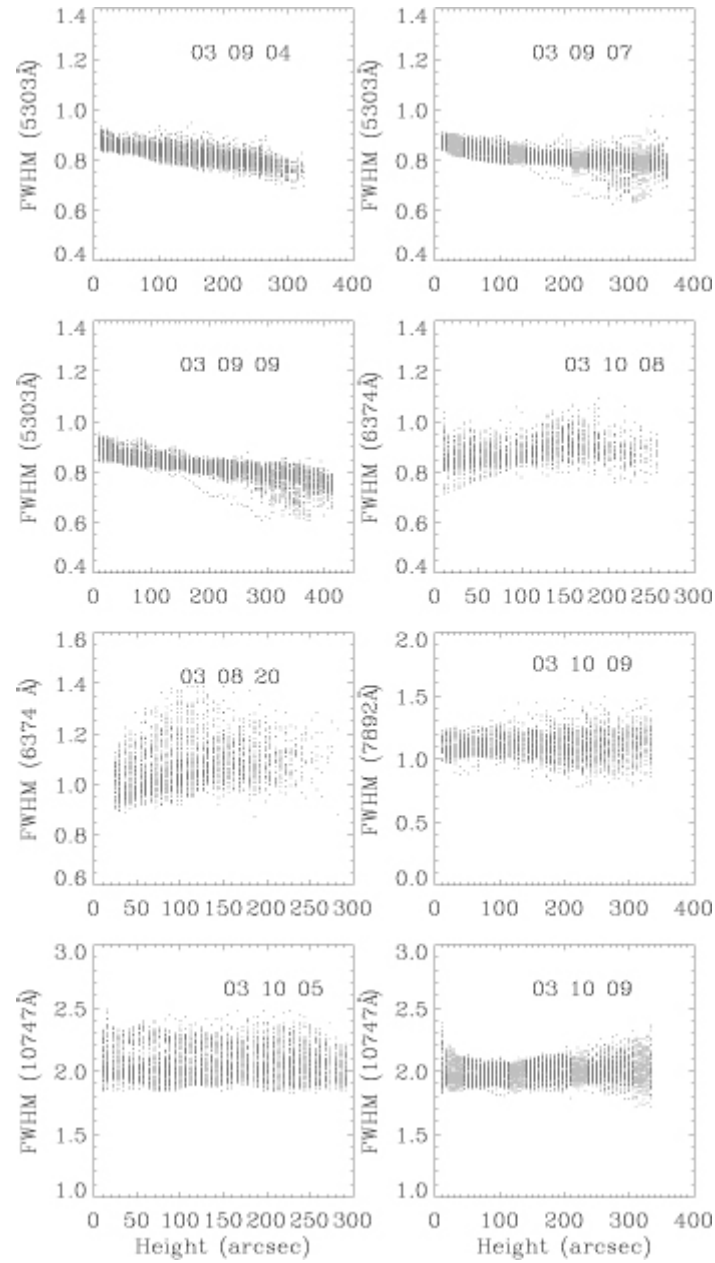
5303 Å

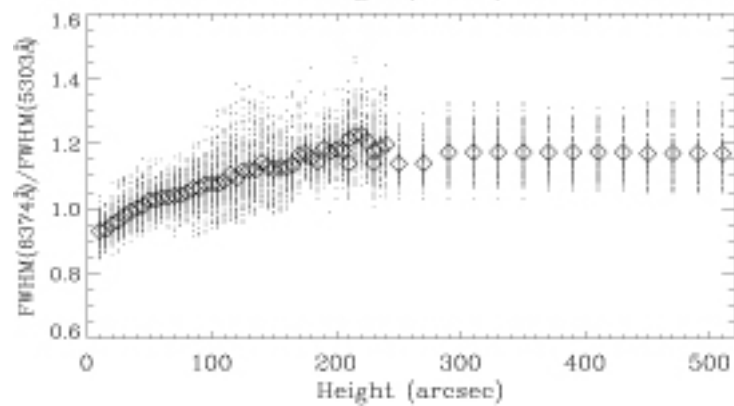
