Possible heating mechanism(s) of solar hot coronal loops

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Problem:
there are two types of active region loops in the solar corona:

1) warm loops (T ~ 1 MK) → Heating by storms of nanoflares
(Warren et al. 2003; Klimchuk 2006, 2009; Ugarte-Urra et al. 2009).

2) hot loops (T > 2 MK) → their foot points ('moss') → **heating mechanism(s)?** →

- ✓quasi-steady heating (Antichos et al. 2003)
- ✓impulsive heating (Testa et al. 2013)
- ✓magneto-acoustic waves (Hashim et al. 2021)
- ✓Torsional Alfven wave (?)

High temperatures of hot coronal loops made it hard to resolve the loop structures. Therefore, researchers focused to study the footpoint of hot coronal loops called "moss" to find indirect observational constrains of the existing heating mechanism(s).

In this work using high resolution data of IRIS, along with simultaneous observations of SDO and SOT, and EIS (in HOP 247), we study the moss area properties through spectroscopy and imaging.

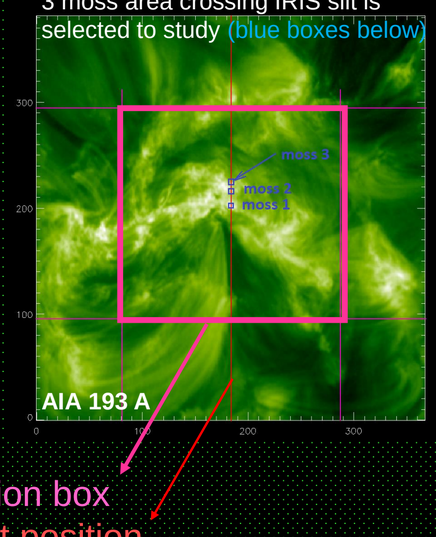
We found some periodicities in the intensity, Doppler shift, and linewidth of the C II 1334.5323 A and Si IV 1402.770 A emission line in the moss area.

Data properties:

2014-03-21 11:34:28-13:42:39

Where	Raster	SJI wavel: cadence, # images
HOP 247, moss high-cadence obs OBS 3800257453: Large sit-and-stare		
x,y: -286",-136" Max FOV: 119"x119" Target: AR Roll: -5 deg	FOV: 0"x119" Steps: 1400x0" Step Cad: 5.5s Raster Cad: 5s, 1 ras	FOV: 119"x119" 1400: 11s, 700 imgs 2796: 11s, 700 imgs

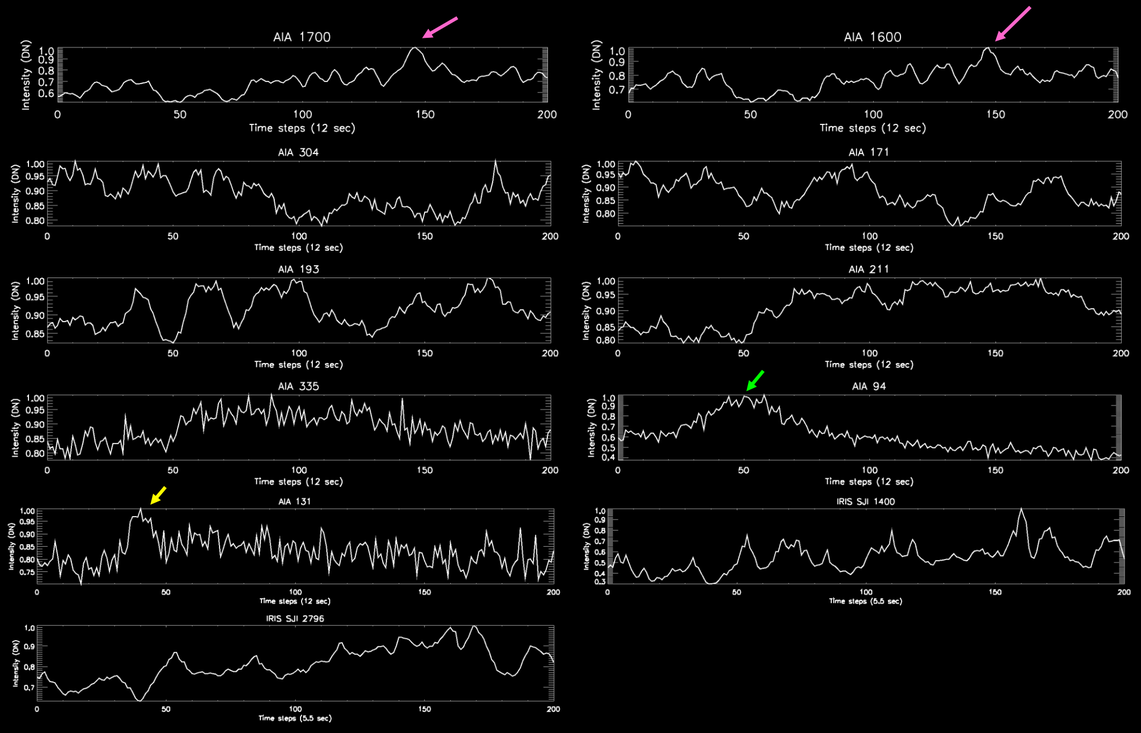
3 moss area crossing IRIS slit is selected to study (blue boxes below)



