THE ANOMALOUS A-TYPE SUPERGIANTS IN THE MAGELLANIC CLOUDS - EVIDENCE FOR POST-RED SUPERGIANT EVOLUTION

R.M. HUMPHREYS
University of Minnesota
Minneapolis MN 55455, USA

R.P. KUDRITZKI, H. GROTH
University München
D8000 München 80, Germany

1. The anomalous A-type supergiants

A group of A-type stars in the field of the Small Magellanic Cloud (SMC) were noticed by Humphreys (1983) to have anomalously strong hydrogen (H) lines and a Balmer jump that are too strong for their luminosities. Their visual luminosities, based on membership in the SMC, are about two magnitudes brighter than one would expect from the appearance of the Balmer series. Humphreys also found that their colours are too red in U-B by 0.2 to 0.3 mag, but show little or no change in B-V relative to normal A-type supergiants; this is consistent with the strong Balmer jump in these stars' spectra. She also concluded that the objects do belong to the SMC.

Earlier, Sanduleak (1972) had identified a group of stars with similar properties in the LMC, but, because of their strong hydrogen lines, rejected them as members. However, Fehrenbach and Duflot (1972) recognized about 30 stars with A and F type spectra with unusually strong H lines. They concluded that they were members of the Large Magellanic Cloud (LMC) because of their large negative radial velocities.

Their spectral anomalies and peculiar colours cannot be explained by the lower metallicity in the Clouds. Earlier, Kudritzki (1973) had shown with some preliminary non-LTE models, that an increase in the He abundance will increase the strength of the Balmer lines. Thus an enhanced He abundance may explain the spectral and colour pecularities of these A-type supergiants. To test this hypothesis we obtained high-resolution spectra of several of these anomalous supergiants.

A group of four stars in the SMC, and two in the LMC, with the anomalously strong H lines and peculiar UBV colours, were observed with CASPEC on the ESO 3.6-metre telescope. The spectra have a resolution of 0.1Å and a wavelength coverage of λλ 3900-4800Å. Six 'normal' supergiants in the LMC and five in the SMC in the same spectral range were also observed.

Fig. 1 shows the behaviour of the equivalent width of H_γ versus the bolometric luminosities of the normal and anomalous stars of spectral types AO-A2 and A3-A8. The clear dependence of the strength of the hydrogen lines on luminosity is obvious and the equivalent widths confirm their greater strengths in the anomalous stars compared to what one would expect at their luminosities.

2. The effects of helium abundance on hydrogen line strengths

We have calculated a grid of NLTE model atmospheres in the range 8750K to 14000K, log g=0.75 to 2.00 and Y = 0.1 to 1.0. Fig. 2 shows the variation of the equivalent width of H_γ with log g for different He abundances with the range of measured widths for the anomalous and normal A-type supergiants. Comparing the anomalous and normal supergiants of similar luminosities, an

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increase in Y of 0.3 to 0.7 is needed to fit the observed H lines without increasing the gravity significantly. This preliminary analysis shows that an enhanced He abundance is a reasonable working hypothesis to explain the anomalous A-type supergiants in the Clouds.

3. Relation to massive star evolution

Because of the evidence for an enhanced He abundance in their atmospheres, it is tempting to speculate that these anomalous A-type supergiants have previously been red supergiants where high mass loss and mixing have brought processed material to the surface. If so, then these stars may be progenitors to the type of star that eventually exploded as SN1987A.

None of these anomalous A supergiants is found brighter than $M_{Bol} = 8$ mag. Either this stage is very short at higher luminosities or stars $\geq 25\ M_\odot$ don't evolve back to warmer temperatures as suggested by Woosley (1988).

These anomalous A-type supergiants are observed in both the LMC and SMC and it may be that the presence of blue loops in this mass range is unique to low metallicity systems. It is therefore important to search for their counterparts in our galaxy.

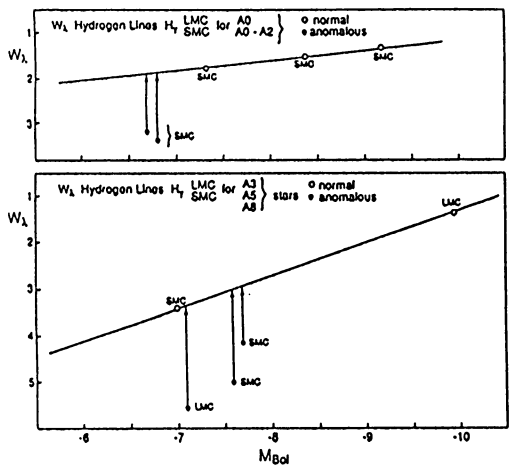

Figure 1. The behaviour of the equivalent width of H_γ with luminosity for the A0-A2 and A3-A8 normal (o) and anomalous (●) supergiants.

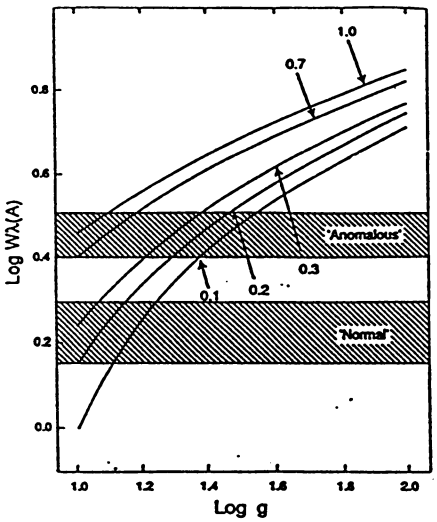

Figure 2. Logarithm of H_γ equivalent width as function of log g and Y for $T_{eff} = 10^4$K.

4. References

Fehrenbach, C., Duflot, M. (1972), *Astron. Astrophys.* **21**, 321.
Humphreys, R.M. (1983), *Ap. J.* **265**, 176.
Kudritzki, R.P. (1973), *Astron. Astrophys.* **28**, 103.
Sanduleak, N. (1972), *Astron. Astrophys.* **17**, 326.
Woosley, S.E. (1988), *Ap. J.* **330**, 218.

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