SOLAR EUV EMISSION LINE PROFILES OF Si II AND Si III
AND THEIR CENTER TO LIMB VARIATIONS

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Abstract. Spectral line profiles of Si II and Si III are presented which were observed both at solar center and near the quiet solar limb with the Naval Research Laboratory EUV spectrograph of ATM/SKYLAB. Absolute intensities and line profiles are derived from the photographic data. A brief discussion is given of their center-to-limb variations and of the optical thickness of the chromosphere in these lines. Nonthermal broadening velocities are found for the optically thin lines from their full width at half maximum intensity (FWHM).

1. Introduction

During the three SKYLAB missions, spectra of many solar phenomena were obtained with the U.S. Naval Research Laboratory (NRL) extreme ultraviolet (EUV) spectrograph of the Apollo Telescope Mount (ATM). This double dispersion grating spectrograph recorded high resolution spectra from 970 Å–4000 Å. The Sun was imaged on the 10 μm × 300 μm slit with a 1 m off-axis paraboloid, resulting in an effective spatial resolution of 2″×60″ (″ is sec of arc). In one of the joint observing programs, spectra were taken at 2″ intervals across the solar limb in an effort to study changes from the photosphere to the chromosphere, and from the transition region to the corona. A number of strong resonance, intersystem and subordinate lines in Si II and Si III appear in these spectra at λ < 2000 Å.

In this paper we present the reduced data giving the center-limb variations of the Si II and Si III line profiles for a quiet chromosphere together with a preliminary discussion of some of the more obvious features of the data. The Si II and Si III lines are of interest in that their depths of formation are expected to cover most of the chromosphere between the approximate temperature limits of 6000 K to 40 000 K.

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In particular, the line profiles and absolute intensities can provide valuable information on the temperature structure and nonthermal velocities in the middle and upper chromosphere. A detailed treatment of these lines must include a solution of the coupled statistical equilibrium and radiative transfer equations. Such analysis is in progress by two of the authors (DAT and RGA) and will be published separately.

A correction has been made to the absolute intensities for lines below 1400 Å which were listed in a preprint of this paper. The method of obtaining the correction curve is discussed in the Data Reduction Section. The magnitude of the correction factor varies linearly on a log scale from 0.0 dex at 1400 Å to 0.6 dex at 1175 Å. This correction also applies to the intensities listed in Kjeldseth Moe and Nicolas (1977) but does not affect the conclusions.

2. Instrumentation

The spectrograph is described in detail by Bartoe et al. (1977). The spectral resolution ($\lambda/\Delta \lambda$) is about 30,000 between 1200 Å and 2000 Å, degrading to 20,000 from 1200–970 Å. The astigmatic spectral line images were uniform, and reflect the average emission in the field-of-view. This permitted densitometer scans to be easily made in the direction of dispersion. The dispersion was 0.240 mm Å$^{-1}$. The spectra were photographed on Kodak 104 Schumann-type film.

The instrument was equipped with an automatic pointing system which stepped the entrance slit in predetermined intervals across the solar white light limb. Spectra inside and outside the solar limb were recorded. The stability of the system was observed to be better than $\pm 1''$.

For this investigation, limb sequences were used from 4" inside the solar limb ($-4''$) (1" is about 750 km at the solar surface) to 12" beyond the limb ($+12''$) in 2" steps. These observations were made on June 13, 1973. A portion of the solar limb was selected in the NW quadrant at solar latitude 35°. No coronal holes were present (Bohlin and Rubenstein, 1975) and no active regions or prominences were near the field-of-view. In addition, spectra taken immediately after the limb scan at 300" inside the limb ($\mu = 0.73$) were used both for comparison with the limb spectra and to derive an absolute intensity scale. The spectra at $\mu = 0.73$ were exposed while the spectrograph slit was slewed back and forth through $\pm 30''$ in order to average over solar inhomogeneities. For completeness, emission lines at the quiet solar center are included. These were taken during the second ATM mission.

3. Data Reduction

Spectral line profile data were reduced for the Si II and Si III lines listed in Table I. Wavelengths and multiplet numbers are taken from Kelly and Palumbo (1973) and Moore (1965). The configurations and atomic parameters were taken from Wiese et al. (1969) and are also shown in Table I. The origin of each of these lines is indicated in the term diagram shown in Figure 1.