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The double main sequence of Omega Centauri ⋆

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Abstract. Recent, high precision photometry of Omega Centauri, the biggest Galactic globular cluster, has been obtained with *Hubble Space Telescope* (*HST*). The color magnitude diagram reveals an unexpected bifurcation of colors in the main sequence (MS). The newly found double MS, the multiple turnoffs and subgiant branches, and other sequences discovered in the past along the red giant branch of this cluster add up to a fascinating but frustrating puzzle. Among the possible explanations for the blue main sequence an anomalous overabundance of helium is suggested. The hypothesis will be tested with a set of FLAMES@VLT data we have recently obtained (ESO DDT program), and with forthcoming ACS@HST images.

Key words. CM diagram – Globular Clusters (NGC 5139)

1. Introduction

Several properties of Omega Centauri (ω Cen), including the large spread in metallicity and the large mass, make it a peculiar object among Galactic globular clusters (GGCs).

Most of the fascinating results on ω Cen come from the evolved stars, mainly populating the Red Giant Branch (RGB). RGB stars have been the object of a large number of both spectroscopic and photometric surveys with various groundbased facilities (Norris & Da Costa 1995, Pancino et al. 2000, Hilker & Richtler 2000) which disclosed the complexity of the ω Cen stellar population.

More recently, the high performances of the Wide Field Channel (WFC) of the Advanced Camera for Surveys (ACS) onboard *HST* have made it possible to explore also the faint unevolved stellar component, more efficiently and with a much higher photometric accuracy than with groundbased facilities. The new observations have made the ω Cen stellar population scenario even more puzzling, and difficult to understand.

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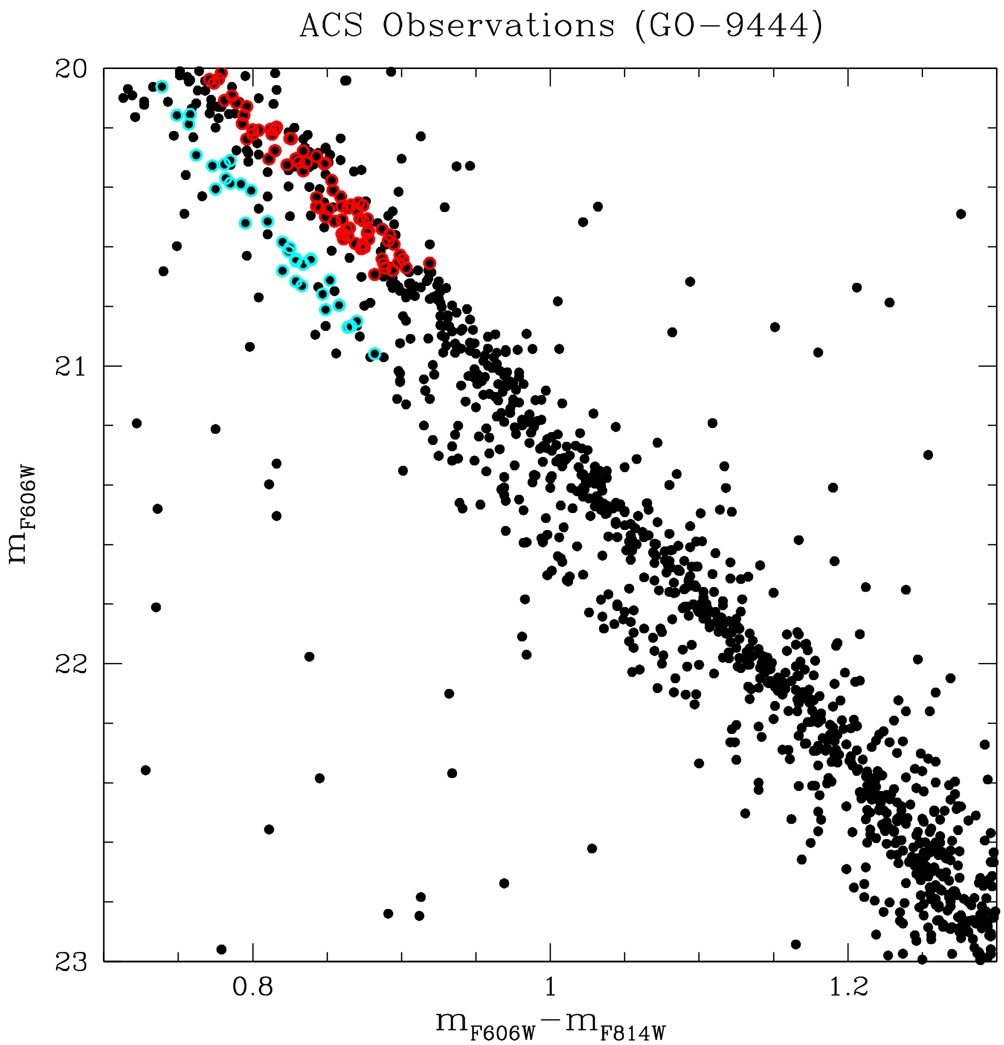

Fig. 1. Color Magnitude Diagram of the ωCen Double Main Sequence. In light and dark grey (blue and red in the electronic version) circles are highlighted the targets of the FLAMES+VLT spectroscopic follow-up.

