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Are there radical cyanogen abundance differences between galactic globular cluster RGB and AGB stars?

Possibly a Vital Clue to the Globular Cluster Abundance Anomaly Problem

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Abstract.
On reading an old paper about galactic globular cluster abundance observations (of NGC 6752) we came across an intriguing result. Norris et al. (1981) found that there was a distinct lack of cyanogen-strong (CN-strong) stars in their sample of AGB stars, as compared to their sample of RGB stars (which had roughly equal numbers of CN-normal and CN-strong stars). Further reading revealed that similar features have been discovered in the AGB populations of other clusters. Recently, Sneden et al. (2000) followed up on this possibility (and considered other proton-capture products) by compiling the existing data at the time and came to a similar conclusion for two more clusters. Unfortunately all of these studies suffer from low AGB star counts so the conclusions are not necessarily robust — larger, statistically significant, sample sizes are needed.
In this conference paper, presented at the Eighth Torino Workshop on Nucleosynthesis in AGB Stars (Universidad de Granada, Spain, 2006), we outline the results of a literature search for relevant CN observations and describe our observing proposal to test the suggestion that there are substantial abundance differences between the AGB and RGB in galactic globular clusters. The literature search revealed that the AGB star counts for all studies (which are not, in general, studies about AGB stars in particular) are low, usually being ≤ 10. The search also revealed that the picture may not be consistent between clusters. Although most clusters appear to have CN-weak AGBs, at least two seem to have CN-strong AGBs (M5 & 47 Tuc). To further complicate the picture, clusters often appear to have a combination of both CN-strong and CN-weak stars on their AGBs – although one population tends to dominate. Again, all these assertions are however based on small sample sizes. We aim to increase the sample sizes by *an order of magnitude* using existing high quality photometry in which the AGB and RGB can be reliably separated. For the observations we will use a wide-field, low- to mid-resolution multi-object spectroscope to obtain data not only on the AGB but also on the horizontal branches and first giant branches of a sample of clusters. With the new information we hope to ascertain whether significant abundance differences really exist.

Key words. AGB stars – Globular cluster – Abundances – Cyanogen

1. Introduction

We are attempting to perform a conclusive test of the suggestion put forward by Norris et al. (1981), which has been touched upon by many authors since and recently explored by Sneden et al. (2000), that there are differences in cyanogen abundance distributions between the first and second giant branches in galactic globular clusters.

Although galactic globular clusters (GCs) are chemically homogeneous with respect to Fe and most other heavy elements (see eg. Kraft et al. 1992), it has long been known that they show inhomogeneities in many lighter elements (eg. C, N, O, Mg, Al). These inhomogeneities are considered anomalous because they are not seen in halo field stars of similar metallicity (see eg. Gratton et al. 2000).

One of the first inhomogeneities discovered was that of the molecule Cyanogen (CN, often used as a proxy for nitrogen). A picture of 'CN-bimodality' emerged in the early 1980s whereby there appears to be two distinct chemical populations of stars in most, if not all, GCs. One population is known as 'CN-strong', the other 'CN-weak' (the CN-weak population might be more informatively called 'CN-normal' – as these stars show CN abundances similar to the Halo field stars). Originally, observations of CN were mainly made in stars on the giant branches but more recently there have been observations on the main sequence (MS) and sub-giant branch (SGB) of some clusters (eg. Cannon et al. 1998). These observations show that there is little difference in the bimodal CN pattern on the MS and SGB as compared with the giants — indicating a primordial origin for the differing populations. Figure 6 in Cannon et al. (1998) exemplifies this situation.

Due to the paucity of asymptotic giant branch (AGB) stars in GCs (a result of their short lifetimes) there have been very few systematic observational studies of the CN anomaly on the AGB in globular clusters (Mallia 1978, is one that the Authors are aware of). What little that has been done has been an aside in more general papers (eg. Norris et al. 1981, Briley et al. 1993, Ivans et al. 1999). However these studies have hinted at a tantalising characteristic: most (observed) GCs show a lack of CN-strong stars on the AGB. If this is true then it is in stark contrast to the red giant branch (RGB) and earlier phases of evolution, where the ratio of CN-Strong to CN-Weak stars is roughly unity in many clusters.

This *possible* discrepancy was noted by Norris et al. (1981) in their paper about abundances in giant stars in NGC 6752. They state that "The behaviour of the CN bands in the AGB stars is... quite difficult to understand... not one of the stars studied here has enhanced CN... yet on the [first] giant branch there are more CN strong stars than CN weak ones." (also see Figure 3 in that paper). More recently Sneden et al. (2000) presented a conference paper on this exact topic. Compiling the contemporaneous preexisting data in the literature they discussed the relative amounts of CN in AGB and RGB stars in the GCs NGC 6752 (data from Norris et al. 1981, M13 data from Suntzeff 1981, and M4 data from Norris et al. 1981 and Suntzeff & Smith 1991). They also discuss Na abundance variations in M13 (data from Pilachowski et al. 1996a and Pilachowski et al. 1996b). Their conclusion for the CN variations was that the clusters in question all showed significantly less CN on the AGB as compared to the RGB. However the data compiled only contained about 10 AGB stars per cluster. In their closing remarks they suggest observations with larger sample sizes are needed — which may be done using wide-field multi-object spectroscopes. This is exactly the conclusion the present authors also came to, inspiring this seminar/conference paper at the Eighth Torino Workshop on Nucleosynthesis AGB Stars held at the Universidad de Granada, Spain, in 2006.

2. Literature Search Results and the Observing Proposal

We conducted a literature search (which may not be complete) to ascertain what work had already been done in terms on CN on the AGB in galactic globular clusters. The results are displayed in Table 1. The main result from this search was that the available number of AGB star observations are not statistically signifihave no impact on the testing for abundance differences as they are not expected to reduce their surface abundance of nitrogen. Indeed, third dredge-up on top of preformation pollution and deep mixing would make the issue even more complex.

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