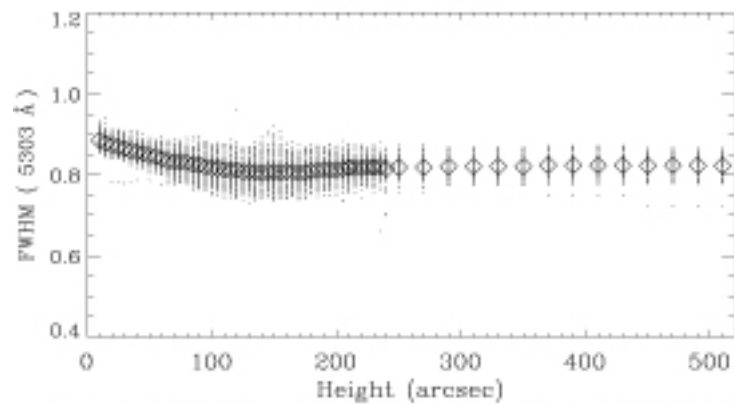
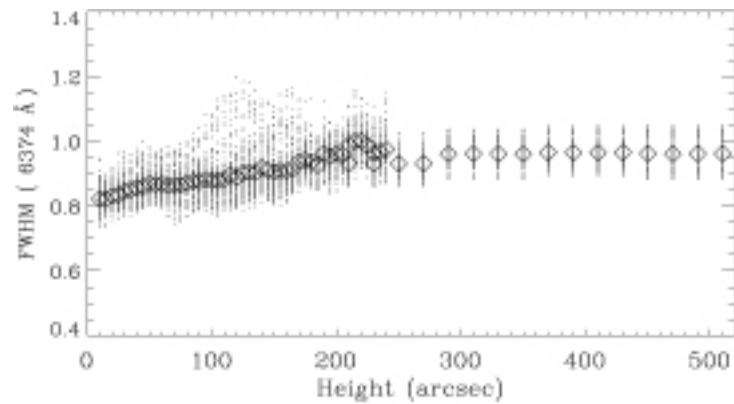








