Poster on solar observations of the FeXIV/FeX line ratio

During the 13th European Solar Physics Meeting (held in Rhodes, Greece, September 12-16, 2011), we had the opportunity to present our work on spectroscopic observations of the Sun.

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Strikis Iakovos-Marios, Kouloumvakos Athanasios, Patsourakos Spiros

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Typical "Flash Spectrum" image: 2009 TSE Russia

Observations and Data analysis.

Coronal temperature is measured by several means of direct or indirect observations (G. Noci,2003 ; Habbal,1993) such observations in the visible, radio observation, observations on the disk in the UV spectral region and dielectronic recombination. At this point we will give more attention to the visible observations and determination of the coronal temperature from line ratios as require the analysis and the purpose of this poster. The estimation of the coronal temperature from line intensity ratios primary depends on the assumption that the density and temperature along a given line of sight where the emission of the spectral line is observed is constant. To determine the temperature from spectral line ratios we compare the line ratio deduced from the observation with those derived from theoretically from the emissivity (R. Esser,1995: Guhathakurta, 1992).

We present the spectral and temperature analysis derived from the measurements during the total solar eclipses of 2006 (Greece), of 2008 (Russia), 2009 (China) and 2010 (Cook Islands). To estimate the coronal temperature we used the FeXIV and FeX line ratio. The reason that we used this specific line ratio is the strong coronal emission of this lines providing us an easy way of analysis and identification of this iron lines. In addition these coronal lines have been used several times in the past for temperature diagnostics and they are among the lines used by SOHO instruments.

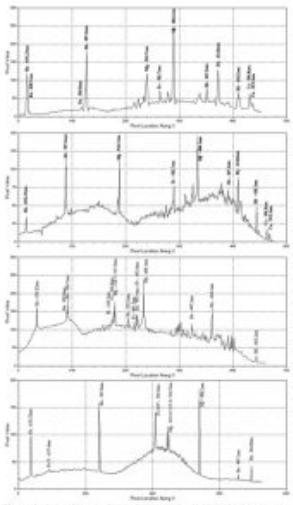


Figure 1: Top to Bottom, 2006 - 2008 - 2009 and 2010 Flash Spectrum Plots by the data aquired during the TSE's

Some first order analysis of the "Flash Spectrum" data collected, have shown many differenses and variations on the highly ionized lines of the Chromosphere and Transition Region through the period we study.

It seems that the lower the Solar Activity is, the less lines are detectable.

Lines	2006	2008	2009	2010
Ba - 456.2nm	+	+	+	+
Ba - 649.7nm	+	-	-	-
Ba - 589.0nm	+	-	+	-
Ba - 586.7nm	+	+	+	+
Fe - 532.3nm	-	+	+	-
Ca - 529.0nm	-	-	+	-
Mg - 518.4nm	-	-	-	+
517.2nm	-	-	+	+
530.3nm	+	+	+	+
Fe - 581.3nm	+	-	+	-
Fe - 495.8nm	-	-	+	-
Ba - 493.4nm	-	+	+	+
Fe - 452.4nm	-	+	+	+
Hβ - 486.1nm	+	+	+	+
Ba - 447.2nm	+	+	+	+
Hγ - 434.0nm	+	+	+	+
Hδ - 410.2nm	+	+	+	n/a
Ca - 396.8nm	+	+	n/a	n/a
Ca - 393.3nm	+	+	n/a	n/a

Table 1: An analytic chart of the lines detected in each eclipse from 2006 to 2010 on the Flash Spectrum images.

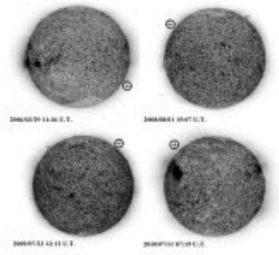
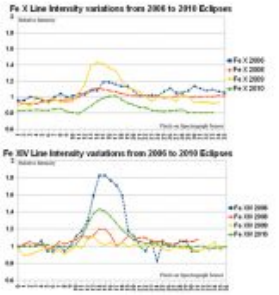


Figure 2: So.H.O. EIT 304 images marked with the points of Solar Corona choosen for measurements.