IRIS observation box
IRIS slit position

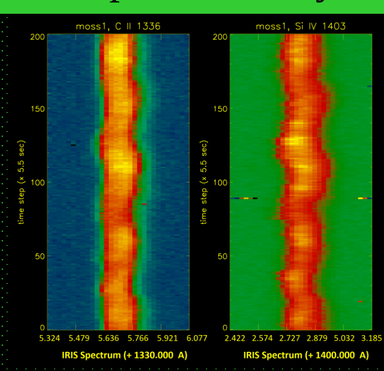
SDO/AIA Moss N.1 light curves:

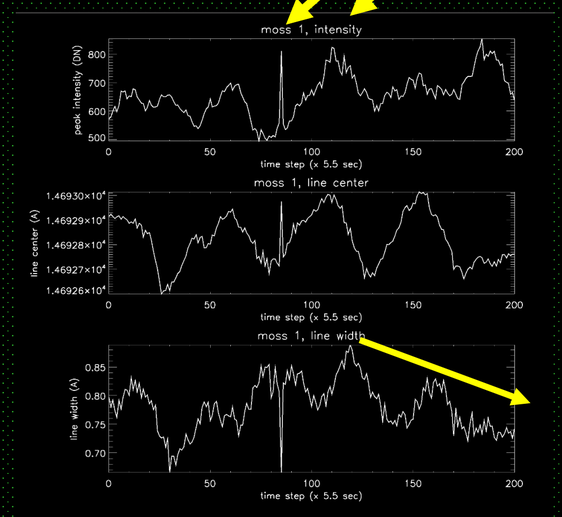
(1) at t=40*12 sec a flare occur at AIA 131 A (yellow arrow)
(2) at t=50*12 sec a flare occur at AIA 94 A (green arrow)
(3) By passing time 211, 193, 171 channels getting brighter slowly.
(4) Periodic behavior is observable on intensity curve of 193 line (~ 5 minute period)
(5) After about 105*12 sec (21 minutes) the intensity of lower atmospheric lines like AIA 1600 and AIA 1700 reach to its maximum.



