

THE ABSOLUTE MAGNITUDES OF WOLF-RAYET STARS HD 151932 AND HD 152270

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ABSTRACT

The absolute visual magnitudes of two Wolf-Rayet stars HD 151932 (WN 7) and HD 152270 (WC 7+08) have been determined from their energy distributions and monochromatic magnitudes least contaminated by emission lines taking into account their membership with the open cluster NGC 6231. It appears that the WN 7 ($M_V = -8.4$) is brighter by about a magnitude in comparison with WC 7 ($M_V = -8.0$).

Key words : Wolf-Rayet Stars—absolute magnitudes

1. Introduction

Estimates of absolute magnitudes of the Wolf-Rayet stars are difficult as they are contaminated by strong emission features. The uncertainties may be as high as 0.5 mag in the V filter (Conti, 1982). Many attempts have been made to overcome this drawback. Pyper (1966) derived the effective temperatures from *UBV* colour indices, corrected for emission and reddening, from the intensity measurements of their spectra. Smith (1968) used narrow-band photometry, thereby avoiding emission features and obtained more reliable values of their absolute magnitudes. More recently Massey and Conti (1982) estimated the M_V for some WR members of the LMC by spectrophotometry. The problem of distance estimates is relatively less in case of members of clusters and associations. Here, we have derived the absolute visual magnitudes of two Wolf-Rayet stars, HD 151932 (WN7) and HD 152270 (WC7+08) which are members of the galactic cluster NGC 6231, by employing narrowband photometry.

2. Observations

The observations were obtained using the Automated Spectrum Scanner (Bappu, 1977) attached to the Cassegrain focus of the 102 cm reflector of the Kavalur Observatory. A central wavelength of 5560 Å, close to the centre of the conventional V band was chosen and 100 Å exit slot was used. This system is similar to that of ν' of Smith (1968). In the 230 Å bandwidth used by Smith, a number of emission features contributed. After examining the spectra of WN7 and

WC7 stars (Bappu, 1973), we chose a slit width of 100 Å such that the emission line contribution is minimum.

Along with the cluster members, including these two Wolf-Rayet stars, ten spectrophotometric standards (Bregier, 1976; Landolt, 1973) were also obtained for the calibration of the system. These values derived for the cluster members, when compared with the V magnitudes obtained by Schild *et al.* (1969) show a standard deviation of 0.01 mag (Figure 1).

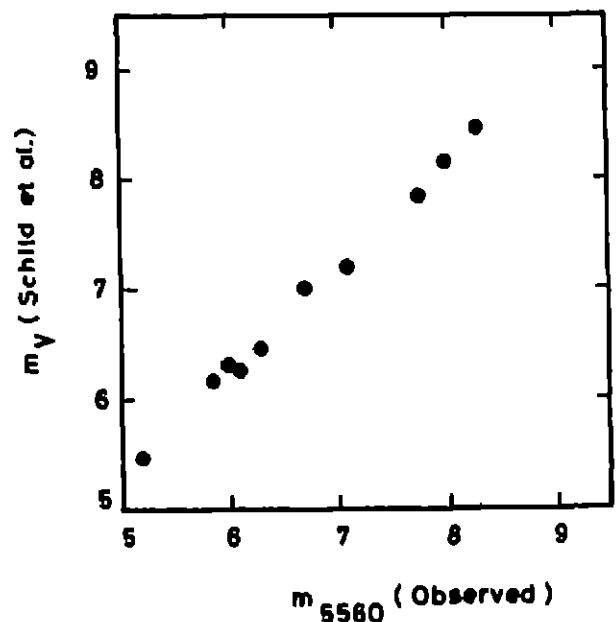


Fig. 1 Relationship between the monochromatic magnitudes obtained by us and the visual magnitudes given by Schild *et al.* (1969) for the cluster members of NGC 6231. Good linearity with minimum scatter is seen.

