ON THE STELLAR GRAVITY AND EFFECTIVE TEMPERATURE DEPENDENCE OF THE RATIO OF TERMINAL TO ESCAPE VELOCITIES IN STELLAR WINDS.

LUIS CARRASCO
Landessternwarte, Heidelberg-Königstuhl
and
Instituto de Astronomia, UNAM, México

Contrary to the results of some investigators, the ratio of terminal to escape velocities ($V\infty/Vesc$) observed for the winds in early-type stars is found to be linearly correlated with log Γ - Γ being the ratio of stellar to Eddington's luminosities.

Although the determination of terminal velocities for O-type main sequence stars from edge velocity information may be somewhat questionable (Lamers, 1980). The determined values for the β and γ fitting parameters for the observed profiles by Conti and Garmany (1980) are tipically on the order of one for these stars. Hence, from the grid of profiles by Castor and Lamers (1979), we estimate that at most a 10% error is introduced by adopting the edge velocities as representative values of the terminal velocities of main sequence O-type stars. With this in mind, we reanalize the data published by Abott (1978), Conti and Garmany (1980), Wolf and Appenzeller (1979) and Hutchings and von Rudloff (1980), for some 70 O- and early B-type stars. The line of stability against radiation pressure disruption due to electron scattering and the location of our stellar sample in the log g - log T_{eff} plane, together with the values for the ratio $R \equiv V\infty/Vesc$ is shown in Fig. 1. From this figure, we can see, - despite observational errors - , a tendency for iso-ratio sequences to lie along parallel lines of constant Γ. $\Gamma \equiv \sigma eL/4\pi GMc$; this being the ratio of stellar to Eddington's luminosities. Hence, we are tempted to investigate the possible correlation - already apparent in Figure 1 - between R and Γ. It is found that they are indeed correlated (correlation coefficient $r^2 = 0.75$) and a least squares regression yields:

$$\frac{V\infty}{Vesc} = R = 3.03 \log\Gamma + 4.98.$$

C. Chiosi and R. Stalio (eds.), Effects of Mass Loss on Stellar Evolution, 75–78.

https://doi.org/10.1017/S025292110009463X Published online by Cambridge University Press

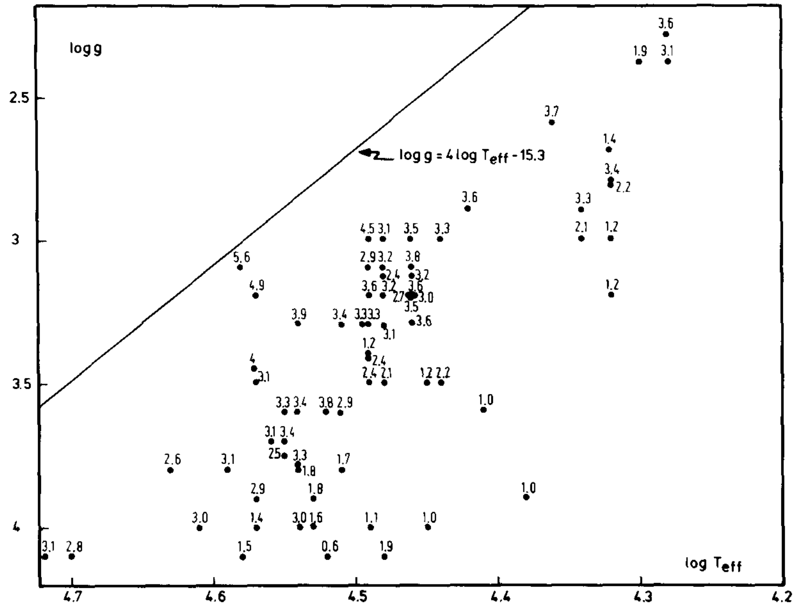

Figure 1: Location of the stellar sample in the log g - Teff plane. Stars are label with their individual R-values (see text). The solid line defines the radiation pressure stability line.