IRIS spectral Analysis

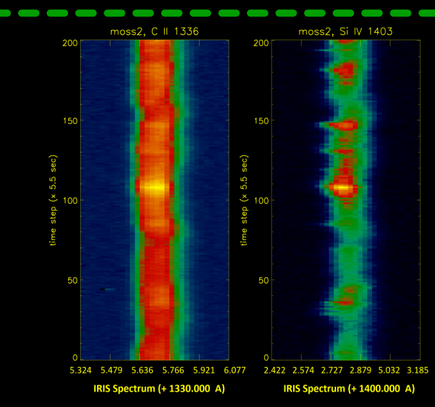
Moss N. 1

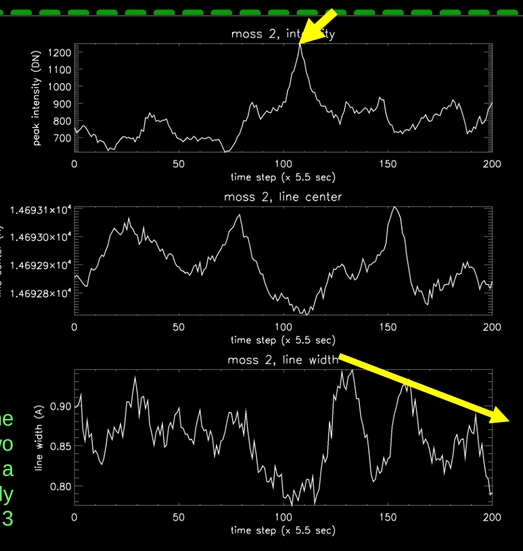




C II 1335 and Si IV 1403 line profiles in moss 1 area show the variation of line width at FWHM as a function of time with periods of about 4.6 minutes. Line centers show similar periodic red/blue shifts of about 8 km/s with some phase difference.

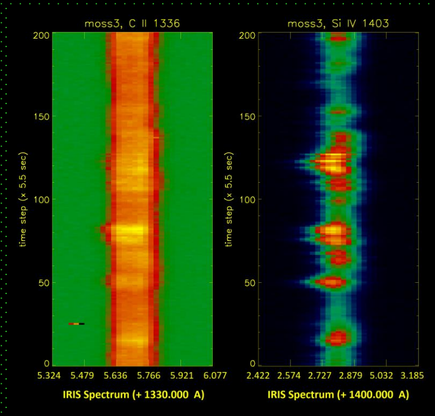
Moss N. 2

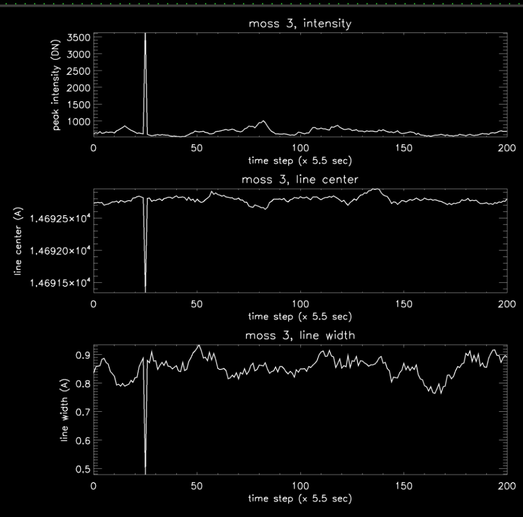




C II 1335 and Si IV 1403 line profiles in moss 2 area show the variation of line width at FWHM as a function of time with two prevalent periods of about 1.2 and 2.3 and minutes. After occurring a flare at t=110*5.5 sec, the spectral line widths increases suddenly and by passing time the amplitude of the line width decays after 3 oscillations. Line centers show similar periodic red/blue shifts.

Moss N. 3





C II 1335 and Si IV 1403 line profiles in moss 3 area show the variation of line width at FWHM as a function of time with periods of about 1.4 minutes.

Conclusion and future work:

(1) Time series of different AIA/SDO channels studied over the moss region number 1, 2, and 3. Oscillatory behavior is seen almost in all channels. A flare occurs at high coronal heights on 131 A channel, then lower layers get heated afterward. After 21 minutes a significant intensity increase is observed at AIA 1600 and 1700 channels.

(2) IRIS CII 1335 and Si IV 1403 Spectral lines are studied by fitting a single Gaussian with a uniform background. IRIS CII 1335 and Si IV 1403 Spectral line widths over the moss areas seems to have oscillatory behavior with periods of about 1.2-4.6 minutes. This, along with periodic red/blue shift changes of the line centers could indicate the presence of Torsional Alfven waves (Jess et al. 2009).

(3) Doppler shift and line width maps of the IRIS spectral lines should be studied over the rest 1200 time steps.

(4) In continue, the SOT C II lines along with HMI magnetogram images should be studied, ass well.

(5) Using wavelet analysis more accurate periods could be obtained.