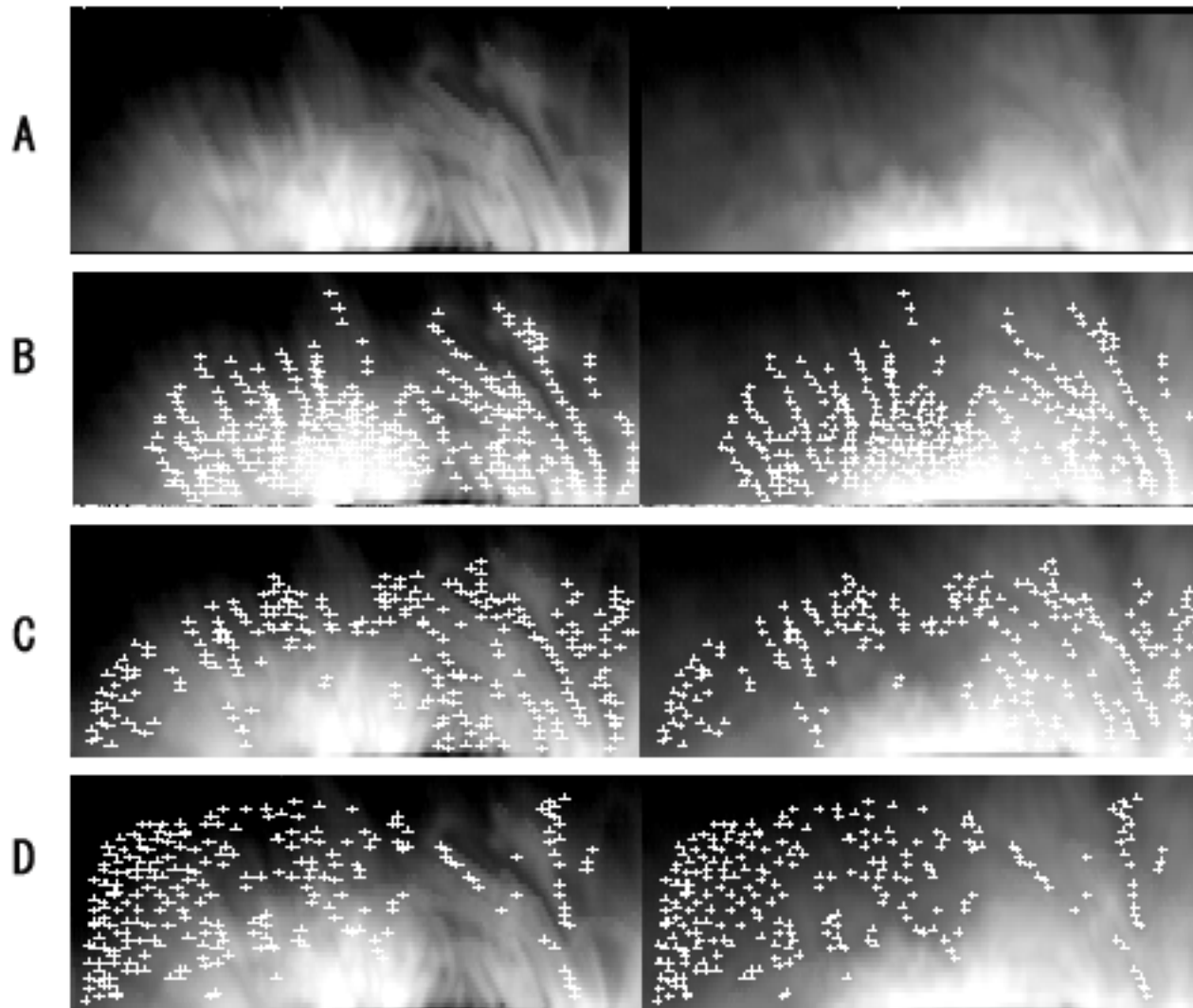


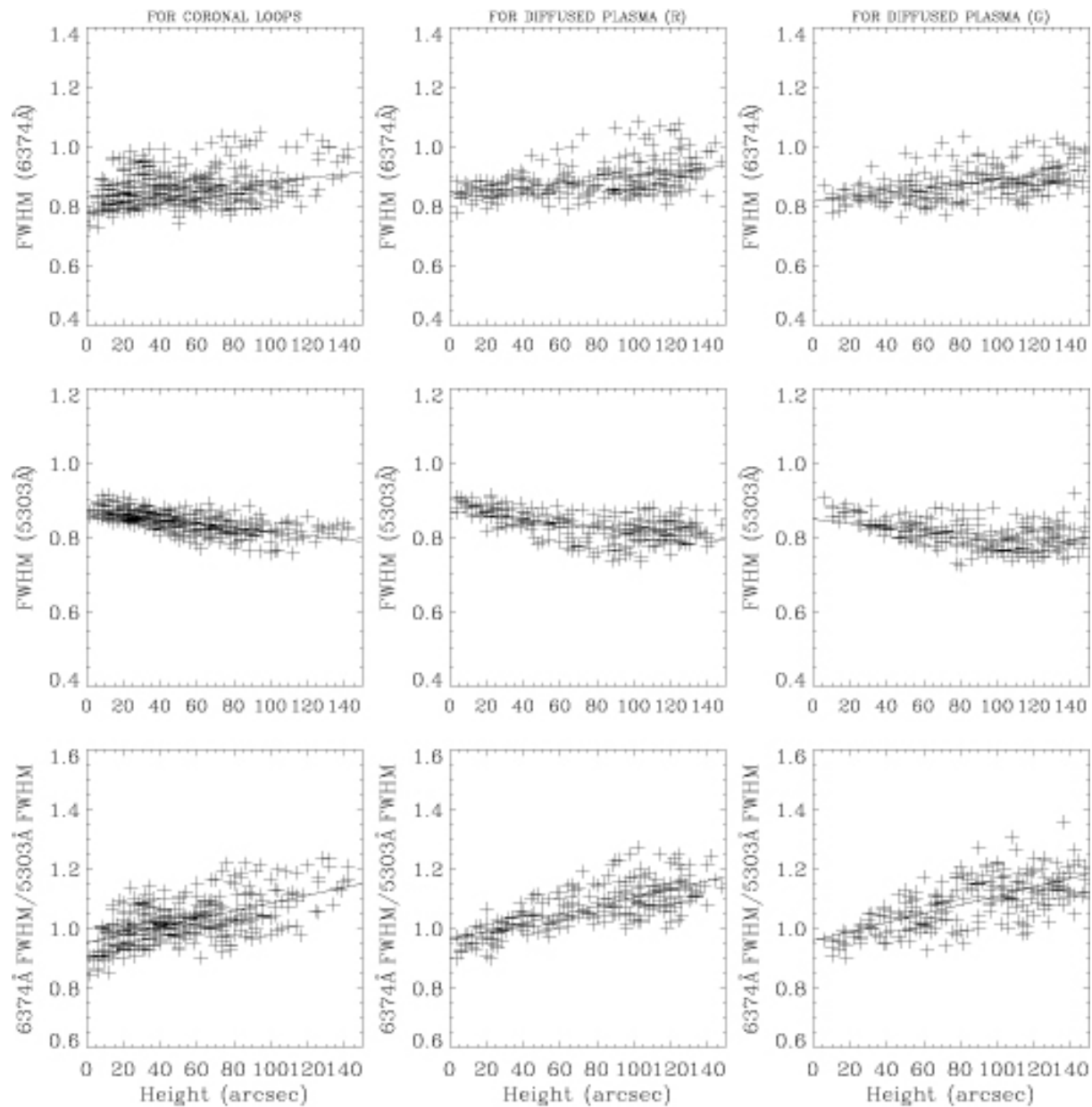


October 26, 2003

6374 Å

5303 Å