In order to get the distribution of colour excess across the cluster we have selected the regions $4300 \pm 10 \text{ \AA}$ and $5000 \pm 10 \text{ \AA}$ since they are relatively free of emission lines in both WN7 and WC7 (Smith, 1968; Bappu, 1973), and have designated them as b and v respectively. These are similar to the b and v bands of Smith (1968) (centered at 4270 \AA and 5160 \AA with bandwidths of 70 \AA and 130 \AA respectively). For this purpose a few bright members within the spectral range O8 to B3 were scanned from 4000 \AA to 5100 \AA with a slit width of 20 \AA .

Assuming the colour variation with the spectral type is very small in the range O8 to B3, the colours of unreddened star 10 Lac, O9V (Kuhl, 1965), have been used to estimate the colour excess $E(b-v)$ of the WR and a few other cluster members.

3. Discussion

The two main difficulties in obtaining the intrinsic magnitudes and thereby the absolute magnitudes of the WR stars are the estimation of the contribution from emission features and that due to interstellar extinction. The former effect is reduced by observations at relatively emission free regions as explained in the previous section. Assuming the ratio of total to selective absorption, $R=3.0$, (Schild *et al.*, 1971) the total absorption A_v can be estimated from the emission free colour excess. By further assuming the distribution of colour excess across the face of the cluster to be smooth, the colour excess of the WR star is taken to be the same as the other cluster member in the vicinity. For HD 152270, it is $E(B-V) = 0^m.64$, the mean of the colour excesses of two cluster members which are very close to it. For HD 151932 the colour excess has been adopted as $E(B-V) = 0^m.50$, same as that of HD 152076, the closeby bright star.

The values of colour excesses $E(B-V)$ obtained by Schild *et al.* (1969) and $E(b-v)$ obtained by us show a linear relationship for the normal members of the cluster (Figure 2). With the help of this relationship the colour excesses of the programme stars can be obtained. In case of HD 151932 we get $E(B-V) = 0^m.42$, which is very close to the value ($0^m.44$), estimated by Schmutz and Smith (1980) independently from the observations of $\lambda 2200 \text{ \AA}$ feature. Hence using these values of $E(b-v)$, the total absorption have been obtained and the intrinsic magnitudes have been calculated for the WR stars.

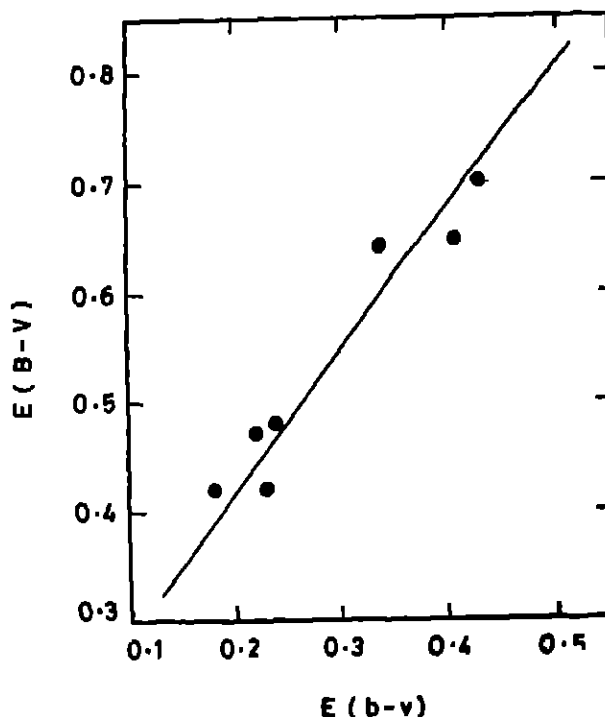


Fig. 2 Relationship between the colour excesses $E(b-v)$ derived in this paper and $E(B-V)$ given by Schild *et al.* (1969) for the cluster members of NGC 6231.

