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TOTAL SOLAR ECLIPSE 2017 IN USA: DEEP CORONAL SPECTRA

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Abstract.
Total eclipses permit a deep analysis of both the inner and the outer parts of the solar corona using the Thomson scattered (inverse Compton effect on free electrons at millions degrees T°) continuum White-Light (W-L) radiations and the spectrum of forbidden emission lines from hot highly ionized ions of iron, nickel, argon, etc. Spectra are largely affected by the superposition of the solar light scattered and diffracted by the interplanetary dust particles orbiting the Sun at large distances but intercepted along the line of sight (los)(Koutchmy & Magnant 1973). Sometimes the parasitic light due to multiple scattering from the ground and from the Earth atmosphere should be removed using the light observed on the Moon image background. After sufficiently dispersing the W-L corona, the Fraunhofer (F) spectrum of the dust corona appears with its absorption (dark) lines of known equivalent widths and the continuum Thomson radiation can be extracted. The identified emission (bright) lines of ions with different degrees of ionization are studied to permit an evaluation of i/ relative abundances (compared to photospheric abundances), ii/ temperatures, iii/ non-thermal velocities and the resulting from the analysis of the departures from a Gaussian profile of net Doppler shifts after integration along the los.

60 spectra were obtained during the totality using a specially designed slit spectroscopic experiment for providing an accurate analysis of the most typical "broadly averaged" parts of the quasi-minimum of activity type corona. With the scanning +/- 3 solar radii long slit a .072 nm FWHM effective resolution was obtained in the range of 510 to 590 nm. The background sky was exceptionally clear during this US total eclipse of Aug. 21, 2017 as observed from our site in Idaho; spectra are without significant parasitic light on the Moon disk. The K+F continuum corona is well exposed up to at least 1 solar radius (Rs) from the limb and further out with a lower S/N ratio, showing several forbidden coronal emission lines. The F-corona can be measured even at the solar limb where its intensity reached near 6% of the K-corona intensity.

Streamers, active region enhancements and polar coronal holes (CHs) are well measured on each 1 sec exposure time coronal spectra see Fig. 1; the 2^{nd} contact showing the chromospheric and the most inner layers emission lines was observed with a fast sequence and exposure time 10 times shorter. New weak emission lines were also discovered and/or confirmed see Fig. 2 ; their identifications are proposed. The rarely observed high FIP ArX (Del Zanna & DeLuca 2018) line is recorded almost everywhere and a new nearby FeX line is well identified; the classical low FIP FeXIV and NiXIII lines are well recorded everywhere without over-exposure. For the 1st time hot lines are also measured at low levels inside the CH regions, at both poles. The radial variations of the corrected non-thermal turbulent velocities of the lines do not show a great departure from the average values. No significantly large Doppler shifts are seen nowhere in the inner and the middle corona although the whole corona is almost covered.(Contesse et al. 2004)

The corona is confirmed to be made of a mixing of hot and less hot components everywhere around the Sun, due to the yet unidentified magnetic origin heating processes reflected in our spectra and in the line profiles. Coronal density variations are well reflected by the K-corona continuum intensity variations the azimuthal and radial direction variations will permit the interpretation of the emission measures to be compared with the simultaneously obtained AIA images from the SDO space mission. The W-L images taken simultaneously shows a much better spatial resolution with images of bright background well known stars that permit to deduce an excellent absolute calibration needed to deduce the electron densities and to check our F-corona model, see 3.

Keywords: Total Solar Eclipse, Solar Corona, Forbidden coronal emission lines

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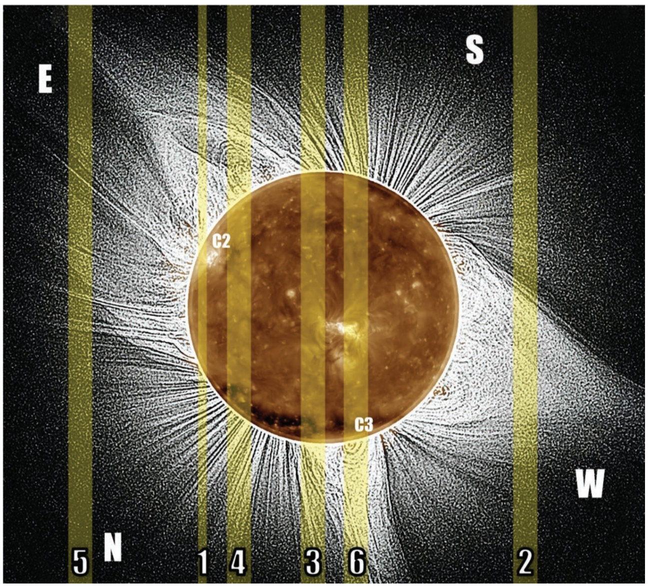

Fig. 1. W-L coronal structures obtained from a highly processed image by J. Mouette, combined with an AIA/SDO 19.4 nm simultaneous image inserted with a correct scaling. Yellow vertical bands show the region covered by the different positions of the entrance slit during the totality, including the scanning transverse to the slit due to the diurnal motion during the burst of 10 spectra taken at each successive position 2, 3, 4, 5 and 6. Position 1 was used to obtain fast spectra (0.1 s exposure time) in the region of the C2 contact. The orientations correspond to a reversed image of the corona seen in the sky on the entrance slit.

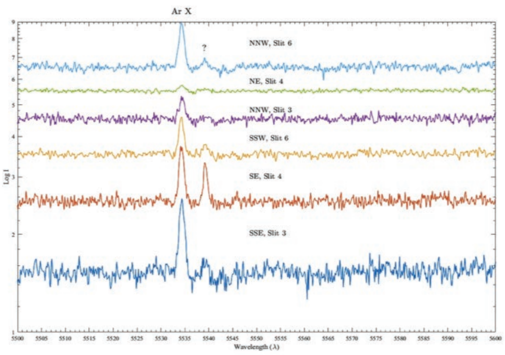

Fig. 2. Summed spectra showing the new line discovered near the predicted and confirmed line of the Ar X at 5534 Å. This line (5540 Å) would be attributed to Fe X or Fe XI (Mason & Nussbaumer 1977). Note the log scale of the intensities and the different positions (see Fig. 1) in the corona giving different intensities depending on the position. Spectra are corrected of the F-corona component.

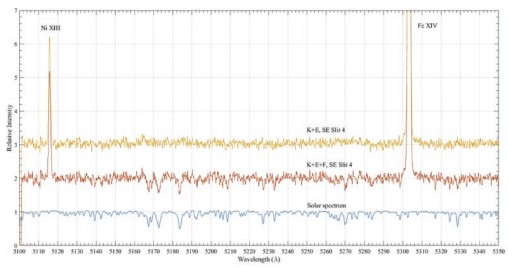

Fig. 3. Extracted deep spectra of the inner corona (slot position "4" see Fig. 1) showing the influence of the F component (contribution about 6 to 7% of the solar spectrum). Note the extended wings of the green line of Fe XIV (Non-Gaussianity).

References

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