FROM WHAT RADIUS DO THE WINDS OF MAGELLANIC CLOUD SUPERGIANTS PRODUCE Fe II EMISSION LINES?

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Abstract
Maximum values for the inner radii at which Fe II emission line formation can take place in the winds of three Magellanic Cloud supergiants have been determined. The lie between 3×10^{13} and 3×10^{14} for R50, R82, and R126.

We have studied the formation of emission lines of singly ionized iron in stellar winds in which hydrogen is almost completely ionized, using the theory of Viotti (1976). The wind was assumed to have a constant velocity in the line forming region, so that the electron density varied as $1/r^2$; r being the distance from the centre of the wind. Two cases of line formation were considered:

(c) The local random (thermal plus "turbulent") velocities are much less than the wind velocity (Sobolev case of line formation in a moving envelope).

(b) The local random velocities are much greater than the wind velocity. This case is suggested when P Cygni profiles are not observed; it is, however, much less realistic physically.

In each of these cases theoretical self-absorption curves were calculated. Such a curve is defined as being the graph of $\log F_c + \log W_\lambda - \log (gf) + 3 \log \lambda$ against $\log (gf) + \log \lambda$ for lines of the same multiplet. Here F_c is the relative continuum flux per angstrom, W_λ the equivalent width, λ the wavelength, and gf the oscillator strength multiplied by the statistical weight of the lower level. When all lines are optically thin, as is usually the case for the forbidden lines, the self absorption curve is replaced by a horizontal line.

In order to compare observations with theory, the values of F_c were first dereddened. This was done by supposing that the forbidden lines of multiplets 6F and 20F, having the same upper term, lay on the same optical thin self-absorption curve (horizontal line); any observed difference being due to differential reddening. After dereddening the observed self-absorption curves of permitted multiplets were shifted vertically and horizontally so as to give a curve which agreed best with the theoretical one. In this method multiplets having the same upper term must not have a relative vertical shift, while those having the same lower term must not have a relative horizontal shift of the

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observed curves (Friedjung and Muratorio 1980). The shifts gave relative populations of terms of different multiplets. The comparison of theoretical and observed self-absorption curves is shown in Figs. 1, 2, and 3.

Maximum inner radii of the FeII line formation region were found by comparing the self-absorption curve of multiplet 38 with that of multiplets 6F and 20F, whose upper term is the lower term of multiplet 38. The method is similar to that used by Friedjung and Muratorio (1980) to determine the radius of the FeII emitting region of S22.

R50 gave, with an E(B-V) of 0.10 and a wind velocity of 70 km s^{-1}, a maximum inner radius of 10 10^{13}cm. A wind velocity of 100 km s^{-1} gives a radius of 8 10^{13}cm. In the case of R82, with a zero E(B-V) and a wind velocity of 150 km s^{-1}, a maximum inner radius of 3 10^{13}cm is obtained. In both these cases an (b) type (see with figure) theoretical self-absorption curve was used for the permitted lines. R126 was analyzed using a (c) type self-absorption curve. E(B-V) was taken as 0.09 and a mean deconvolved line half-intensity width of 0.54Å led to a radius of 2 to 3 10^{13}cm.

Friedjung, M., Muratorio, A. 1980, Astron. Astrophys. 85 233
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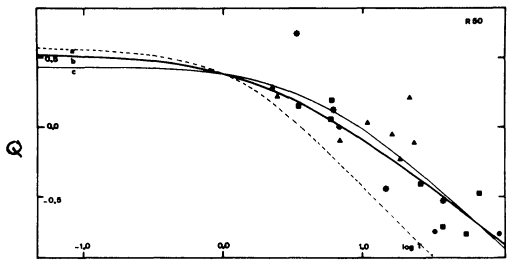

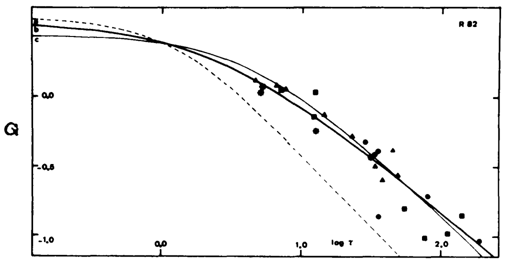

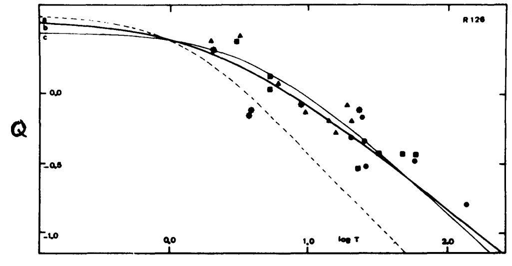

W_λ F_λ flux in the emission line

gf oscillator strength
λ wavelength
N level population
g statistical weight
symbols multiplets 27• 28• 37▲ 38■

$Q = \log W_\lambda F_\lambda - \log gf + 3 \log \lambda$

for stars R50, R82 and R126
Observational points are shifted for each multiplet in order to fit the theoretical self absorption curves

a) $Q = \log (1 - e^{-\tau})/\tau$

b) $Q = \log 2 \int_{v=-\infty}^{+\infty} \int_{w=0}^{+\infty} \int_{\theta_0=-\pi/2}^{\pi/2} e^{-\frac{\tau}{w}(\theta_0 + \frac{\pi}{2})} \frac{\cos^2\theta_0}{w^2} \, d\theta_0 \, dw \, dv$

c) $Q = \log 2 \int_{1}^{+1} \int_{w=\sqrt{1-v^2}}^{+\infty} \left(\frac{\sqrt{1-v^2}}{w}\right) \left(\frac{1-e^{-\tau}}{\tau_0}\right) dw \, dv$

for case b and c $\tau = \frac{\tau_0}{\sigma\sqrt{2\pi}} \int_{-\infty}^{+\infty} e^{-\frac{v^2}{2\sigma^2}} dv$

with a $\frac{1}{r^2}$ gas density law

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