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DENSITY DIAGNOSTICS OF SOLAR EMISSION LINES FROM NITROGEN-LIKE IONS

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ABSTRACT

Steady state level population of 13 levels of nitrogen-like ions; Ne IV, Mg VI, Si VIII, and S X have been computed as a function of electron density and temperature. We have accounted for collisional and spontaneous radiative processes. Photo-excitations among the ground term levels have also been considered. Using the computed level populations line intensities have been obtained as a function of electron density and temperature. This study indicates that line intensity ratios for nitrogen-like ions can be used as a density monitor of the solar plasma. Absolute line fluxes from these ions at earth distance have been computed and compared with values obtained using various satellite and rocket measurements.

INTRODUCTION

The study of solar EUV emission lines has been widely used to derive the electron density and temperature of the solar plasma. Lines emitted from beryllium-like ions have been extensively used to probe the solar transition region and the astrophysical plasma /1, 2, 3, 4, 5, 6/. The lines in the boron-like ions have also been used as a density monitor of the solar plasma /7, 8, 9, 10, 11, 12, 13/. The density diagnostics of solar emission lines from carbon-like ions /14, 15/ and oxygen-like ions /16/ have been studied in detail. However, the method of determining the electron density from emission lines is not new and has been used since long /17/ for O II lines of nitrogen sequence. The density sensitivity for the O II line ratio occurs around 10^3 cm^{-3} and is useful for probing gaseous nebulae. If more highly ionized ions in the nitrogen sequence are considered, examples have been found that are useful at solar densities /18, 19/. Forbidden lines of the ions of Mg VI, Si VIII, S X and Ar XII have been considered by Feldman et al. /19/. In the present investigation we have considered the first 13 levels of nitrogen-like ions. According to the ionization equilibrium calculations of Jordan /20/, Mg VI has maximum relative ion abundance at 4 x 10^5 K, Si VIII at 8 x 10^5 K and S X at 1.4 x 10^6 K. Lines emitted from these ions are therefore useful in probing the solar chromosphere-corona transition region and the inner corona.

The schematic energy level diagram comprising the first 13 levels of nitrogen-like ions has been shown in Figure 1. The various physical processes considered in the present investigation include the electron collisional excitations and spontaneous radiative de-excitations for permitted transitions; electron excitations and de-excitations, spontaneous radiative de-excitations among the ground term levels.

LINE EMISSION

The line emission from a given volume element in the solar atmosphere in a steady state is given by the expression

$$E(j,i) = \frac{1}{4\pi} A_{ji} \; E_{ij} \; N_j \; (\text{ergs cm}^{-3}\ \text{sr}^{-1}\ \text{s}^{-1})$$

Where E_{ij} is the energy of transition between upper level j and lower level i, A_{ji} is the radiative transition probability and N_j is the number density of the ions in excited level j. Thus the number density as a function of electron density and temperature has been evaluated by solving all the detailed balance equations for the atomic levels shown in Figure 1. The integrated line fluxes have been computed using the model atmosphere of Elzner /22/.

Computed Line Fluxes from the entire Solar Disk at Earth's distance

TABLE 1 SiVIII-Ion, N(Si)/N(H) = 5.01 x 10^{-5} (Relative Abundance of Silicon, Kato/21/)

Transition	Wave length Å	Flux (10^{-3} ergs cm^{-2} s^{-1})	
		Calculated	Observed*
13, 2	214.75	0.43	0.7^a
13, 4	232.84	0.08	
12, 2	216.79	0.13	3^a, 5^b
12, 3	216.92	1.20	
12, 4	235.24	0.06	
12, 5	235.56	0.30	0.5^a
10, 2	276.84	0.53	
10, 3	277.05	0.06	
10, 4	307.65	0.07	
9, 2	276.89	0.09	
9, 3	277.10	1.32	
9, 5	309.26	0.18	
8, 1	314.31	1.34	6^b, 1.3^d
7, 1	316.21	2.56	11^b, 2.4^d
6, 1	319.83	3.82	22^b, 3.8^d
5, 1	944.44	0.36	
4, 1	949.24	0.16	
2, 1	1445.78	0.24	

TABLE 2. SX-Ion, N(S)/N(H) = 1.99 x 10^{-5} (Relative Abundance of Sulphur, Kato /21/)

Transition	Wave length Å	Flux (10^{-3} ergs cm^{-2} s^{-1})	
		Calculated	Observed*
12, 3	180.78	0.21	
12, 5	196.84	0.06	
9, 3	228.64	0.24	
9, 5	255.07	0.04	
8, 1	257.13	0.79	5^b
7, 1	259.49	1.53	5.2^a, 17^b, 1.5^d
6, 1	264.24	2.15	4.9^a, 20^b, 2.0^d
5, 1	776.58	0.10	
4, 1	787.78	0.05	
3, 1	1196.92	0.08	0.45^c
2, 1	1213.62	0.14	1.4^c

* Notes for the Tables 1 and 2

a Observed line fluxes from Malinovsky and Heroux /27/
b Observed line fluxes from Behring et al. /28/
c Observed line fluxes from Sandlin et al. /29/
d Observed line fluxes from Austin et al. /30/

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