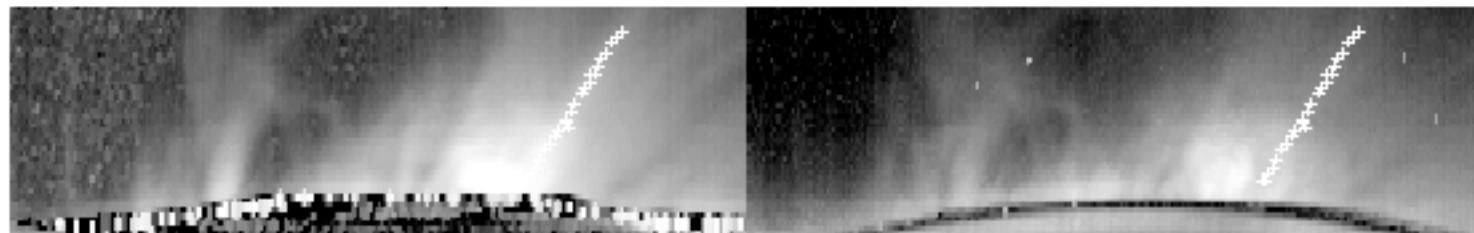




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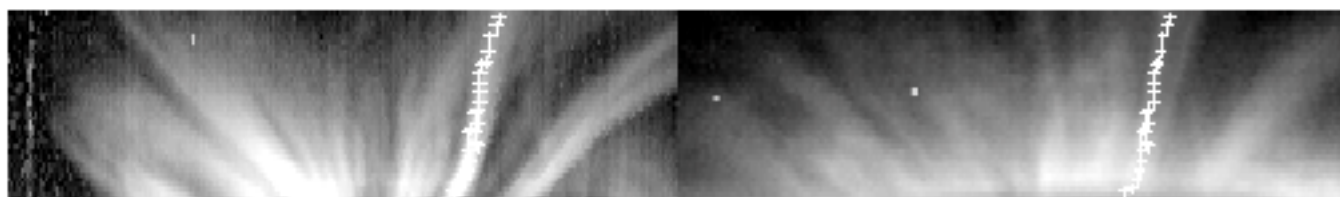
7892 Å



