TEMPERATURE STRUCTURE AND CONDUCTIVE FLUX IN THE CHROMOSPHERE-CORONA TRANSITION REGION*

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Abstract. Observations of UV-line intensities referring to the whole undisturbed Sun are used to investigate the chromosphere-corona transition region. For the evaluation of the integral representing the theoretical line intensities it appears to be an improvement to consider not the temperature gradient but the conductive flux to be nearly constant in the line-forming region. The variation of conductive flux with temperature calculated in this way is indeed small. Moreover, in the conductive flux versus temperature diagram the scatter of points is found to be less with coronal values of relative abundances than with photospheric ones. The results are used for determining the temperature structure of the transition region.

1. Introduction

Observed UV-resonance line intensities have already been used to derive element abundances and to investigate the chromosphere-corona transition region. A convincing interpretation of the UV emission of the Sun will probably first be possible when the UV lines are observed with high spatial and spectral resolution. It seems to us, however, that the investigations based on the intensities of the lines emitted by the whole solar disk may be improved to a certain degree. In the present investigation effects of spicular absorption and self-absorption are neglected.

2. Analysis

The basic equation used expresses the flux $E$ in ergs cm$^{-2}$ s$^{-1}$ at the distance of the Earth, from a resonance line. Considering spherical symmetry, following Pottasch (1967), it is given by

$$E = 2.4 \times 10^{-20} g f A_{el} \int \frac{N_i(T_e)}{N_{tot}} N_e^2 T_e^{-1/2} 10^{-5040W/T_e} dh$$

where $f$ is the absorption oscillator strength of the observed line, $g$ is the Gaunt factor, $A_{el}$ is the number density of the element relative to hydrogen. The integral is taken over the line-forming region, $h$ is the height of the emitting layer. $N_i(T_e)/N_{tot}$ represents the relative ion density of the element. $N_e$ is the electron density, $T_e$ the electron temperature, and $W$ is the excitation energy for the transition in eV.

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The expression given by Equation (1) assumes that the line arises from collisional excitation followed by a radiative return and that the lower state of this transition is the ground state and all except a negligible fraction of ions concerned are in this ground state. According to Pottasch (1967) this would be true for ions whose outer electron configuration is \( s(2S_{1/2}), s^2(1S_0) \) and \( p^6(1S_0) \). For the configurations \( p, p^5(2P) \) and \( p^2, p^4(3P) \) and \( d(3D) \), we are faced with the case where the ion population is split between two levels in the case of doublet or among three levels in the case of the triplet.

For a single line the right-hand side of Equation (1) must be multiplied by the fraction of the total ion population which is in the lower level of the transition. Let this fraction be \( p_j \), subscript \( j \) denotes the lower level of the excitation. The split levels of the ground state of an ion which constitute the lower levels for the resonance transitions are metastable levels. These levels, under the physical conditions prevailing in the transition region, may be mainly populated by collisional processes. \( p_j \) therefore may be approximated by Boltzmann distribution. Since the energy difference between these lower levels are small the \( p_j \)'s are approximated by the ratio of statistical weights.

The more complete expression for \( E \) is now given by

\[
E_j = 2.4 \times 10^{-20} g f_j A_{el} p_j \int N_e^2 g_1(T_e) \, dh, \tag{2}
\]

where

\[
g_1(T_e) = \frac{N_i(T_e)}{N_{tot}} T_e^{-1/2} 10^{-5040W/T_e}. \tag{3}
\]

In an approximation introduced by Pottasch (1964, 1967) \( g_1(T_e) \) can be considered to be a relatively sharply peaked function, a suitable averaged value of it can be taken out of the integral in Equation (2). Because of the sharpness of \( g_1(T_e) \) one can assume that a line is effectively formed at a temperature at which \( g_1(T_e) \) is maximum. Equation (2) can be written as

\[
p_j A_{el} \int N_e^2 \, dh = \frac{E_j}{2.4 \times 10^{-20} g f_j \langle g_1(T_e) \rangle}. \tag{4}
\]

Whereby \( \int N_e^2 \, dh \) belongs to a relatively small temperature range. It is assumed that \( g \) does not depend significantly on the ground state splitting. If, for instance, we have three levels which are important in contributing to the total ion population then Equation (4), after summation over the three levels with \( \sum_1^3 p_j = 1 \), would, following Pottasch (1967), lead to

\[
A_{el} \int N_e^2 \, dh = \frac{1}{2.4 \times 10^{-20} g \langle g_1(T_e) \rangle} \left( \frac{E_1}{f_1} + \frac{E_2}{f_2} + \frac{E_3}{f_3} \right). \tag{5}
\]

By choosing suitable values for \( A_{el} \) the observed fluxes can be fitted to a mean curve in the \( \int N_e^2 \, dh \) versus \( T_e \) diagram. In this way Pottasch derived relative abundances of elements, the relative coronal abundances, which were somewhat different from the