Oso-7 Results on Coronal Emission Near 304 Å

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Abstract. The spectral composition and spatial distribution of equatorial coronal emission near 304 Å is examined. Spectral scans indicate that the predominant line is from Si xI. Comparisons of observations with calculations of intensity changes with altitude indicate that collisional excitation is important near the Sun but that photoexcitation becomes dominant beyond about 1.3 R⊙ from the solar center. Observed and calculated intensities are in approximate agreement for abundances and electron densities that are within the range of observed values.

1. Introduction

From the discovery of the solar Lx line of He II by Violett and Rense (1959) to the recent detailed spectroheliograms by Tousey et al. (1973), considerable progress has been made toward the understanding of the spectral composition, line widths, spatial distributions, and temporal variations of chromospheric emission near 304 Å. In this paper, we examine an area that has not been explored – the spectral composition and spatial distribution of coronal emission near 304 Å.

Observations of the whole Sun indicate that the 303.78 Å line of He II is the predominant one but that the 303.32 Å line of Si xI is also appreciable. Initial measurements (resolving power of 1000) near solar minimum (Tousey et al., 1965) gave the result that the Si line was about 5% of the He line. A recent result by Heroux et al. (1974) (FWHM line shape of 0.6 Å) gives 12%. Results with better resolution during nonflare periods near solar maximum give average values of 17% (Freeman and Jones, 1970) and 15% (Behring, 1974).

Since the He line is produced mainly in the chromosphere while the Si line is coronal, it may be expected that there should be a tendency for the Si line to become predominant outside of the solar disk. On the other hand, resonance scattering of the He line may be important in the corona, and coronal He emission may be appreciable. Lx of He II may be similar to Lx of H I which has been found to be the predominant line from the corona in its wavelength region and to be due to resonance scattering from the rare H I in the corona (Gabriel, 1971).

In the following section, model dependent calculations for the coronal emission for both the He and Si lines are given. Oso-7 observations are presented in the following section and compared with the results of calculations.

2. Calculated Intensities

In this section, calculated intensities for the 303.78 Å line of He II and the 303.32 Å
line of Si I are given for lines of sight between 1.1 and 2 $R_\odot$ from the solar center. A number of simplifying assumptions are made. One that may be questioned is that of spherical symmetry. This may be viewed as a first approximation for average densities etc. along a line of sight and is related to measured electron densities which are similarly average values along lines of sight. Uniform temperatures and abundances are also assumed; these may also be viewed as appropriate average values. In the selection of line fluxes for calculations of resonance scattering, average values appropriate for 1972 are used since OSO-7 measurements made in that year are presented.

2.1. COLLISIONAL EXCITATION

The collisional excitation rate per ion is $P_c = q n_e$; Van Regemorter's (1962) excitation rate coefficients for $q$ are used with the oscillator strength, $f=0.416$, for He II and $f=0.29$ for Si I (Smith and Wiese, 1971). For $T=1.7 \times 10^6 K$, $q=0.35 \times 10^{-8} \text{ s}^{-1} \text{ cm}^3$ for He II and $q=0.24 \times 10^{-8} \text{ s}^{-1} \text{ cm}^3$ for Si I. For these ions, Van Regemorter's rate coefficients vary slowly with $T$ for coronal temperatures.

The brightness, $B_c$ (photon cm$^{-2}$ s$^{-1}$ sr$^{-1}$), for collisional excitation is

$$B_c = \frac{1}{4\pi} \int q n_e^2 \left( \frac{n_{\text{ion}}}{n_e} \right) \text{dx},$$

where $x$ is along a line of sight. With the assumptions that $q$ and $n_{\text{ion}}/n_e$ are nearly constant or are suitable average values, (1) is evaluated with

$$n_e = 3.2 \times 10^8 R^{-2} e^{-A(1-1/R)} \text{ cm}^{-3},$$

where $R$ is the distance from the solar center in solar radii and $A$ is a parameter. For $A=7$ (used below) and $R$ between 1.1 and 3, this expression for $n_e$ is within 10% of Newkirk's (1967) equatorial solar minimum model and about 0.8 times Allen's (1973) solar maximum model.

Numerical integration gives:

$$B_c = \frac{0.65 q^{3/2} r_\odot q n_e^2 (q) n_{\text{ion}}/n_e}{4\pi},$$

where $q$ is the minimum distance in solar radii to the line of sight. Results for other density models of the same form vary approximately with $n_e^2(q)$ and the inverse square root of the parameter $A$ in (2).

2.2. PHOTOEXCITATION

For the photoexcitation rate per ion, $P(s^{-1})$, the expression of Gabriel (1971) may be rewritten:

$$P = \frac{\pi e^2 f\lambda^2}{mc^2} \int \phi \int L' L \text{ d}\lambda \text{ d}\Omega (s^{-1}),$$

where $\phi$ is the line flux in photon cm$^{-2}$ s$^{-1}$ sr$^{-1}$, d$\Omega$ is an element of solid angle, and