September 10, 1998

6374 Å

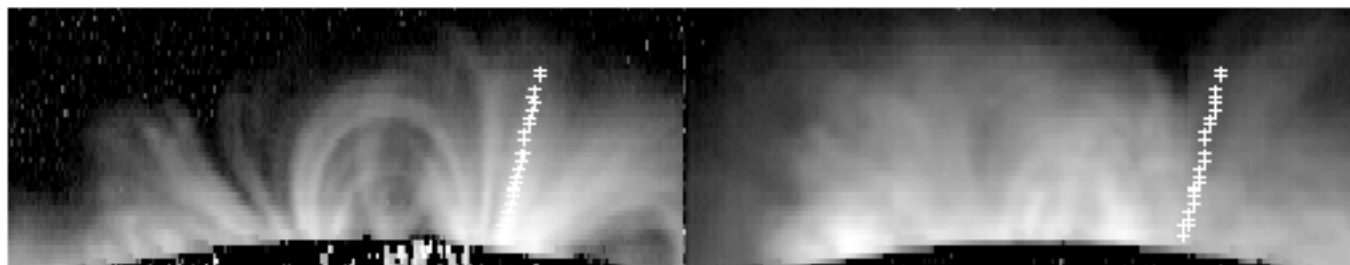
10747 Å

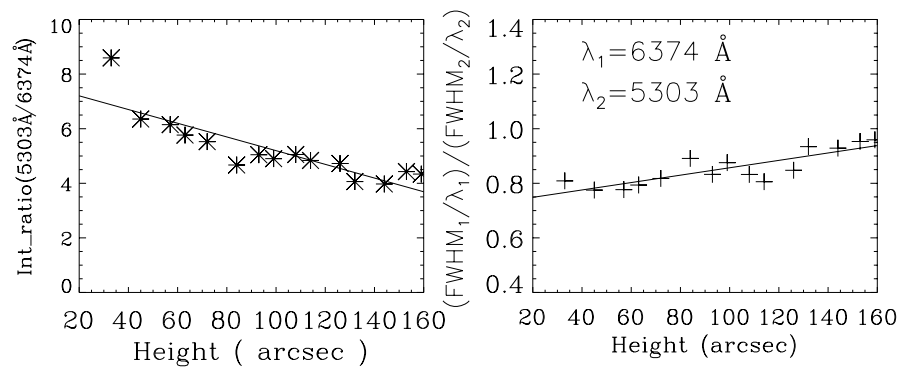
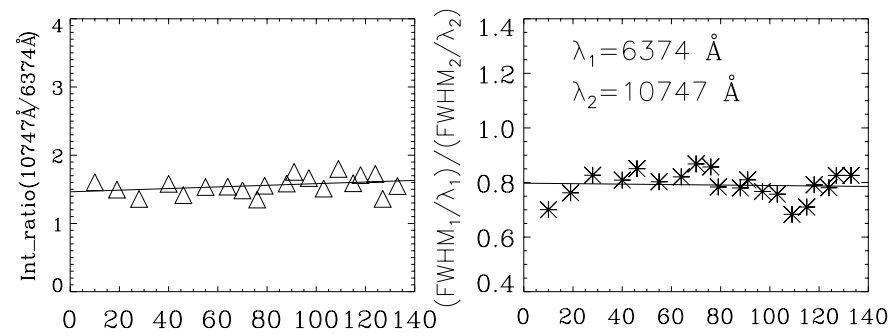
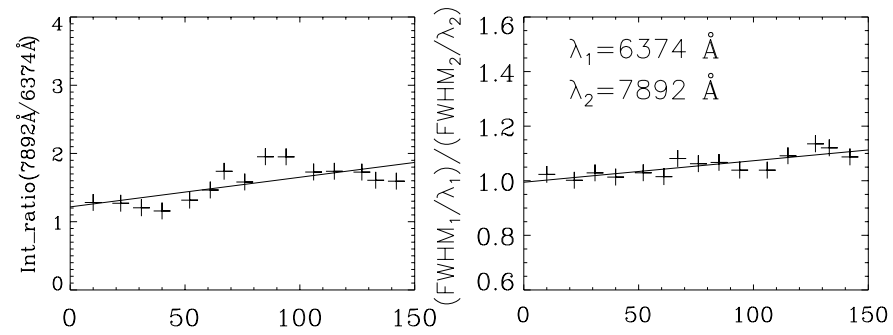


