LUMINOSITIES OF LMC OB STARS

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1. INTRODUCTION

Our knowledge of the spectra of stars in other galaxies is essentially limited to those which are extremely luminous. In the LMC, slit spectra of ~ 200 stars have been obtained (Feast, Thackeray and Wesselink 1960, Ardeberg et al. 1972) down to V $\sim 12\overset{m}{.}5$ ($M_V \sim -6\overset{m}{.}5$). Using an objective prism technique, Brunet et al. (1975) have been able to detect 272 OB stars with $12\overset{m}{.}2 < m_{pg} < 14\overset{m}{.}8$ in the LMC. At the fainter limit this survey should include relatively normal O and early B dwarfs and giants. The principal aim of the present investigation was to obtain spectra of these stars for comparison with galactic stars and to apply the techniques of MK classification and measurement of Hγ equivalent widths to determine their luminosities and hence a distance modulus to the LMC.

The absolute magnitude calibration of the MK classification of O stars has recently been considered by Conti and Alschuler (1971), Walborn (1972, 73) and Crampton and Georgelin (1975); that of the equivalent widths, W, of Hγ by Balona and Crampton (1974). A previous determination of the distance modulus of the LMC from the equivalent widths of luminous B stars by Hutchings (1966) gave $(V_o - M_V) = 17\overset{m}{.}6$, a value considerably smaller than that currently accepted ($18\overset{m}{.}6$, van den Bergh 1976). To explain this anomaly, it has been suggested the Balmer lines are abnormally strong in LMC (and SMC) stars, and perhaps this phenomenon is related, in the case of the SMC, to the weakness of the metal lines.

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2. MEASUREMENTS AND RESULTS

Thirty spectra with a dispersion of 47 Å mm^{-1} taken with the Carnegie image tube spectrograph on the CTIO 4m telescope were obtained of 17 of the bluest stars from the list of Brunet et al. Fourteen spectra of 7 galactic stars to act as MK and W standards were obtained with the same equipment. Although these standards served reasonably well for the spectral classification, the transformation between the equivalent widths measured from the image tube plates and Petrie's system could not be determined confidently. Because of this, and the small number of spectra per star, the results are of a preliminary nature.

The average distance moduli and their dispersion for the 17 stars resulting from the use of various calibrations are:

Method	(V_o-M_V)
MK, Blaauw (1963)	$18\overset{m}{.}91 \pm 0\overset{m}{.}59$ (11 stars only)
MK, Walborn (1972, 73)	18.82 ± 0.53
MK, Conti & Alschuler (1971)	18.67 ± 0.56
MK, Crampton & Georgelin (1975)	18.52 ± 0.60
W, Balona & Crampton (1974)	18.57 ± 0.83
van den Bergh (1976)	18.58

Unfortunately, the majority of the stars are classified as 07.5-09.5 III stars, so that the distance moduli rest on the calibrations of only a few MK types. More observations are required to explore the calibrations in detail but it appears that both the calibration of Blaauw and that of Walborn assign a somewhat high luminosity to these types of stars if the true distance modulus is $\sim 18\overset{m}{.}6$.

The $H\gamma$ distance modulus agrees well with the other determinations but its error is large and since the W's are not yet reliably tied to galactic standards, this may be fortuitous. Measurements of the He I and Si IV lines in the spectra indicate that these are of normal strength so perhaps then it is not surprising that the H lines appear normal too.

It is worthwhile exploring what the various calibrations are based on. All of the MK calibrations are based on main sequence fitting of galactic clusters and are ultimately related to the Hyades, (with a distance modulus of $3\overset{m}{.}0$). The $H\gamma$ calibration is tied to the distance modulus of the Pleiades which was taken to be $5\overset{m}{.}55$. This is the distance derived by Blaauw (1963), also from a main sequence fit to the Hyades. However, Crawford (1977) finds (V_o-M_V) (Pleiades) = $5\overset{m}{.}51$ based

largely on trigonometric parallaxes of A and F stars, and Petrie (1964) found $5^m.37$ again independently of the Hyades. Thus, it is not clear that the Pleiades distance modulus is seriously in error, and since all of the calibrations are related to the Pleiades, perhaps the Hyades problem does not affect them at all.

The mean value of the distance modulus to the LMC from the three recent calibrations of the MK types of O stars is $18^m.67$. Since this value agrees well with the $H\gamma$ equivalent width modulus, and with the modulus determined by a variety of other methods, it appears that the O stars in the LMC are quite similar to those of our Galaxy.

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DISCUSSION

PAYNE-GAPOSCHKIN: What would be the result of applying the same method to the Small Cloud? I believe the luminosities of Small Cloud supergiants show some anomalies.

CRAMPTON: It will be interesting to find out. I have no data yet, but I believe Azzopardi and his collaborators in France are presently working on this problem.

WALBORN (to PAYNE-GAPOSCHKIN): The Of star Sanduleak 80, the only one known in the SMC, has a reasonably normal M_V of $-7\overset{m}{.}3$ on the assumption of a true modulus of $19\overset{m}{.}3$.

(to CRAMPTON): In your compilation of LMC modulus determinations, one of the most discrepant was that from novae. It is interesting that the well-observed nova 1977b studied by Canterna and Schwartz gives $18\overset{m}{.}6 \pm 0\overset{m}{.}2$.

Can you suggest any explanation of Hutchings' earlier result? Did you measure Hγ for any of the same stars Hutchings studied?

CRAMPTON: The discrepancy with the result by Hutchings probably arises mainly from a) problems with the calibration of super-supergiants for which there are few galactic ounterparts, and b) problems with the measurement of Hγ equivalent widths at low dispersion, or on image tube spectra.

PARTHASARATHY: Absolute magnitudes of some of your program stars may be in error. Some of them must be binaries.

CRAMPTON: Duplicity is certainly a problem, particularly since corrections for duplicity were made in the Balona and Crampton calibration.

LESH: Isn't it true that calibration of MK spectral types for B stars - especially the Blaauw calibration - is based mainly on the distances of the stars in Scorpio-Centaurus, and so is essentially independent of the controversy surrounding the distance modulus of the Hyades?

CRAMPTON: The Blaauw calibration for B stars is in good agreement with the results obtained from the use of Sco-Cen - but the distance of Sco-Cen itself is the subject of controversey.