Light Elements in the Universe
Proceedings IAU Symposium No. 268, 2009
C. Charbonnel, M. Tosi, F. Primas, & C. Chiappini, eds.

doi:10.1017/S1743921310004059

The helium spread among the stars of 47Tuc

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Abstract. We show that the current data of the HB branch of 47 Tuc show a particular feature that cannot be explained if a single population with an unique mechanism of mass loss is considered. We find that a spread in helium abundance among the stars is necessary, of ∼0.02. We indicate that the same variation in helium is present among the sub giant branch stars and suggest that is responsible of the spread in luminosity of the bright sub giant branch, while only a small part of the second generation is characterized by C+N+O increase and gives the faint sub giant branch.

Keywords. globular clusters: individual (47 Tuc); stars: horizontal-branch, evolution, abundances

1. Introduction

Spectroscopic data show chemical anomalies in most of 47 Tucanae stars consisting in bimodal CN band strengths (Briley 1997) and Na-O anticorrelations(Carretta *et al.* 2009).

These results indicate that the abundance spread in 47 Tuc is not due to an evolutionary effect, rather to the existence of an original stellar population (first generation, FG) and of a second generation (SG). Stars in the SG formed from material processed through the hot CNO cycle in the progenitors, belonging to the FG, but not enriched in the heavy elements expected in supernova ejecta, according to todays' new paradigm for the formation of galactic GCs (D'Ercole *et al.* 2008 and reference therein).

The recent photometric data by Anderson *et al.* (2009) seem to confirm the existence of multiple populations in 47 Tuc. In particular, they found a splitted sub giant branch (SGB) with at least two distinct components: a brighter one with a small and real spread in magnitude (∼0.06 mag) and a second one containing about 10% of star a little (∼0.05 mag) fainter.

Our idea is that CN-strong stars all belong to the SG, and were formed from gas showing the signature of CNO processing and a helium enrichment, but that only a small percentage of SG stars are increased in the overall CNO content.

2. The results

Following the suggestion of D'Antona & Caloi (2008) we decided to investigate this hypothesis using the morphology of the HB of 47 Tuc, where a population with a larger helium abundance should emerge. In Figure 1 we show a zoom of the CMD of 47 Tuc at the HB level (filled circle) based on images of 5 sec in F606W and F814W from ACS (GO-10775, PI Sarajedini).

In particular we note that at m_{F606W}-m_{F814W} ∼0.675 mag there is a particular feature in the data: a step in luminosity between the blue and brighter and red and dimmer part

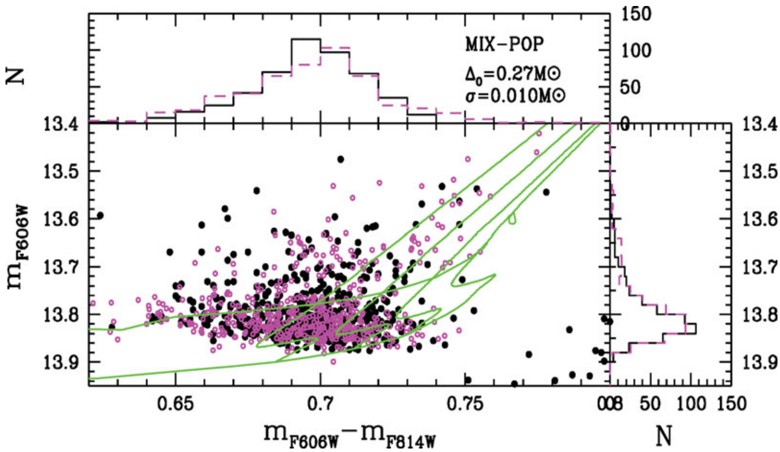

Figure 1. Comparison between observed (filled circle) and synthetic HB stars (open circle-magenta in the electronic version) calculate as described in the text considering an helium spread among stars of $\Delta Y \sim 0.02$. The dashed histograms refer to synthetic populations while solid ones are those relative observations.

of HB. Our simulations show that a single mechanism mass loss can't reproduce this feature, while if we consider two different populations with two different helium contents it is possible to do a good job. The solid lines in the Figure are ZAHBs calculated from our models and reported in the observational plane using a reddening E(606-814)=0.038 mag. An apparent distance modulus $(m–M)_{F606W}$=13.09 mag was chosen in order to fit a ZAHB of pristine Y(=0.25) to the lower envelope. ZAHB for Y=0.28 is also reported together with HB evolutionary tracks of stars with masses M=0.63, 0.66, 0.70 and 0.80 solar masses.

Open circles are synthetic stars obtained using a gaussian mass loss around the central value $\Delta M_0=0.27 M_\odot$ and $\sigma=0.010 M_\odot$. The synthetic population is built under the hypothesis that 70 % of stars have a N(Y) constant between Y=0.25 and Y=YUP=0.27. Other details of the model are reported in Di Criscienzo *et al.* (2010, in preparation). The two histograms for both magnitudes and colours show the comparison between the data and our simulations. The most interesting result is that the same variation in helium N(Y) can also explain the spread of the bright SGB observed by Anderson *et al.* 2009 while the faint SGB is made of stars with higher C+N+O (for details see Di Criscienzo *et al.* 2010).

We interpret these results as the confirmation that SG in 47 Tuc consist of about 70 % of stars, as suggested by spectroscopic studies.

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https://doi.org/10.1017/S1743921310004059 Published online by Cambridge University Press