New Views of the Magellanic Clouds
IAU Symposium, Vol. 190, 1999
Y.-H. Chu, N.B. Suntzeff, J.E. Hesser, and D.A. Bohlender, eds.

The Formation of Carbon Stars in the Magellanic Clouds from Mass Transfer in Close Binaries

Ju. Frantsman

Astronomical Institute, Latvian University, Raina Blvd. 19, Riga, LV-1586, LATVIA

Abstract.
The presence of the carbon stars in the MC with luminosities higher or lower than predicted for thermally–pulsing (TP) AGB stars, can be explained by processes that happen during the early AGB (E–AGB) stage. I examine this assumption by means of a population simulation technique. I find that there must be TP–AGB C and S stars in the MC that formed as a result of mass transfer in binary systems. Their presence may influence the age determinations of MC clusters.

The classical N–type carbon stars are associated with the TP–AGB stage. There are two groups of carbon stars whose luminosity and effective temperatures indicate that these stars are not on this stage.

1. Both theory and observations show that the minimum luminosity of carbon stars in the TP–AGB stage is about $M_{bol} = -3\overset{m}{.}0$. But according to *JHK* photometry (Westerlund et al. 1992, 1995) and a low–dispersion spectroscopic survey (Rebeirot et al. 1993) of carbon stars, the SMC N–type stars fainter than $M_{bol} = -3\overset{m}{.}0$ are rather common. These stars reach luminosities as low as $M_{bol} = -1\overset{m}{.}0$

2. Suntzeff et al. (1993) have reviewed the results of photometry of LMC carbon stars which earlier were discovered as CH–stars (Hartwick & Cowley 1988; Cowley & Hartwick 1991). These carbon stars are significantly bluer than ordinary carbon stars in the LMC. The mean bolometric magnitude is $M_{bol} = -5\overset{m}{.}3$ while the brightest members reach $M_{bol} = -6\overset{m}{.}2$.

We assume that these stars are in an E–AGB evolutionary phase and are the result of evolution of close binary systems. The carbon-enriched medium was transferred from a carbon TP–AGB star to its secondary companion which is at an earlier stage of evolution. The secondary becomes a carbon star, and remains so during its subsequent evolution up the AGB, including the E–AGB and TP–AGB stages.

The populations of AGB stars formed as a result of both single star evolution and mass transfer in close binary systems have been theoretically modeled by the method of synthetic evolution. The details are described by Frantsman (1998). The simulations of the carbon star population (luminosity functions) are presented in Figure 3 of Frantsman (1997). The most significant result is a substantial extension of the carbon star luminosity towards the lower luminosities as compared to the TP–AGB carbon stars. There are two reasons why the faint carbon stars in the MC have been discovered only recently: i) they are apparently fainter in comparison with TP–AGB stars and ii) they have higher effective temperatures. It is likely that E–AGB carbon stars cannot be formed in the Galaxy because of high initial heavy element abundance. Another result is that a few high luminosity E–AGB stars ($M_{bol} = -5^m$) must exist. It is interesting to note that E–AGB stars can reach high luminosities only if the heavy element abundance is low, which is typical for the MC but not for the Galaxy. Only massive E–AGB stars reach high luminosity, comparable to the TP–AGB star luminosity.

The N–type carbon star population in the MC is probably not homogeneous but consists of objects which belong to two different stages of evolution. The maximum luminosities of these groups are comparable, but effective temperatures differ significantly. The borders of regions occupied by stars on the E–AGB and TP–AGB phases in the HR diagram also are presented by Frantsman (1997) in his Figure 5.

During the evolution along AGB through the thermal pulsing stage, the stars remain at constant luminosity, and therefore the differences in the luminosities of carbon stars in the MC must be rather small. But there are some clusters where the most luminous carbon stars are much more luminous than the rest. Such high luminosity stars (in comparison with other TP–AGB stars) are found mainly in rich clusters where many TP–AGB stars are observed. This must affect the age determinations of a cluster if the luminosity of the TP–AGB is used.

References

Cowley, A.P., & Hartwick, F.D.A. 1991, ApJ, 373, 80

Frantsman, Ju. 1997, A&A, 319, 511

Frantsman, Ju. 1998, this volume "The initial–final mass relation for stars with different initial chemical composition"

Hartwick, F.D.A., & Cowley, A.P. 1988, ApJ, 334, 135

Rebeirot, E., Azzopardi, M., & Westerlund, B.E. 1993, A&AS,97, 603

Suntzeff, N.B., et al. 1993, PASP, 105,350

Westerlund, B.E., Azzopardi, M., Breysacher, J., & Rebeirot, E. 1992, A&AS, 91, 425

Westerlund, B.E., Azzopardi, M., Breysacher, J., & Rebeirot, E. 1995, A&A, 303, 107

https://doi.org/10.1017/S0074180900118339 Published online by Cambridge University Press