Indications of Short Periodicity in the FeXIV 503.3nm Emission Line at the 2008 Solar Eclipse

Donald H. Liebenberg

***Abstract*—Observations at the 1 August 2008 total solar eclipse in western China were obtained through a narrow band interference filter centered on the 530.3 nm FeXIV emission line at a cadence of 30 frames/second. A simplified analysis indicates that in a position near the base of a coronal streamer a short period intensity periodicity is found. The analysis and results are presented.**

***Index Terms*—Astrophysics, Signal sampling, Sun**

I. INTRODUCTION

Since the discovery by Leighton and his co-workers [1] of a five minute oscillation in the solar photosphere a search for oscillations in the upper solar atmosphere has been conducted [2], [3]. Oscillations in the solar corona were reported [4] from temporal intensity measurements of the 530.3 nm FeXIV emission line observed during the 1973 solar eclipse 74 min totality from the Concorde 001. Oscillations in coronal loops were published by R. S. White et al. [5] and E. Verwichte et al. [6]. D. R. Williams et al. [7] used a solar eclipse corona imaging system in the FeXIV emission line and reported a strong 6 second oscillation in an active region coronal loop. Solar eclipse observations in the visible-light corona by P. Rudawy et al. [8] concluded that while a number of periodicities in the local brightness curves were obtained from wavelet analysis none was found to be physically important. The 1 August 2008 eclipse provided the opportunity for ground based observations of the FeXIV 530.3 nm coronal emission line intensity oscillations.

II. INSTRUMENTATION AND LOCATION

A. Instrumentation

To isolate the 530.3 nm emission line a narrow band filter from E. Barr Associates provided a flattened peak and steep edges pass band of 0.51 nm FWHM and a peak transmission of 64% with blocking between 200 and 1100 nm. The filter was fitted to the front of a 2X telephoto lens of the Sony DCR TRV820 digital camera. The camera was attached to a battery operated equatorial mount.

B. Location

The eclipse was intercepted near Yiwu in Xinjiang Uygur Zizhiqu province of Western China. The observing site at an altitude above 2000 m had been prepared by the Chinese government and included facilities and a museum. Totality lasted about 1 m 56 s. While some clouds were in the vicinity the whole eclipse totality was seen through clear skies.

III. DATA REDUCTION

The intensity vs time data at a cadence of 30 frames/second was written to a DVR and a set of images at 1 s interval was captured for analysis; a single frame image is shown in Fig.1. MIRA Pro7, a software program from Mirametrics Inc., was used to digitize each frame and process to a gray scale, centered and rotated to positions of interest. The radial intensity from each single frame formed a data

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D. H. Liebenberg is retired and holds an Adjunct Professorship in the Department of Physics and Astronomy at Clemson University, Clemson, SC 29634. (Phone 864-944-7175; e-mail dlieben@clemson.edu)

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set at a measured time from second contact and at one angular position on the coronal image. These data were moved into KaleidaGraph, a software program from Synergy Software.

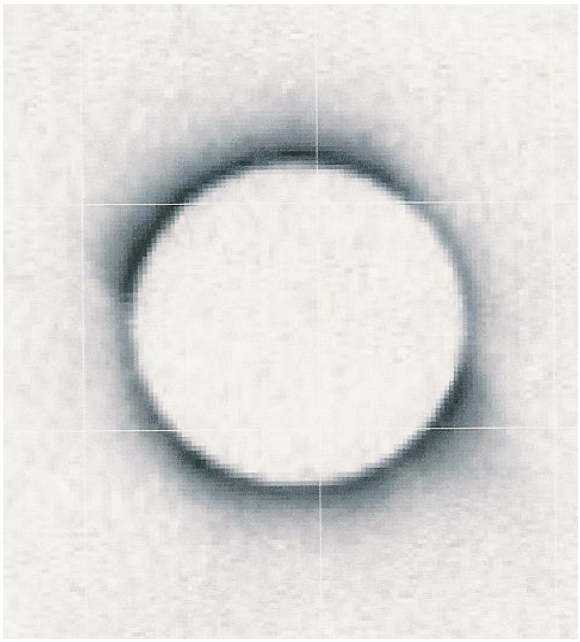

Fig. 1 FeXIV emission line single video frame in black and white oriented to the view in the sky. The coronal streamer is at 4 o'clock.

The solar diameter was determined from the images and from the spacing between limbs as shown in Fig. 2 and provided the radial distance parameter.