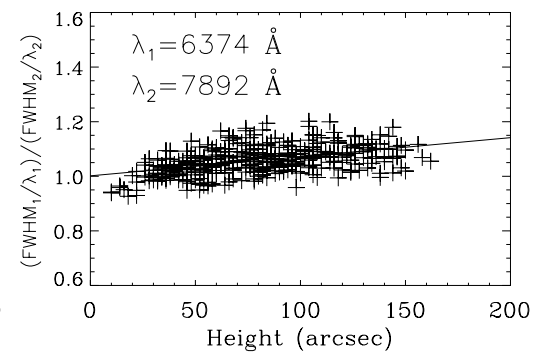
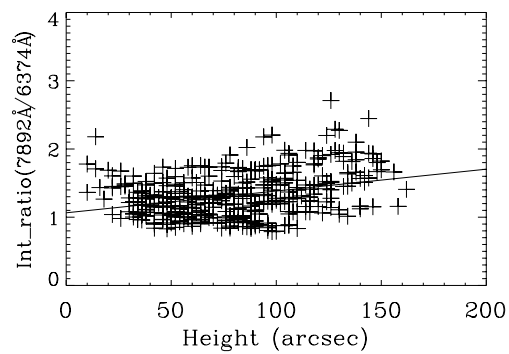
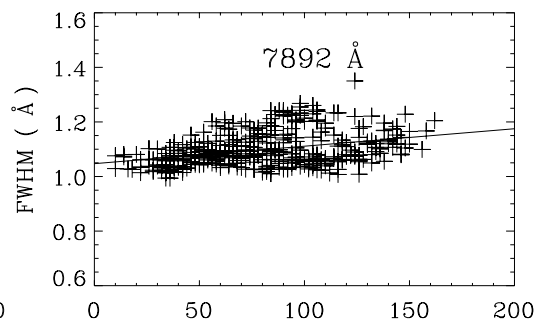
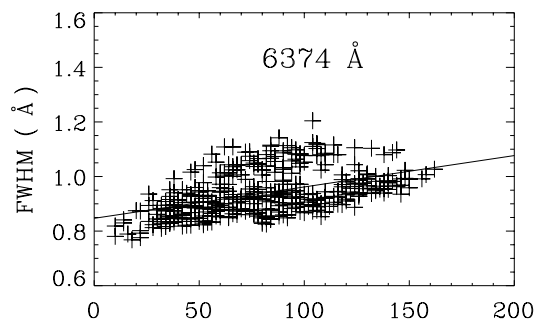
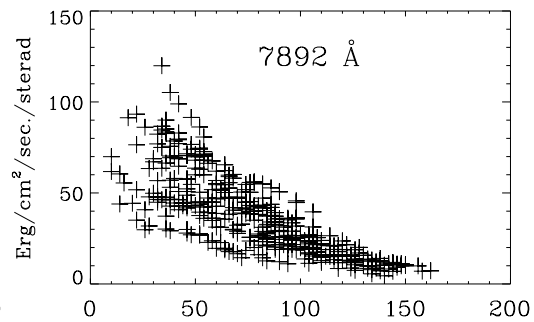
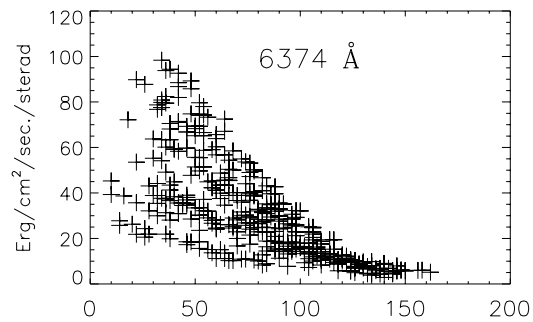
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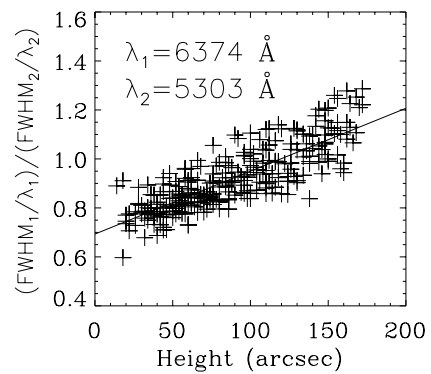
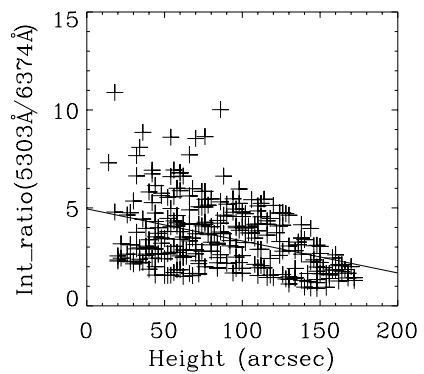
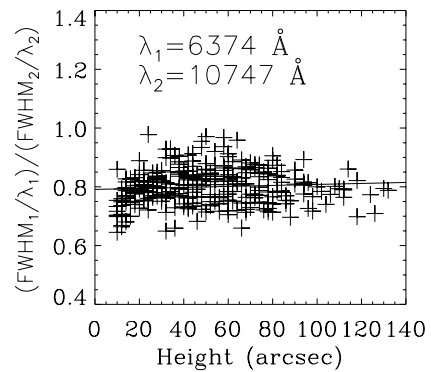
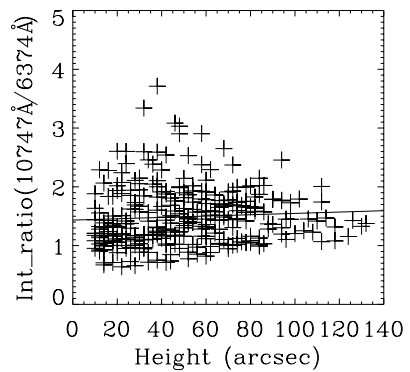
6374 Å