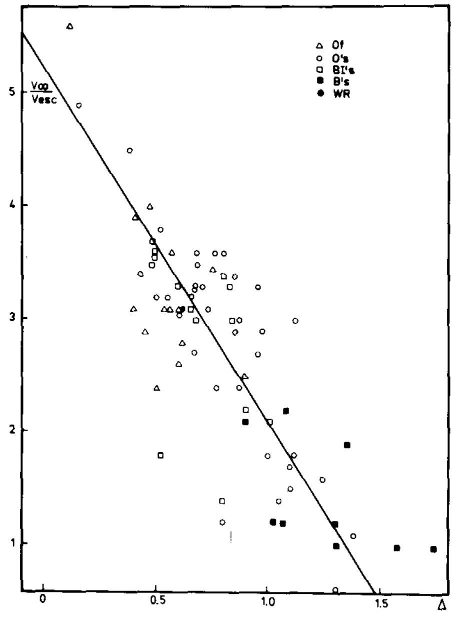

Figure 2: The V∞/Vesc ratio is plotted against the parameter Δ, for the stellar sample used. The solid line represents a regression through the points.

https://doi.org/10.1017/S025292110009463X Published online by Cambridge University Press

In Figure 2, the ratio R is plotted versus the parameter $\Delta \equiv -\log \Gamma + 0.05$. ($\Delta$ being an observational quantity calculated from the effective temperature and surface gravity scales adopted in this paper), it is defined here simply as: $\Delta = \log g - \log T_{eff}^4 + c$, c being a constant. For observational studies Δ is a more reliable parameter than Γ, since it is independent of both the masses and absolute luminosities adopted for the stars. Though Δ, of course, depends on the gravity and effective temperature calibrations.

The observed scatter in Figure 2 is likely due to observational uncertainties of the stellar parameters used in this paper. Nevertheless, it is apparent from this figure that O-type stars of different luminosity classes, including the Of's, and B-type stars of luminosity classes III and higher, have values of R that are dependent on the position of the stars in the H-R diagram.

The erroneously supposed approximate constancy of $R \simeq 3$, has been, in the past (Abbott, 1978), taken as strong evidence in favor of radiatively driven winds, in early type stars. We would like to point out that variations of $R \equiv V_\infty/V_{esc}$ are expected even for theories like that developed by Castor et al. (1975), since the parameters α and k that determine the force multiplier - due mainly to CIII lines - must depend on the position of the stars in the H-R diagram, through the ionization state of the photosphere, which in turn most depend on both the surface gravity and effective temperature of the stars.

Finally, the relation between R and α, namely $R = \alpha^{1/2}/(1-\alpha)^{1/2}$ allows us to incorporate the effect reported here to stellar evolution codes of massive stars, that take into account evolutionary effects of the mass loss rates, such as those developed by Chiosi and Nasi (1978).

References

Abbott, D.C., 1978, Astrophys.J. 225, 893

Castor, J.I., Abbott, D.C. and Klein, R.I., 1975, Astrophys.J. 195, 157

Castor, J.I. and Lamers, H.J., 1979, Astrophys.J.Suppl. 39, 481

Chiosi, C., Nasi, E. and Sreenivasan, S.R., 1978, Astron. Astrophys. 63, 103

Conti, P. and Garmany, C.D., 1980, Astrophys.J. 238 190

Hutchings, J.B. and von Rudloff, I.R., 1980, Astrophys.J. 238, 909

Lamers, H.J., 1980, in "The Universe in the Ultraviolet", R.D. Chapman ed.

Wolf, B. and Appenzeller, I., 1979, Astron.Astrophys. 78, 15

DISCUSSION

CHIOSI: How did you determine the Γ factors in your study? Are they based on evolutionary tracks or empirically determined?

CARRASCO: I deduce the Γ factors from observational parameters of the stellar photosphere deduced from the visible part of the spectrum, namely the surface gravity and effective temperature. Hence, they are free from uncertainties in both total luminosities and radii.

LAMERS: There may be another way to look at the terminal velocities. If one plots V_∞/V_{escape} versus T_{eff}, one finds a decrease from $V_\infty/V_{esc} \simeq 3.5$ for O-stars to $V_\infty/V_{esc} \simeq 1$ to 1.5 for A supergiants (e.g. Lamers; in The Universe in the Ultraviolet; ed. D. Chapman, Goddard Symposium, 1980).

CARRASCO: I agree entirely that V_∞/V_{esc} is a function of T_{eff}. The point here is that it is also a function of the surface gravity. In fact is a function of Γ, which is a combination of both.

PANAGIA: From data available in the literature (see Panagia and Macchetto, this Conference) the terminal velocity is found to be very well correlated to the effective temperature but completely independent of the Γ value. On the other hand, the escape velocity is an obvious function of Γ. This is what I believe introduces a dependence in the ratio $V_{terminal}/V_{escape}$.

CARRASCO: The dependence of V_{esc} in Γ is only to the 1/2 power. We have found a dependence of V_∞/V_{esc} with Γ even in the case when a correction of this order is taken into account. In this latter case one finds a dependance $R \simeq \log \Gamma^{2.4}$ +const. Hence it is effect not due to the dependance of V_{esc} with Γ.

https://doi.org/10.1017/S025292110009463X Published online by Cambridge University Press