2. The ω CenDouble Main Sequence

Figure 1 shows a zoom-in of the color magnitude diagram (CMD) from ACS@HST data of ω Cen presented by Bedin et al. (2004a) [see the paper for a full description of the data base]. The CMD is calibrated to the Vega-mag system (Bedin et al. 2004b, subm.) in the plane ($m_{\rm F606W} - m_{\rm F814W}$) vs. $m_{\rm F606W}$. This CMD confirms the presence of a double main sequence (DMS) in the color magnitude diagram (CMD) of ω Cen, first detected by one of us (Anderson 1997, Anderson 2002).

The main sequence bifurcation that we observe represents a real puzzle, for at least two reasons:

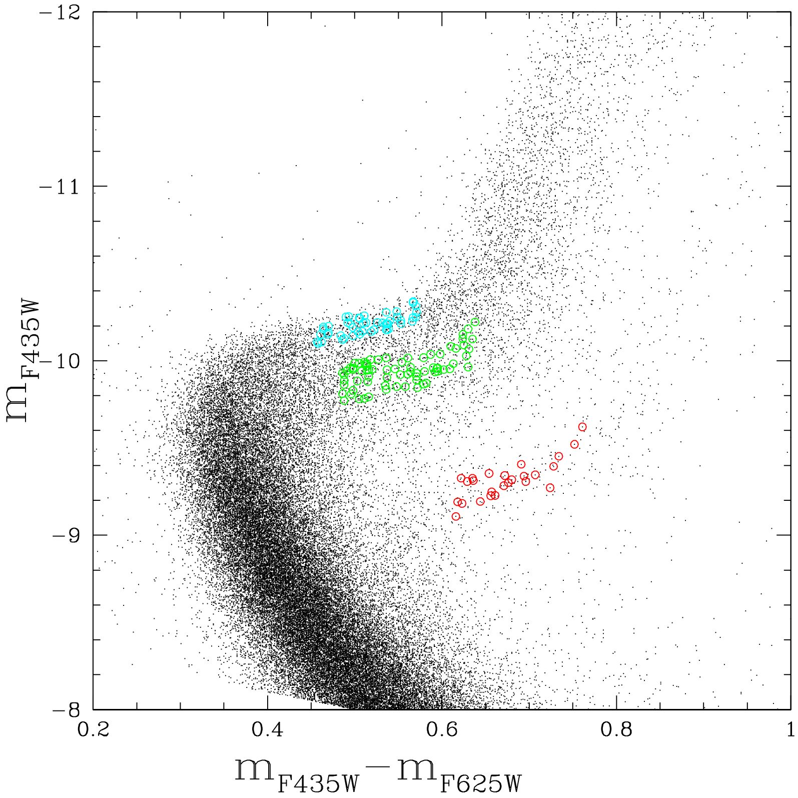

Fig. 2. Instrumental Color Magnitude Diagram around the turn off. Circles highlight the target stars for the spectroscopic follow-up.

1) The bifurcation itself is puzzling. The many detailed photometric (Pancino et al. 2000) and spectroscopic (Norris, Freeman & Mighell 1996) investigations of the RGB stars indicate a spread of metallicities, not two distinct populations. The only truly distinct population seen is the metal-rich component (Pancino et al. 2000).

2) The less populous of our two main sequences (MS) is the blue one. This is even more difficult to understand. Assuming that all the stars in the two MSs are members of ω Cen, any canonical stellar models with canonical chemical abundances tell us that the bluer MS *must* be more metal poor than the red MS. However, both spectroscopic (Norris & Da Costa 1995) and photometric (e.g., Hilker & Richtler 2000) investigations show that the distribution in metallicity of the ω Cen stars begins with a peak at [Fe/H] ~ -1.6, and then tails off on the metal-rich side.

Undoubtely, the striking result presented raises more questions than it answers. Various explanations have been suggested in Bedin et al. (2004a), none of them very conclusive.

The bluest of the two sequences could represent an intermediate metallicity ([Fe/H] = -1.1) population of stars formed from material polluted by intermediate mass asynptotic giant branch (AGB) star ejecta. This material should be helium enhanced. An overabundance of helium (Y> 0.3) could explain the blue color of the sequence. Observational Signatures of this pollution should be a high helium (Y > 0.3) abundance, high *s*-process element overabundance (e.g. [Ba/Fe] > +1.0), and possibly high C values.

The presence of an object with a metallicity [Fe/H]~ -1.0 in background, at $\sim$1.7kpc from ω Cen could also explain the MS bifurcation, but this possibility seems rather unlike.

3. Future Work

Very recently, thanks to a project on ESO Director Discretionary Time, we acquired new spectroscopic observations at FLAMES@VLT + GIRAFFE and UVES for 17 blue MS stars and 17 red MS stars. The targets have been selected among the objects highlighted with light and dark grey circles in Fig.1 (blue and red in the electronic version). In addition, several sub giant branch stars have been observed, selected among those highlighted in Fig.2.

The purpose of these observations is to measure the abundance of some of the elements which may indicate a past pollution episode (in particular we look for Barium over-abundance), providing an essential ingredient for the interpretation of the new *HST* results, and possibly for solving the puzzle still represented by the star formation history of ω Cen.

Four additional *HST*-orbits during Cycle 13 have been granted to our group, to study in detail the color distribution of the MS stars down to the Hydrogen Burning Limit. Thanks to our ability in measuring proper motions (Anderson & King 2000), the new *HST* data will allow to investigate any difference in the kinematic properties of these two MS populations.

These two new data set will certainly contribute in solving the stellar population puzzle of ω Cen.

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