ABUNDANCE OF Fe RELATIVE TO H AT 1.5 SOLAR RADII

M. P. NAKADA, R. D. CHAPMAN, W. M. NEUPERT, and R. J. THOMAS
Laboratory for Solar Physics and Astrophysics,
NASA-Goddard Space Flight Center, Greenbelt, Md. 20771, U.S.A.

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Abstract. The abundance of Fe relative to H is obtained by using resonantly scattered intensities of \( \lambda 284 \) of Fe xv that were measured with OSO-7 and resonantly scattered intensities of \( L_\alpha \) of H i that were obtained by Gabriel (1971). Because of possible differences in electron densities along lines of sight for these non-simultaneous measurements and in relative calibrations, results are rather uncertain but still indicate that the average Fe abundance relative to H in the corona appears to be at least as large as a recent photospheric abundance. Some limitations in using this method for obtaining abundances are examined for future experiments with simultaneous measurements and well calibrated detectors.

1. Introduction

Although electron collisions may be the principal excitation process for many ions near the base of the corona, photoexcitation may become dominant at greater heights. This can happen for certain intense coronal lines since collisional excitation, which varies as \( n_e \), tends to decrease more rapidly with height than photoexcitation which varies approximately with the dilution factor, \( D \). For instance, at and beyond about 1.5 solar radii from the solar center the \( \lambda 284 \) line of Fe xv appears to be dominated by photoexcitation. By taking ratios of the scattered intensities of this line to those of \( L_\alpha \) of H i (Gabriel, 1971) at the same heights, it appears possible to obtain Fe abundances relative to H. Previous studies have given abundances relative to electrons or to other heavy elements since no identifying radiation of H was available (de Boer et al., 1972; Walker et al., 1974; Malinovsky and Heroux, 1973; Pottasch, 1968; Jordan, 1966; Dupree, 1971 as tabulated by Withbroe, 1971).

Simultaneous measurements of scattered intensities would be ideal since this would tend to minimize uncertainties due to differences in densities along lines of sight. Since such measurements are not available, measurements by Gabriel of \( L_\alpha \) on March 7, 1970, are used together with the \( \lambda 284 \) results from Neupert et al. for 1972 that have been published in Solar-Geophysical Data. A spectroheliogram for \( \lambda 284 \) is shown in Figure 1.

The purpose of this report is mainly to examine the use of resonance scattering as a method for obtaining abundances relative to H. Abundances of Fe are obtained for these non-simultaneous measurements and some uncertainties in the procedures used are examined.

2. Excitation by Resonance Absorption and Electron Collisions

In this section, the excitation of Fe xv by resonance absorption and electron collisions
is evaluated. The approximate fractional brightness due to resonance scattering is also given.

Let $P$ be the photoexcitation rate per ion. Gabriel's expression for $P$ may be written:

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

(1)

where $f$ is the oscillator strength, $\phi$ is the line flux in photon cm$^{-2}$ s$^{-1}$ sr$^{-1}$, $d\Omega$ is an element of solid angle, and $L'$ and $L$ are emission and absorption line shapes normalized so that the integral of each separately over wavelength is 1.

Measurements by Feldman and Behring (1974) indicate that coronal emission line shapes are approximately Gaussian with a mean random turbulent velocity, $\zeta$, of 30 km s$^{-1}$ in addition to thermal Doppler broadening. This shape is assumed for $L'$. For $L$, only thermal Doppler broadening is assumed. With the assumptions that line shapes are independent of direction and that emission and absorption temperatures