

# ANALYSIS OF EUV OBSERVATIONS OF A CORONAL ACTIVE REGION MADE DURING THE 7 MARCH 1970 ECLIPSE

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**Abstract** (*Monthly Notices Roy. Astron. Soc.*). Rocket observations of the EUV solar spectrum obtained during the total eclipse of 7 March 1970 showed the presence of a large coronal condensation on the NE limb (Gabriel *et al.*, 1971). The condensation shows the existence of loop structure, which defines the local magnetic fields, and is apparent in forbidden lines including those of Si VIII, Si IX, S XI, Fe IX, Fe XI and Fe XII which lie between 1200 Å and 2050 Å (Jordan, 1971). These lines are formed in the temperature range  $9.3 \times 10^5$  K to  $2.0 \times 10^6$  K. The photographic observations of the active region show clearly that the spatial distribution of material varies considerably with its temperature.

The populations of the excited levels emitting the forbidden lines were calculated as a function of density and temperature using currently available atomic data. The  $^1S_0-^3P_1$  line of Fe XI and the  $^2P_{1/2}-^4S_{3/2}$  line of Fe XII have intensities which are proportional to  $N_e^2$ . The decrease in the intensity of these lines as a function of increasing height along the apparent loop structures closely follows that expected in hydrostatic equilibrium at the temperatures where these ions are predominantly formed. Therefore the change with height in the line of sight path-length,  $L$ , must be small for these emission lines.

An initial analysis using calculated level populations showed inconsistencies with the apparent temperature structure. Therefore the following normalisation process was used to determine the level populations.

A region of the quiet corona was chosen from the eclipse data and the variation with height of the density dependent line ratios in Fe XII,  $^2P_{1/2}-^4S_{3/2}/^2D_{3/2}-^4S_{3/2}$  was used to show that the electron density was constant apart from hydrostatic variations. Similarly the temperature dependent line ratios Si VIII/Si IX and Fe XI/Fe XII were used to show that one temperature could be attributed to the region. The temperature giving the best fit to all the observed intensities was found to be  $T_e = 1.45 \times 10^6$  K. The scale height at this temperature was used to determine the line of sight distance in a spherically symmetric atmosphere. The electron density was calculated from the absolute intensity of the Si VIII line and was found to be  $3.3 \times 10^8$  cm<sup>-3</sup>. Thus through knowing  $N_e$ ,  $T_e$  and  $L$  the excited level population could be found independently of the atomic data. These populations are up to an order of magnitude larger than those calculated using available atomic data, and the populations depending on the smallest excitation rates need the largest correction.

The abundances which give intensities consistent with the data are  $N(\text{Si})/N(\text{H}) = 4 \times 10^{-5}$ ;  $N(\text{S})/N(\text{H}) = 1 \times 10^{-5}$ ;  $N(\text{Fe})/N(\text{H}) = 8 \times 10^{-5}$ .

The normalised populations were then used in the analysis of the active region data. In the active region it is found that each emission line is formed predominantly at a temperature close to the peak of the ionization equilibrium distribution, indicating a range of temperatures present in a given line of sight. The active region contains material both hotter and cooler than the average quiet corona. The temperature at which most of the material exists varies with height and position in the active region; the higher, outer regions contain more cool material, and the lower, central regions more hot material. At a chosen point at a height of  $\approx 20000$  km in the left side of the loop (see Figure 1) the electron density increases with temperature

