SOME PROPERTIES OF STELLAR TRANSITION REGIONS

Mikael Saxner
Astronomiska Observatoriet
Uppsala

1. Introduction

Among the strongest lines from stellar transition regions are the resonance lines of N V (1240Å), Si IV (1394,1403Å), and C IV (1549Å), which are all observable by the IUE.

In an earlier paper (Saxner, 1981) it was noticed that there is a correlation between the fluxes in these three lines. In Fig. 1 the ratio of the N V to the C IV flux is plotted against the ratio of the C IV to the Si IV flux. Verbally the correlation may be stated as follows: the Si IV flux and the N V flux are covarying; if one is strong the other also tends to be strong, and vice versa. In all cases the C IV line is the strongest.

The paucity of points above and below the main diagonal in the diagram could be explained if there were objects with only one of the Si IV and N V fluxes too weak to be detected. However, the points along the lower

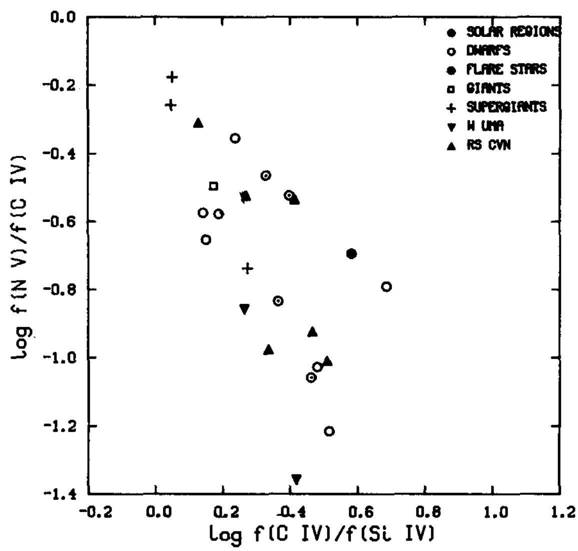

Fig 1. *Observed relation between the transition region emission line fluxes*

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part of the diagonal are observed despite having both Si IV and N V weak. Thus the correlation is probably not due to a selection effect.
The correlation also seems to be the same for widely differing types of objects, and is likely to reflect some common property of all stellar transition regions. In this paper we suggest that the correlation is the result of different stellar transition regions having a similar shape, while other properties, such as pressure and geometrical extent, may vary. This together with optical depth effects can explain the observed distribution.

2. The model

To investigate the effects of the shape of the transition region we have assumed that the temperature gradient varies as

$$\frac{dT}{dz} = \alpha \cdot T^{\beta} \tag{1}$$

between two temperatures T_0 and T_1 chosen such that all of the radiation in the three lines is formed within this temperature interval.
The transition region is assumed to be static and to have constant pressure p_0. It does not, however, have to be homogeneous.
The ionization equilibria needed in the calculations are taken from Jordan (1969). In accordance with these data we have chosen $\log T_0 = 4.4$ and $\log T_1 = 5.8$.
Throughout this model transition region the equation of radiative transfer is solved with the source function

$$S_\lambda = \frac{n_e C_{12}}{B_{12}} \tag{2}$$

where $n_e C_{12}$ is the electron collision excitation rate to the upper level, and B_{12} is the Einstein coefficient for absorption. This particular form for the source function is valid when self-absorption is negligible compared to collisional excitation, and when spontaneous decay dominates over collisional de-excitation.
The equation of transfer is solved separately for each component of the multiplet and the total intensity in the multiplet is obtained by integration over the line profiles.

3. Results

For a given value of β different values of the pressure p_0 define a curve in Fig. 1. In our computations the pressure was varied to cover the whole range of optical depths in the lines.
The parameter α in Eq. (1) is a function of β, the stellar gravity, and the fractional amount of mass, x, between T_0 and T_1 compared to all mass above T_0. In the computations we have used $g = 10^4$ and $x = 0.1$. Other choices for these parameters merely move the point along the given β-curve.
In Fig. 2a the theoretical curves for different values of β are shown together with the observed points. The fit is not very good, especially in the left-hand part of the diagram where the observed points seem to

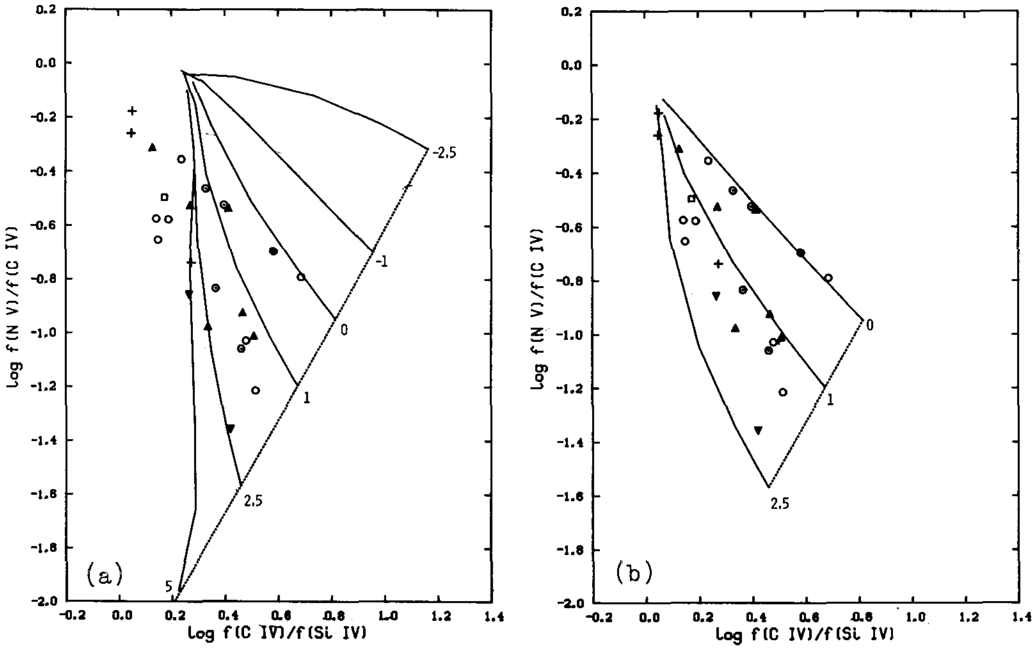

Fig 2. The solid curves show the theoretical relations without microturbulence (a), and with a microturbulence of 30 km s^{-1} (b). The curves are marked with their value of β. The dotted lines mark the optically thin limit. Also shown are the observations.

have stronger Si IV emission than the model predicts. In Fig. 2b we show the result if we introduce a microturbulent velocity of 30 km s^{-1}. Here the fit is much better, both as regards position and slope. A further increase of ξ to 100 km s^{-1} gives almost identical result. This is not surprising, since at 30 km s^{-1} the microturbulence already dominates over the thermal velocities.

4. Conclusions

There are two main conclusions to be drawn from this investigation. Firstly, if we take the observational scatter into account, we find from Fig. 2b that β lies between about 0.5 and 1.5 . As defined here, β is some kind of "integrated" mean over a large temperature interval, and the present result cannot rule out the possibility that β is close to -2.5, the value expected for constant conductive flux, in the higher transition region.

Secondly a comparison of Fig. 2a and b shows that there must exist small-scale turbulence in stellar transition regions with velocities exceeding about 20 km s^{-1} in order to explain the observed distribution.

5. References

Jordan, C., 1969, MNRAS, 142, 501
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