5303 Å









Summary

- Most of the coronal loops show decrease in line width of the 5303 line where as increase in width of 6374 line with height above the limb. The 7892 line show increase with height but with less slope as compared to that of 6374 line. The 10747 show negligible change with height
- All these observations indicate that variation in line width is related with the temperature of the ion the line represents
- The emission line with temperature of maximum abundances greater than 1.6 MK show decrease in line width and less than 1.6 MK show increase in line width with height
- The slope of variation depends on the associated temperature and is negligible for emission line around 1.6 MK

- The trend in the variation of line width is independent of the shape, size, topology of the coronal loops. To explain it further, line width of the 5303 line decreases in all types of loops such as small or big; open or closed; face-on or end-on; radial or non-radial and that of 6374 increases with height. The magnitude of variation may be different for different coronal loops, may be it depends upon the underlying magnetic field, density, temperature etc.
- The FWHM of [Fe x] and [Fe xiv] emission lines do not show change with height after a distance of about 250 arc sec and normalized ratio is 1 suggesting that plasma at larger heights at uniform temperature and non-thermal velocities. The value of height after which line width does not vary may depend on the physical properties of coronal structure.

Intensity Ratio

- The intensity ratio of [Fe xi] to [Fe x] line generally increases with height above the limb indicating increase in temperature with height. This agrees with the findings of Kano and Tsuneta showing that emission measure is highest at the loop top.
- The intensity ratio of [Fe xiii] to [Fe x] line shows small variation with height above the limb. One would have expected a larger variation with height considering the similar change in temperature with height as observed from the variation in [Fe xi] to [Fe x] line ratio and the abundances of ions as a function of temperature.

- To our surprise the intensity ratio of [Fe xiv] to [Fe x] line decreases with height above the limb. Considering the above mentioned logic it should have increased with height much steeply. The decrease in this intensity ratio implies the loop top is cooler if observed in [Fe xiv] emission line.

FWHM Ratios

- The normalized FWHM ratios with respect to wavelength indicate that the ratio is 1 for the [Fe xi] to [Fe x] line near the limb as expected because temperature of maximum abundances for both these ions are nearly equal (1.2 and 1.0 MK, respectively).
- But it decreases with height above the limb and becomes 0.85 at 150 arc sec. If the loops are magnetically isolated and isothermal what makes the ratio to decrease with height?
- Similarly other ratios of FWHM varies with height above the limb

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 as some authors have tried.
- The assumption here is that the different type of plasma behave differently but we have shown that the properties of 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.

Conclusion

- The thin coronal loops are not magnetically shielded
- The gas pressure might be comparable to or more than the magnetic pressure.
- It implies that coronal structures are highly dynamic in nature.