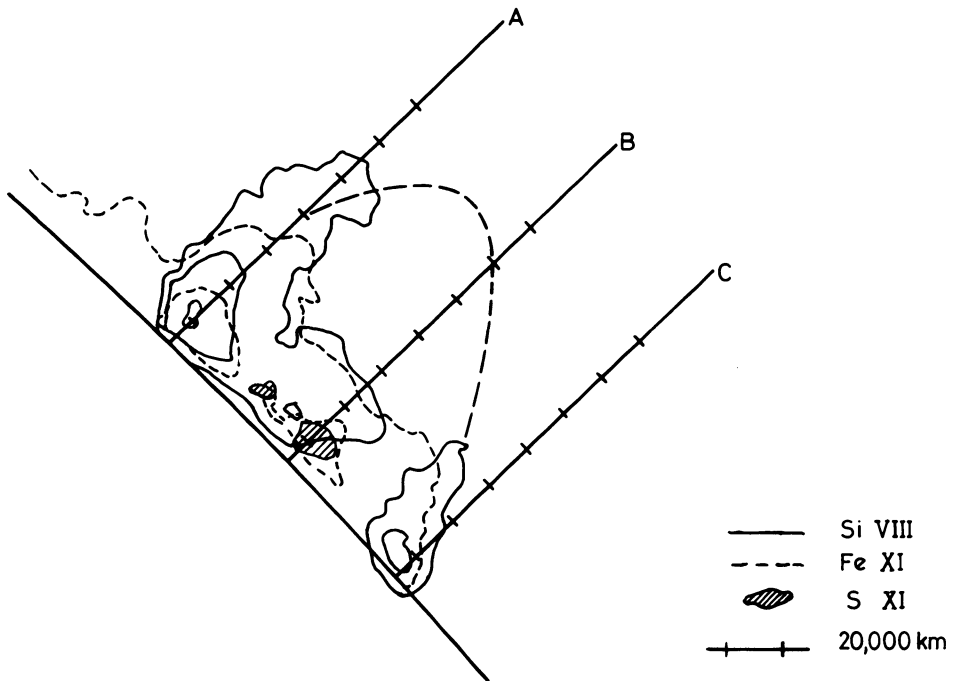


Fig. 1. A diagram of the active region seen at the limb during the 7 March 1970 eclipse. For Si VIII and Fe XI the isophotes for maximum and half-maximum intensity are shown. Only the maximum intensity isophote is shaded for S XI.

from  $1.8 \times 10^9 \text{ cm}^{-3}$  at  $9.3 \times 10^5 \text{ K}$  to  $4.2 \times 10^9 \text{ cm}^{-3}$  at  $1.7 \times 10^6 \text{ K}$ . The line of sight path-length decreases by a factor of 9 over the same temperature range. The minimum magnetic field strength needed to balance the gas pressure varies between 4 G and 18 G. These values are typical of the entire region at 20000 km, but the structure as a function of position will be described in more detail later.

## References

- Gabriel, A. H., Garton, W. R. S., Goldberg, L., Jones, T. J. L., Jordan, C., Morgan, F. J., Nicholls, R. W., Parkinson, W. H., Paxton, H. J. B., Reeves, E. M., Shenton, D. B., Speer, R. J., and Wilson, R.: 1971, *Astrophys. J.* **169**, 595.
- Jordan, C.: 1971, *Solar Phys.* **21**, 381.

## DISCUSSION

*Aller*: I agree that population calculations could be in error by a factor  $\approx 2$ .

*Pneuman*: I believe Werner Neupert, using X-ray data, has observed cases in loops where the temperature actually increases with height in the corona, rather than being isothermal. If this is the general case, the implications for coronal heating mechanisms are interesting. Do you find any such indications from your observations?

*Jordan*: We find that high loops are cooler than low loops.

*Stewart*: Calcium observations give higher temperature at the tops of loops.

*Jordan*: This is probably a short-lived flare loop.

*Jefferies*: High-density, high-temperature concentrations in the center of loops were previously found by Orrall and Lyot (1952).

*Jordan*: We use the loop geometry for our condensation model while he used cylindrical geometry. Also, we find the core of the loop to be both denser and hotter than the outside.

*Gabriel*: The present model is very much in line with that proposed by J. Parkinson from analysis of X-ray measurements from OSO-5. By measuring the change in emission as active regions pass over the limb, he derives a model in which the hot dense material is low in the structure.