THE EVOLUTION OF AGB STARS IN THE MAGELLANIC CLOUDS

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ABSTRACT. Photoelectric observations of over 100 C stars in the Small Magellanic Cloud (SMC) and 20 in the Large Magellanic Cloud (LMC) were carried out with the Johnson JHK system using the standard ESO equipment on the 3.6m telescope. The limiting magnitude is about K = 13.7.

1. Introduction

We have used the GRISM spectra (spectral range 4350 - 5300Å; dispersion 2200Å/mm) to select stars for spectroscopy and JHK photometry with a good coverage in magnitude, colour and carbon content. Spectra of about 50 stars in the SMC and 15 in the LMC have been obtained with the Boller and Chivens spectrographs on the ESO 3.6 and 2.2m telescopes and with the ESO Faint Object Spectrograph and Camera (EFOSC), mainly with CCD chips as detectors. The dispersions are between 114 and 230Å/mm and the spectral range covered is 4500Å to 7000Å. The faintest star observed has K = 13.4 mag. The spectra have been analyzed with the aid of the ESO IHAP system.

2. Measurements

We have measured the C_2 and CN strengths in the spectra as equivalent widths between 4820 and 5220Å and 5720 and 5840Å, respectively; the integrated intensity of the D-lines; a gradient using the "windows" between 6770 and 4820 Å; and the ^{12}CN and ^{13}CN-band strengths at 5750 and 5790Å. The quantities are used to separate C_2-poor and C_2-rich stars and to identify J-type stars (Bouigue 1954) and C-stars with low CN content. A comparison of the present $^{12}CN/^{13}CN$ ratios with Gow's (1977, Fig. 7) shows that our J-type stars have an isotope ratio of $^{12}C/^{13}C \approx 4$; the normal and C_2-poor stars have $^{12}C/^{13}C \approx$ 20-25.

We have used published JHK photometry in addition to our own photometry. All data have been transferred to the Johnson JHK system (cf. Frogel *et al.* 1978). Reddening corrections are from Cohen *et al.* (1981) or for clusters as suggested by the various observers. To facilitate comparisons with previous work we have used m-M = 18.6 for the LMC and 19.1 mag for the SMC. Bolometric absolute magnitudes, M_{bol}, and effective temperatures, log T_{eff}, have been calculated following Wood *et al.* (1983) and Bessell *et al.* (1983), respectively.

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2. The Hertzsprung-Russell diagrams

We have identified the early Asymtotic Giant Branches (AGB) for various age groups using published JHK photometry of M and S stars in clusters of known SWB (Searle *et al.* 1980) classes and identified transition regions. The field carbon stars in the Magellanic Clouds follow evolutionary sequences from the M-(S)-C transition regions beginning as C_2-poor stars. For the least massive stars (SWB class VII) the transition occurs directly from M to C. Some of them pass through a J-type stage. The C_2 strength increases as the star approaches the final stage of Mira-type.

The most massive C stars are in the LMC and are often of J-type, and CO rich. They may be related to the most luminous of the two M-giant branches (Frogel & Blanco 1983). If their masses are between 3.3 and $5M_o$ they may have converted ^{12}C to ^{13}C in a hot-bottom burning process (Renzini & Voli 1981). With a falling temperature the dredged-up ^{12}C will again dominate. Eventually, a conversion of ^{12}C to ^{14}N occurs and luminous MS stars may form. The most luminous AGB star in the SMC, the MS variable HV11452, is more luminous than all the LMC stars in our sample. Its predecessor may have been over $5M_o$ and evolved without passing the C-star stage. C stars of average mass end as luminous Ce stars of nearly the same luminosity as the MS stars but much redder.

The carbon stars in the SMC cover a range in M_{bol} from -3 mag to -5.9 mag. In the LMC the range is -3.8 mag to -6.5 mag. The transition from M via S to C occurs in both Clouds at about $M_{bol} \approx -4.6$ but at a log T_e about 0.05 higher in the SMC. In the SMC the early AGB branches are blue-shifted relative to those in the LMC. The C_2-poor stars fall in the M-(S)-C transition regions with J-type stars next to them. The faintest stars form a sequence extending from the top of the early AGB-branch of class VII. They represent an older and lower-mass population.

The coolest of the more luminous J-type stars in the SMC as well as in the LMC have the strongest ^{13}C. Both have log $T_e = 3.47$.

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