# THE INTERPRETATION OF EUV SPECTRA OF SUNSPOTS

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## 1. INTRODUCTION

We report here on EUV observations of a sunspot observed by the Harvard instrument on Skylab. The observational data used here have been presented in a previous paper by Noyes et al. (1982), in which line identifications and intensities for the wavelength region 350 - 1350 A were given. Several electron density sensitive line ratios suggest a constant density, rather than constant pressure, emitting region, while temperature diagnostic line ratios of several ions yield temperatures below the temperatures expected in ionization equilibrium.

## 2. SUNSPOT PARAMETERS

### a) Electron density

For the temperature range 0.6 - 3 x $10^5$K a constant density of $10^{10}$cm$^{-3}$ fits the data, while for the $10^6$K plasma the density has decreased by an order of magnitude and a constant pressure approximation may be a valid assumption. The line ratios used in the analysis were from the ions Si III, C III, N IV, O IV, O V and Mg VIII.

### b) Ionization balance

Analyses of transition region emission from the Sun generally assume ionization equilibrium, but departure from equilibrium can affect the interpretation of observed line intensities. We used temperature diagnostic line ratios of N III, O III, S IV, O IV, O V and Ne VII. All but Ne VII, which is formed at a much greater temperature than the other ions, show temperatures lower than the equilibrium temperature and lower than the averaged quiet Sun.



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c) Model

It has been suggested that the energy radiated at transition zone temperatures is derived from the enthalpy of cooling, downflowing gas from active regions in general (Pneuman and Kopp 1977) and for sunspot plumes in particular (Foukal 1976). The observed departures from ionization equilibrium is thus consistent with those expected for a radiatively cooling gas. In our model we assume a constant density ($10^{10} cm^{-3}$), constant velocity flow (7 km/s) beginning in ionization equilibrium at log T = 5.8. The inferred slope of the emission measure from the model is substantially shallower than the observed, although photoionization can account for some of the discrepancy. The model however can match the overall energetic needs for the transition region, and it accounts for the observed shift away from ionization equilibrium. Other modifications which might account for the remaining discrepancy include random sudden reheating of the cooling gas (Raymond and Foukal 1982) or a geometry in which the line of sight intersects the cooling flow where the gas is at a few x $10^5$K, but much of the lower temperature cooling occurs outside the instrumental field of view.

References

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