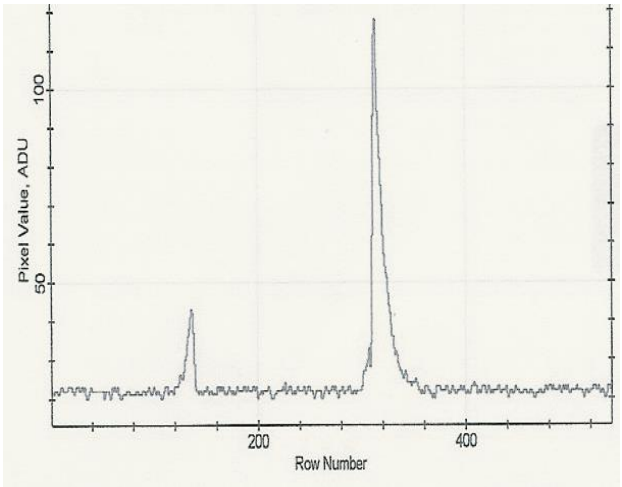

Fig. 2 Radial scan across image to capture FeXIV intensity variation and to determine coronal diameter.

Correction for the depth of the eclipse was made. The data sets were moved to PSI-Plot, software from Poly Software International, for preparing the 3D graphs of intensity, radial distance, and time. The pixel intensity response has a range of 0-250, the radial extent of the data was cut off at 1.5 R⊙ or less, and the time is in seconds from 2nd contact. The data span a time of over 50 seconds at a constant magnification and sensitivity of the digital camera. The time span was limited by the Poly Software handling of the data sets. An example of the 3D graph of data is shown in Fig. 3. The image of Fig. 1 was rotated by 27 degrees counterclockwise to the base of a bright streamer on the right limb. These data begin at the lunar limb and the slight increase in intensity indicates the lunar limb is exposing more of the inner corona.

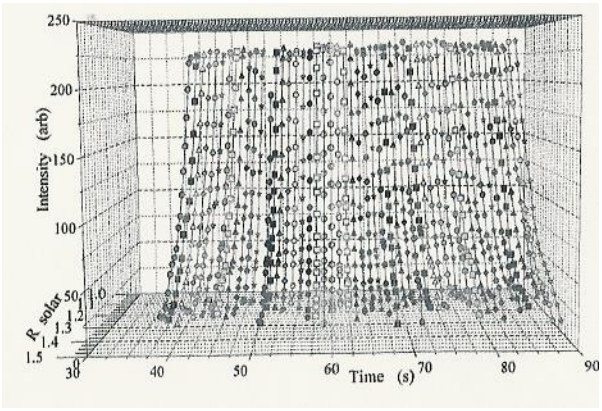

Fig. 3 Radial intensity digitized scans with time after 2nd contact. The scans begin at the lunar limb.

IV. Results and Discussion

A. Results

The 1 s interval data sets over the 53 s span at constant image size and sensitivity were reduced at various angles about the base of the bright streamer. From Fig. 3, at -27 degrees, the data are successively truncated at increments of 0.05 R⊙ to visually examine the truncated data set for periodicity. Fig. 4a shows a periodicity of about 30 s at 1.20 R⊙. This periodicity was also noticeable in adjacent radial positions of 1.15 and 1.25 R⊙. Improvement in the visualization of the periodicity by plotting the intensity versus time at one solar radius requires manual transformation of the data from the radial slices of Fig. 4a. A few such data sets have been prepared and Fig. 4b is an example of the

data from Fig. 4a. A smooth curve of the Stineman function of Kaleidagraph is applied to the data.

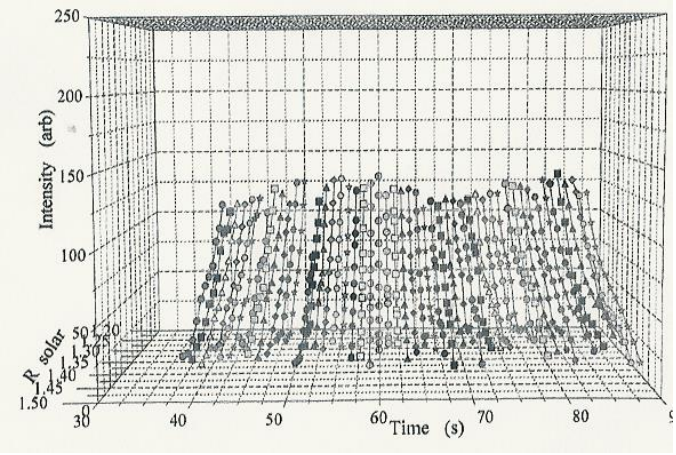

Fig. 4a Radial intensity scans versus time truncated at R⊙=1.20. A period of oscillation is about 30 seconds.

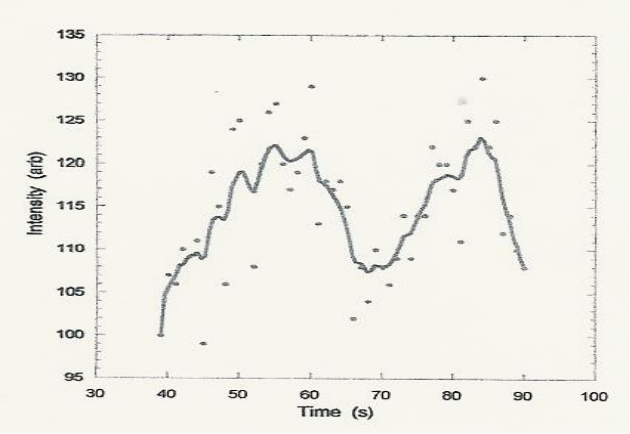

Fig. 4b Intensity versus time at R⊙=1.20. A smooth curve from the Stineman function is applied.

