AGB stars in Galactic Globular Clusters – Are They Chemically Distinct to Their Fellow RGB and HB Stars?

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AGBs in Globular Clusters

- High quality photometry is now making the AGB accessible in GCs, we can now get good numbers of AGBs.

M5 (SDSS)
Quantifying Cyanogen Abundance: The S(3839) CN Index

- Cyanogen (CN) is a molecule whose abundance is thought to track that of Nitrogen. It absorbs over a few regions in the spectrum. Here we consider the Blue CN bands.

\[
S(3839) = -2.5 \log \frac{\int_{3846}^{3883} I_{\lambda} \, d\lambda}{\int_{3891}^{3916} I_{\lambda} \, d\lambda}
\]

Norris et al. (1981)

- So basically you see how much flux is missing in a wavelength region due to CN absorption by comparing to piece of 'continuum' nearby. Only need fairly low (~2 Ang) resolution.
CN Bimodality in GC Giants

This is not observed in halo field stars!
(see eg. Langer et al, 1992)

Fig. 5.—The generalized histogram of $\delta S(3839)$ for 49 red giant branch stars. Each star is represented by a Gaussian of dispersion 0.045 mag, the estimated error of measurement. Note the bimodal nature of the distribution.


- Note trend with Temp.

The upper diagram is used to define CN strong and CN weak groups within the cluster by filled and open symbols. (The half-filled circles represent the CN intermediate population. The upper diagram is used to define CN strong and CN weak groups within the cluster by filled and open symbols.)
More recent work has shown that the CN bimodality extends down to the Main Sequence, suggesting that the bimodal composition has primordial origins.

Figure 6. The 47 Tuc colour–magnitude diagram, using the same data as Fig. 2 but with the symbols of Fig. 4 to distinguish between the CN-strong and CN-weak stars.
More GC Weirdness? – CN in AGBs

- Norris et al. 1981 noted that their sample of AGB stars in NGC 6752 were all CN-weak (triangles = AGBs).
- Could this be chance, due to the small sample size – or is something strange happening on the AGB??

An Interesting Proposition

• Nothing on the HB should change the CN abunds

• So RGB stars should have the same distribution as AGB stars

• Not much data on AGB stars

• Need to be able to separate AGB and RGB…

• Try a systematic approach
Excellent Photometry Needed

• Excellent photometry is needed in order to split the two giant branches.

• v versus v-y CMD gave good AGB-RGB splitting for NGC 6752.

(NGC 6752 data from Frank Grundahl)

(yellow = raw data)
Spectra Collected: Number of AGBs

- 5 nights on AAT Multi-object spectrograph 2dF/AAOmega
- Data collected for 241 AGB stars across 9 clusters (plus many RGB & HB stars).

<table>
<thead>
<tr>
<th>NGC 1851</th>
<th>Identified</th>
<th>Observed</th>
<th>Other Work</th>
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<tr>
<td>34</td>
<td>20</td>
<td>?</td>
<td></td>
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<tr>
<td>NGC 288</td>
<td>15</td>
<td>14</td>
<td>?</td>
</tr>
<tr>
<td>NGC 362</td>
<td>27</td>
<td>20</td>
<td>?</td>
</tr>
<tr>
<td>NGC 6752</td>
<td>26</td>
<td>24</td>
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</tr>
<tr>
<td>M2</td>
<td>25</td>
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<tr>
<td>Omega Cen</td>
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</table>
Results: NGC 6752

- The cluster that Norris et al 1981 investigated.
- RGB nicely bimodal, as expected.
- And on the AGB....

NGC 6752 (Field 1, 16 AGBs)

**Strong to Weak Ratios**

RGB = 80:20
AGB = 0:100
Results: GC Pair Comparison

- NGC 288 and 362 have similar metallicities ([Fe/H] ~ -1.2) but different HB morphologies \( \rightarrow \) compare CN behaviour.
Results: NGC 288 (Blue HB)

- The normal CN bimodality is seen on the RGB.
- And on the AGB....

NGC 288 photometry: Grundahl et al., 1999.
Results: NGC 362 (Red HB)

Summary/Discussion

• Our preliminary results clearly show there is something strongly effecting the numbers of CN-strong and CN-weak stars between the RGB, HB and AGB.

• It appears to be related to the HB morphology of the GCs.

• GCs with red HBs show little or no change in the ratio of CN-strong to CN-weak stars going from the RGB to AGB.

• However in GCs with very blue HBs it is amazing to find that there are zero CN-strong stars on the AGB (eg. 6752, 288) – the CN-strong stars seem to ‘disappear’ when moving from the RGB to AGB.

• So what is happening??
  – Maybe the CN-strong stars don't ascend the AGB at all? (an idea also suggested by Norris et al. 1981). The fact that this feature is (mainly) seen in GCs with blue HBs suggests this may be the case, since the blue HB stars should have low masses.
  – Primordial abundance variations (eg. He, N) may affect mass loss or other evolution.