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Abundances from a large spectroscopic survey in ω Centauri

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ω Centauri, the largest globular cluster of our Milky Way, is an outstanding object in many aspects. Studies on the red giant branch (RGB) revealed a large spread in iron abundance, which ranges from [Fe/H]~ -2.0 to -0.4 dex and the existence of multiple sub-populations that do not only differ in their element abundances but also in their spatial and kinematic distributions (e.g. Norris et al. 1997). Furthermore more recent photometric studies suggested the existence of an age spread between these subpopulations (e.g. Hilker & Richtler 2000).

In order to draw further conclusions on the origin of ω Centauri we analysed a large sample of spectra with medium resolution of stars near the age sensitive subgiant branch and main sequence turnoff region observed with FORS2/MXU at the VLT. For the metallicity calibration our dataset comprises spectra with known [Fe/H] values: of the chemically homogeneous globular cluster M55, standard stars and a grid of synthetic spectra taken from Bailer-Jones (2000). To quantify the strength of the absorption lines we defined line indices (mostly for Fe, but also Ca, Mg and H lines) with central widths adjusted to the resolution of our spectra. As a measure for the Fe abundance we combined several line indices to a mean Fe indictor. We corrected for the temperature effect by using a temperature dependent mean Balmer index. From the derived metallicities and in combination with photometric data kindly provided by Rey *et al.* (2004), we were able to disentangle the age-metallicity degeneracy. We determined the ages by interpolating in a grid of Yonsei-Yale isochrones taken from Kim *et al.* (2002). We assumed $[\alpha/\mathrm{Fe}] = 0.3$

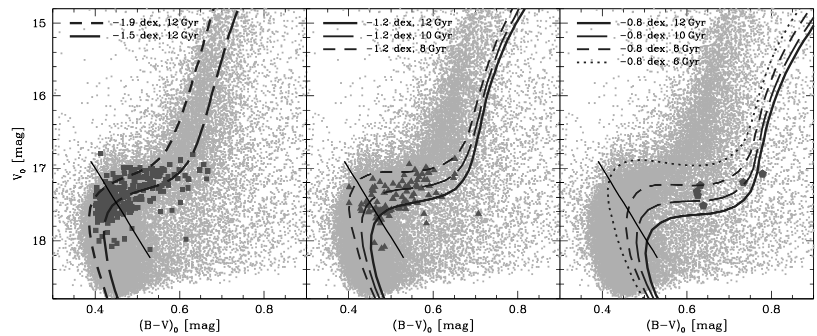

Figure 1. The position of stars of different abundances compared with isochrones of different ages and metallicities. The abundance ranges for the highlighted stars are: left: $-2.0 <$[Fe/H]< -1.4, middle:$-1.4 <$[Fe/H]< -1.0, right:$-1.0 <$[Fe/H]. The dominant metal poor population is best fit by 12 Gyr isochrones. More metal-rich stars scatter around isochrones that are up to 2 Gyr younger. The most metal-rich stars are distributed between the 9 to 11 Gyr isochrones.

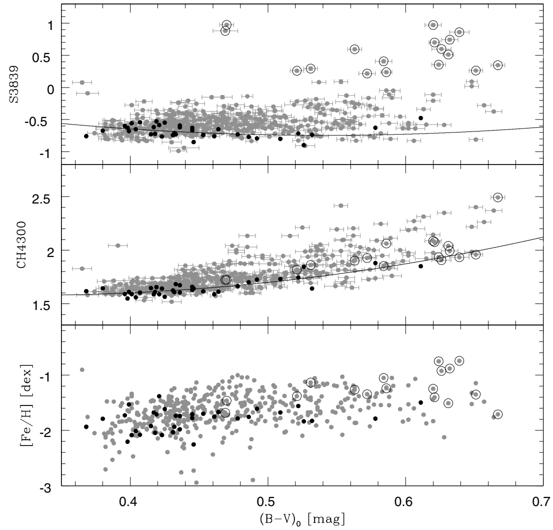

Figure 2. From top to bottom, S(3839), CH(4300) and [Fe/H] vs. $(BV)_0$ for stars in ω Cen and M55 (black). The fit curves of the M55 data indicated the temperature effect in the indices. Highlighted by circles are the most CN-rich stars. These stars are reidentified in the CH(4300) vs. $(B-V)_0$ and [Fe/H] vs. $(B-V)_0$ diagrams.

dex for stars with [Fe/H]< -1.0 dex and [α/Fe] $= 0.1$ dex for stars with [Fe/H]> -1.0 dex (Pancino *et al.* 2002). The resulting age-metallicity dependencies are shown in Fig. 1. Our results confirm an age spread of up to 4 Gyr in the sense that the metal-rich stars are on average younger than the dominant metal-poor population (Hilker *et al.* 2004).

The CN and CH absorption bands were measured by the commonly used indices S(3839) and CH(4300) (e.g. Norris *et al.* 1981). Again, M55 served as a comparison object for estimating the strength of the CN and CH variations and to estimate the effect of temperature on these indices. Specifically, we found that the line strength of CH(4300) is strongly anticorrelated with temperature, while the strength of S(3839) shows a very week temperature effect. The analysis of star-to-star CN and CH variations revealed, as for the RGB, the existence of a large scatter toward very high CN and CH abundances. From an inspection of the location of the most CN-rich stars in the corresponding CH(4300) and [Fe/H] vs. $(B-V)_0$ diagrams, we found that the CN-rich stars tend to be more CH-weak, and mainly belong to the metal-rich populations (Fig. 2).

Our study shows that ω Centauri definitely has experienced a complex chemical enrichment history with yields of different types of stars contributing. This has not been observed in any other globular cluster. The results provide further evidence for a prolonged star formation history as would be expected for a dwarf galaxy.

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