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The Na-O anticorrelation in subgiants of metal-poor globular clusters: NGC 6397, M55 and M30 ⋆

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Abstract. We present the preliminary analysis of data gathered at VLT-UT2 with UVES for NGC 6397, M55 and M30, to get more insight on the well-known Na-O anticorrelation in metal-poor globular clusters. Our results show that the previoulsy quoted homogeneity in NGC6397 was likely due only to poor statistics. M55 shows hints of large spreads in O and Na abundances, while data for M30 are still under scrutiny. We analyzed as well data collected during the FLAMES Science Verification in NGC 2808, a more metal-rich cluster. The first analysis of high-resolution UVES red arm spectra and of moderately high-dispersion GIRAFFE spectra indicate that (i) groups of Na-rich/O-poor and Na-poor/O-rich stars do exist also in this cluster; (ii) large variations in the abundance of the proton-capture element Na are present along the RGB, at all luminosities, from the tip down to the level of the Red Horizontal Branch; (iii) evidences of a significant contribution of evolutionary effects in the spread of Na are weak, for NGC 2808, at odds with its peculiar HB morphology.

Key words. Stars abundances – Stars Population II – Galaxy Globular clusters

1. Introduction

Leaving aside the very peculiar case of ω Centauri, it has been evident for more than 30 years (Osborn 1971) that the hypothesis of monometallicity holds for globular clusters (GCs) only as far as heavy elements are concerned. Early studies (see the comprehensive reviews by Smith 1987 and Kraft 1994) based on indexes from photometry or low dispersion spectroscopy clearly demonstrated that the lighter elements (*in primis* carbon and nitrogen) showed marked differences along the RGB in several GC's. Moreover, striking variations in the CH band strenghts, anticorrelated with CN (and NH, when accessible) strenghts were observed in several nearby clusters even down to turn-off and main sequence stars (see e.g. Cannon et al. 1998 and references therein).

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⋆ Based on data from ESO LP 165.L-0263 and the FLAMES SV data

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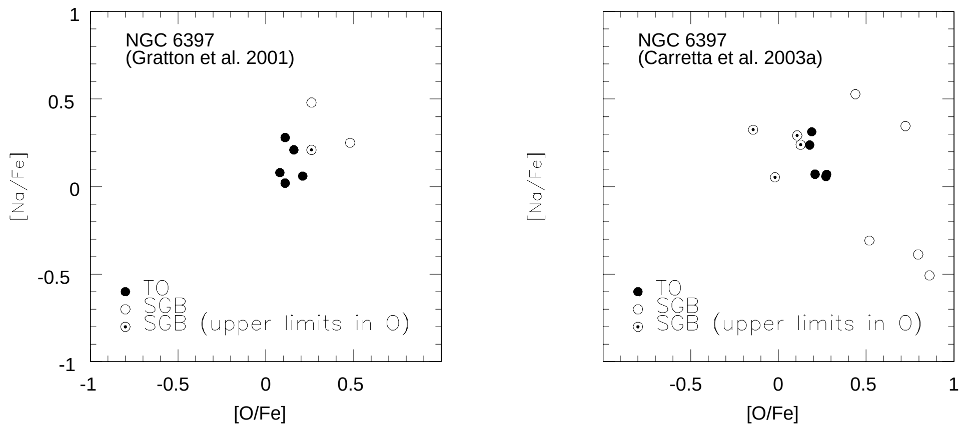

Fig. 1. Left panel: [Na/Fe] ratios as a function of [O/Fe] in subgiants and turn-off stars in NGC6397 from data by Gratton et al. (2001). Right panel: the same, but with the reanalysis by Carretta et al. (2003a), with 6 new SGB stars added to the sample. Notice how a clear anti-correlation is now evident in the new data.

2. The Na-O anticorrelation

The most striking evidence is given by the Na-O anticorrelation, extensively studied by the Lick-Texas group (see Ivans et al. 2001 for updated references). The existence of Na-rich and O-poor stars side by side to Na-poor and O-rich objects is presently interpreted as the signature of the action of high temperature proton capture fusion. The nuclear NeNa cycle which enhances Na is expected to operate in the same fusion zones in which the ON part of the CNO cycle is fully operative (Langer et al. 1993). Larger Na abundances should then accompany larger N and smaller O abundances.

However, the environment clearly plays a major role: Gratton et al. (2000) clearly demonstrated that field stars are fully explained through the classical first dredge-up and a second mixing episode taking place above the magnitude level of the RGB-bump. The Na-O anticorrelation is the most convincing evidence of proton-capture nucleosynthesis; however, it is restricted only to high density environments, since Gratton et al. (2000) showed that Na and O abundances are hardly involved in the normal evolution of isolated field stars climbing up the red giant branch. In a still unknown way, the large number of interactions between stars in GCs has to be involved in reproducing the observed pattern of chemical abundances.

Nowadays, there is no more debate on the mechanism, while the site of the nuclear reshuffling is not as clear: either in the presently observed stars or in previous nucleosynthetic generations, and very likely a contribution of both is required. The next step is then to study large samples of cluster stars in homogeneous way, to disentangle the relative weight of primordial abundance variations and internal evolution in producing the observed chemical pattern, as suggested e.g. by Pilachowski et al. (1996).