A distance modulus of $11^m.6$ has been derived for the cluster NGC 6231 by Garrison and Schild (1979) as well as by Levato and Malaroda (1980). This value was adopted by us to get the absolute magnitudes of the WR members and are given in Table 1.

For HD 151932, the value agrees with the statistical deductions of Lundstrom and Stenholm (1982) in which the value adopted for WN7 is $-8^m.4$ for galactic stars and $-8^m.6$ for LMC members. Bappu (1973) indicated a possible presence of a late type companion for this star. Saggewiss (1974) attributed the observed radial velocity changes to oscillating outer envelope. Willis (1980), from the UV observations, suspects the binary nature, but it is not yet established. In the absence of any confirmation regarding its binary nature, we have computed the absolute magnitude assuming this to be a single star.

HD 152270, is known to be a double lined spectroscopic binary (van der Hucht *et al.*, 1981) of period 8.88 days and the companion is of spectral type O5-8. The absolute magnitude of the WR component may be derived by assuming that the companion is on the Main Sequence. This value thus derived is $5^m.0 \pm 0^m.4$ and is again in agreement with the deduction of Lundstrom and Stenholm

Table 1. The absolute magnitudes of the Wolf-Rayet Stars HD 161932 and HD 162270

| HD | Sp. Type | Crawford <i>et al.</i> (1971) | | | Graham (1966) | Seggewies (1974) | | Schild <i>et al.</i> (1969) | Smith (1968) | Present work with | |
|--------|------------|-------------------------------|------|------|---------------|------------------|------|-----------------------------|--------------|-------------------|--------------|
| | | (a) | (b) | (c) | | (a) | (b) | | | $E(B-V)$ | $E(b-v)$ |
| 161932 | WN 7 | -5.8 | -6.6 | -6.4 | -6.6 | | | -6.4 | -6.6 | -6.5 ±0.3 | -6.4 ±0.3 |
| 162270 | WC7 + O6-8 | - | -6.4 | -6.4 | -6.4 | -6.3 | -6.4 | -6.4 | -6.7 | -6.4 ±0.3 | -6.2 ±0.3 |

Notes : Crawford *et al.* (1971): (a) Individual colour excesses $E(b-v)$ are used
 (b) Average value of the colour excess over the region is used
 (c) Colour excess derived on the basis of spectral type
 Graham (1966) Distance by H β photometry; Interstellar absorptions by *UBV* photometry
 Seggewies (1974) (a) Using cluster membership
 (b) Using cluster data of Schild *et al.* (1971)
 Schild *et al.* (1969) Distance by *UBV* photometry

1982), of $-5^m.0$ for galactic WC7 stars. Seggewies (1974) derives a value of $-4^m.4$ for the WR component but the estimate is based on broadband filter photometry.

The Table includes the results from other sources as well. All the estimates have been corrected for a distance modulus of $11^m.6$ for uniformity. The notes that follow the table show that for most of the estimates no corrections have been applied for the emission line contributions. The eleventh column gives our results in which the value of the colour excess has been assumed to be same as that of nearby stars, while the last column gives the results with derived colour excesses. In the above estimates presented in the Table no correction for the presence of the companion of HD 162270 has been made.

For HD 162270, we see from the Table that the closest agreement with our value is that of Smith (1968). Even, here the differences are mostly due to contributions from emission lines.

As can be seen from the Table, there appears to be a difference of about $1^m.5$ in the M_V of WN7 star (HD 161932) compared to WC7 star (HD 162270). This supports the deductions of Lundstrom and Stenholm (1982). Similar difference has also been noticed by Turner (1982).

This technique of narrowband photometry can be extended for more Wolf-Rayet stars in the clusters and associations, in order to derive more accurate values of their absolute magnitudes.

Acknowledgements

One of the authors (BSS) wishes to thank Drs. J. C. Bhattacharyya and N. K. Rao for helpful discussions.

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