EVOLUTION OF S STARS IN THE MAGELLANIC CLOUDS

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ABSTRACT. Early S stars occur between M and C stars in the colour magnitude diagrams of intermediate age globular clusters in the Magellanic Clouds. Most have $-4.2 \geq M_{bol} \geq -4.8$ and are probably brighter in younger or more metal rich clusters. The galactic globular cluster NGC 6723 contains two marginal S stars at $M_{bol} \sim -3.3$. The rare CS stars have $M_{bol} \sim -6$, with no faint examples.

Rich intermediate-age clusters in the Magellanic Clouds contain S stars in a luminosity interval between M and carbon stars, confirming that they represent an intermediate stage in the increasing ratio of C/O in the outer layers (Bessell, Wood & Lloyd Evans 1983). These S stars have spectral types equivalent to early or middle M with luminosities in the range $-4.2 \geq M_{bol} \geq -4.8$. The luminosity boundaries depend on age and metal content of the cluster, being brighter in the younger or more metal rich clusters (Lloyd Evans, in press). This is understandable as the quantity of pre-existing oxygen and heavy elements will be smaller if the envelope mass is small and the metal abundance low (Renzini & Voli 1981).

Open clusters of similar age in the Galaxy are so poor that they contain few carbon stars while no S stars are known to be members. Two unusually red stars in the globular cluster NGC 6723 have enhanced ZrO and extend the S star domain to $M_{bol} = -3.3$. ω Centauri contains even fainter S stars but there is evidence that these result from a primordial composition which is unusually rich in heavy elements (Lloyd Evans, in press).

The field of the Magellanic Clouds contains carbon stars brighter than the brightest found in the clusters, which have $M_{bol} \sim -5.6$. Two large amplitude variables with CS spectra in the SMC (Lloyd Evans 1980) have $M_{bol} \sim -6$, at the upper end of the field carbon star luminosity function, and AGB stars brighter than this have MS or M spectra (Wood, Bessell & Fox 1981, and preprint (WBF)). CS and SC spectra have not been found among the less luminous AGB stars in clusters or the field

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and in particular NGC 121/V8, a faint carbon star with colours which place it between S and C stars (WBF), has a featureless spectrum in the red. This may result in part from a higher surface temperature; the M→S→C transitions appear to occur at lower temperature in more luminous (massive) stars. A second reason for the absence of faint CS stars is that the number of shell flashes required to produce a carbon star is quite small so that the carbon enrichment process occurs by large steps so that any narrow range in C/O will rarely occur. The carbon enrichment process at high luminosity may be much more gradual, because the large envelope mass dilutes new material so that many shell flashes are needed to produce a carbon star or because newly-formed ^{12}C is being converted into ^{14}N at the base of the envelope (WBF). Each star will thus pass through the S→C transition more gradually, with a higher probability of attaining the narrow range of C/O required for a CS or SC spectrum.

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