3. The metal-poor globular clusters: NGC 6397, M55, M30

Fig. 1 summarizes preliminary results for NGC 6397 and underlines the relevance of a good statistics: in the left panel are displayed results from Gratton et al. (2001), while in the right panel there are first results by Carretta et al. (2003a), who added

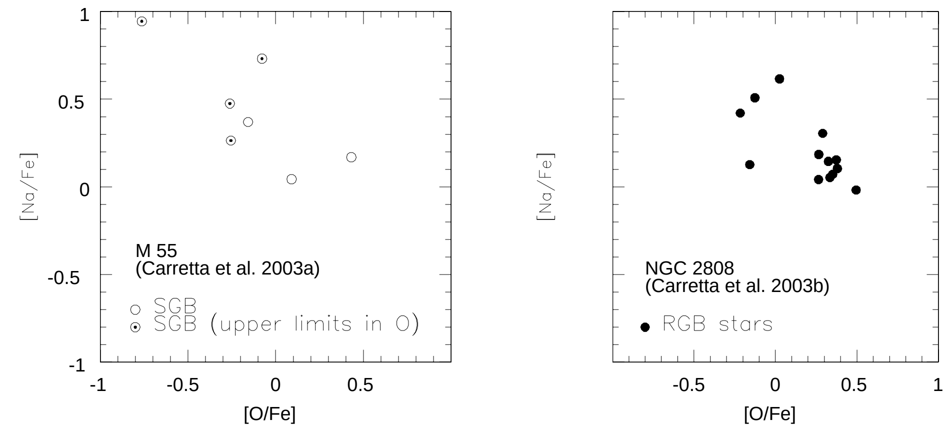

Fig. 2. Left panel: the Na-O anticorrelation in M55 (only SGB stars) from Carretta et al. (2003a). Right panel: Na-O anticorrelation in NGC 2808 (Carretta et al. 2003b). Stars in NGC 2808 are RGB stars observed with the fiber-fed UVES Red Arm during the FLAMES Science Verification.

to the observed sample another 6 subgiants. This preliminary result shows that when a sufficient number of stars is taken into account, the apparent homogeneity of NGC 6397 disappears, revealing a strong hint of Na-O anticorrelation in this cluster. The existence of the anti-correlation is also evident in M55 (see Fig. 2, left panel), meaning that the signature of products of the NeNa cycle is a phenomenon likely diffused among every cluster.

Data for M30 are still under scrutiny; at present we only derived atmospheric parameters and the average metallicity ([Fe/H]= -2.17 with $\sigma = 0.08$ dex) for 8 subgiants and 2 turn-off stars in this cluster.

4. NGC 2808: first detection of large variations in proton-capture elements

No one of the previous clusters offers the opportunity of studying large samples, being based on UVES, a single-object spectrograph. However, instruments as FLAMES@VLT provide the required next step, i.e. the high multiplexing gain. Using spectra acquired during the FLAMES Science Verification we uncovered for the first time that (i) groups of Na-rich/O-poor and Na-poor/O-rich stars do exist also in this cluster (Carretta et al. 2003b) (see Fig 2, right panel); (ii) large variations in the abundance of the proton-capture element Na are present along the RGB, at all luminosities (Fig. 3), from the tip down to the level of the Red Horizontal Branch (Carretta et al. 2003c); (iii) evidences of a significant contribution of evolutionary effects in the spread of Na are weak, for NGC 2808, at odds with its peculiar HB morphology. In fact, while in M13 the number of Na-rich giants increases toward the tip, maybe indicating a larger relevance of evolutionaty effects (Pilachowski et al. 1996), in NGC 2808 we observe the opposite. At face value, this result could indicate that in this cluster we are seeing the effect of primordial abundance variations and that possible evolutionary effects are present only as an overimposed “noise”.

In conclusion, large samples are really required to ascertain the relevance of evolutionary vs primordial contributions in different clusters, but the data acquired un-

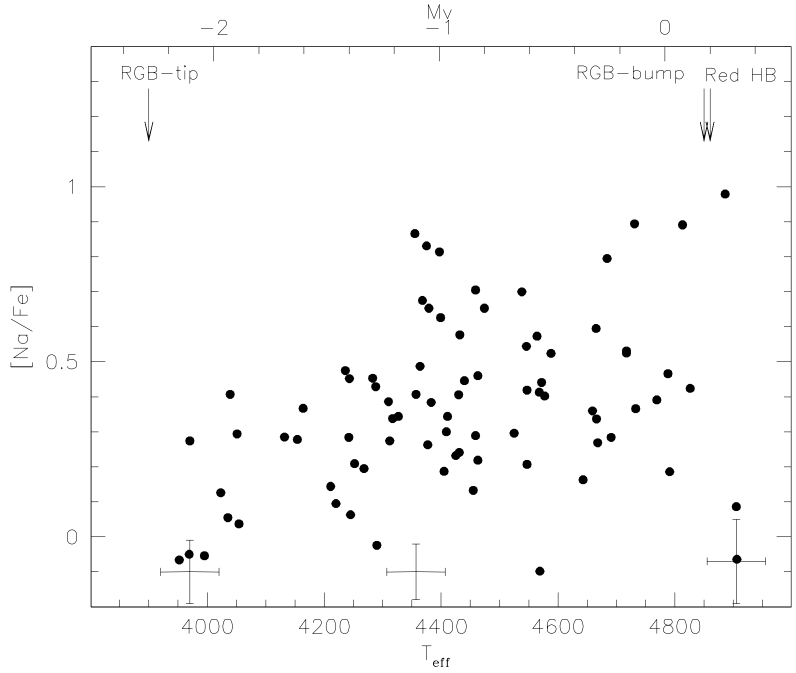

Fig. 3. [Na/Fe] ratios as a function of T_{eff} along the RGB of NGC 2808. Typical absolute magnitudes are indicated at the top and random errors are displayed at the bottom of the Figure

til now with the new generation of efficient spectrographs show that we are on the right road to better understand the origin of the Na-O anticorrelation in globular clusters.

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