In Fig. 4a, the possibility that motion of the mount/camera might shift the radial sharply declining intensity by enough to cause an apparent periodicity is not likely. Data from the opposite limb should then show an inverse effect and Fig. 5 is such a data set cut-off at 1.20 R⊙, the maximum indication of periodicity in Fig. 4a. As may be seen there is little indication of an inverse periodicity.

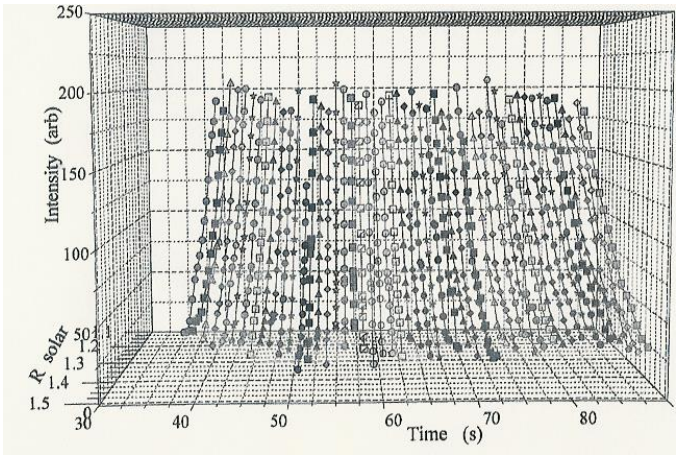

Fig. 5 Radial Intensity scans with time after totality from the limb opposite that of Fig. 4. The data are also truncated at R⊙=1.2. There is little evidence of an oscillation.

Further, such a motion would introduce periodicity at all radial distances on one frame and would be seen in adjacent angular data sets. And a similar examination of data from the normal to this diameter shows no indication of periodicity.

The angular extent to which the periodicity extends was examined from nearby data sets. Data sets were taken at -24, -25, -28, -29 degrees in addition to the -27 degree data emphasized in this report. The angular data sets span the region of the bright coronal streamer. For the data set at -25 deg or 2 deg from the Fig. 3& 4 data, there is some indication at 1.20 R⊙ of periodicity with minima shifted by about -5 seconds although the maxima are less distinct. Some indication remains at 1.25 R⊙ but much less at 1.15 R⊙. At this angle the radial line crosses near the edge of the streamer.

B. Discussion

At present these data are indicative of short periodicities in the solar corona. Similar data at other solar eclipses have been obtained and show regions where short periodicities are indicated. Although beyond the scope of this report, there have been suggestions that short periodicities, 30-60 seconds, are expected. A useful review of oscillations and periodicities observed and predicted has been published by M. Aschwanden [8].

Rudawy et al. [7] found no physically important periodicities from a wavelet analysis of their visible-light eclipse data. The present observations, in the forbidden emission line of FeXIV, sample a much

smaller region of the corona along a line of sight due to the larger exponent of the intensity variation with radial distance from the solar surface, $I \sim 1/r^n$. Thus the detection of a localized density or temperature change resulting in an intensity change in the FeXIV line would be improved.

V. Conclusion

Temporal observations were made of the coronal FeXIV emission line at 530.3 nm at the 1 August 2008 total solar eclipse. Manual analysis of these data at 1 second intervals spanning more than 50 seconds was examined in data slices at a constant solar radius. They indicate a periodicity of about 25 seconds in a limited region near the base of a bright streamer. Additional results would be useful.

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Donald H. Liebenberg (PhD), Physics University of Wisconsin, Madison, WI '71)

He was a STAFF MEMBER at Los Alamos National Laboratory 1961-1987, on leave as PROGRAM DIRECTOR FOR SOLAR-TERRESTRIAL RESEARCH at the National Science Foundation 1967-1968, on leave as PROGRAM DIRECTOR FOR LOW TEMPERATURE PHYSICS at the National Science Foundation 1981-1988, on leave from the National Science Foundation as PROGRAM MANAGER in Condensed Matter, Basic Energy Sciences, Department of Energy 1986-1987, SCIENTIFIC OFFICER, Office of Naval Research 1988-1995, ADJUNCT PROFESSOR OF PHYSICS, Department of Physics and Astronomy, Clemson University, Clemson, SC.

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Dr. Liebenberg is a Fellow and Life Member of the American Physical Society, member of the American Astronomical Society, and member of the American Geophysical Union.