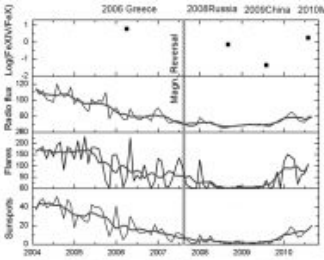


Figure 3: Correlation of the Fe Measurements with other Solar Activity indicators (Sunspots - Radio Flux 10.5 - Flares)

The line ratio from 2006 (Greece) decreases until 2009 (China) as it is expected from the extended minimum of the 23rd solar cycle. Between 2006 and 2008 the drop of the line ratio follows the sunspot number drop of the descending phase. At 2009 the drop seems to be steeper than 2006-2008 and the extended minimum of 2009 with 259 spotless days seems to contribute further to the drop of FeXIV intensity and the rise of FeX. At our last observation of 2010 (Mangaia) we see a significant rise. This rise comes together with the beginning of the new Sunspot Cycle which started, according to sunspot number, at the first months of 2010.

Fe X & Fe XIV Observations.

After the Data-Reduction and the Calibration of the images, measurements of the Relative Intensities have been made using the following equation:

$$RI(true)Fe = \frac{Iobs - Ibac}{Ibac}$$

where *"RI(true)Fe"* is the true relative intensity of the multiple ionized Iron line *"I Obs"* is the intensity of the line with a correction factor added to correct the non linear effect of the grating from the spectrograph. *"I background"* is the intensity of the continuum background (noise). All the measurements have been made at Heliographic Latitudes between 30o and -30o in places that have been selected, not to be near active regions or coronal holes so that our measurements would not have been affected from these areas of high or low density respectively. Then our measurements have been averaged to give us the final results. Using the above equation to our measurements we construct the table with the results [Table 2].

	Relative intensity			
	2006 Greece	2008 Russia	2009 China	2010 Mangaia
FeX (6374A)	0.02	0.0734	0.1031	0.0738
FeXIV (5303A)	0.12	0.0531	0.0045	0.1329
FeXIV/FeX	6	0.7234	0.0436	1,8008
log(FeXIV/FeX)	0.7781	-0.1406	-1.3605	0,2554

Table 2: Relative intensities of the FeX & FeXIV ionized lines.

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Coronal Temperature Estimation.

For the purposes of our analysis we use the CHIANTI atomic database for spectroscopic diagnostics of astrophysical plasmas. We compute the intensity per emission measure for each iron line between the limits of 5.8-6.5 in units of log[T] and density fixed at log[Ne]=7.0. The ionization database we used is the chianti provided database and as for the abundance database we selected the coronal database provided by chianti as well. The line ratio from the above data is plotted at figure 4. From the results of our observations and the theoretical line ratio produced, we estimated the temperature of solar corona for every eclipse observations. The results are summarized in table 3.

The temperature starts to drop, from its higher value of 2006 eclipse, until 2009 and then rise again at 2010 as the new solar cycle starts again. The drop of the temperature between 2006 and 2008 was 440.000K indicating the deep solar minimum of these years. While the new solar cycle starts at 2010, the expected rise of the temperature between 2009-2010 was 312.000K.

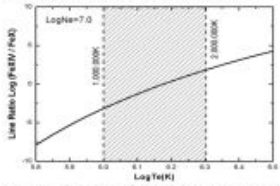

Figure 4: Line Ratio as a function of Coronal Temperature as calculated by Chianti code.

	Temperature Estimation			
	2006 Greece	2008 Russia	2009 China	2010 Mangaia
log(FeXIV/FeX)	0.7781	-0.1406	-1.3605	0.2554
Temperature log(T)	6.2279	6.0891	6.00704	6.0977
Temperature(K)	1.690.000	1.473.000	1.258.000	1.562.000

Table 3: Corona Temperature Estimations as a function of Fe Line Ratio as observed in TSE's

References:

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