Stellar Populations as Building Blocks of Galaxies
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Mn, Cu, and Zn abundances in metal-rich globular clusters

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Abstract. Metal-rich globular clusters are important to study the chemical evolution of the Galaxy and one of the best approaches to better understand the physical processes occurring in stellar populations as building blocks of galaxies. We report on Mn, Cu, and Zn abundances of giant stars in metal-rich Galactic globular clusters ($-0.70 <$ [Fe/H] < -0.11), measured on spectra obtained with the UVES spectrograph on the 8-m VLT UT2-Kueyen telescope.

Keywords. globular clusters: individual (NGC 6553, NGC 6528, 47 Tucanae); stars: abundances

1. Introduction

Metal-rich globular clusters are important to study the chemical evolution of the Galaxy and they are key tracers of the thick disk and bulge populations. We present Mn, Cu, and Zn abundances of giant stars in three metal-rich globular clusters: 47 Tucanae ([Fe/H] = −0.67, Alves-Brito *et al.* (2005)), NGC 6553 ([Fe/H] = −0.20, Alves-Brito *et al.* (2006)), and NGC 6528 ([Fe/H] = −0.11, Zoccali *et al.* (2004)).

The sample consists of 5 giant stars of 47 Tucanae, 5 giant stars of NGC 6553, and 3 giant stars of NGC 6528 all observed with UVES spectrograph at the 8.2m Very Large Telescope. With the UVES standard setup 580, the resolution is R $\sim$ 45 000 for a 1 arcsec slit width, or R $\sim$ 55 000 for a slit of 0.8 arcsec, covering the range 4800-6800 Å.

2. Analysis

The analysis is based on Plez *et al.* (1992) model atmospheres. Abundances were obtained using spectrum synthesis of the 600 nm Mn I triplet, 481 nm Zn I and 510, 521, 578 nm Cu I lines. For lines of Mn I and Cu I, the hyperfine structure has been taken into account. The adopted solar abundances for Fe, Mn, Cu, and Zn are from Grevesse & Sauval (1998): $\epsilon(\mathrm{Fe})_\odot$=7.50, $\epsilon(\mathrm{Mn})_\odot$=5.39, $\epsilon(\mathrm{Cu})_\odot$=4.21, and $\epsilon(\mathrm{Zn})_\odot$=4.60.

3. Results and conclusions

The main findings are mean values of $-0.44 \leqslant$ [Mn/Fe] $\leqslant -0.35$, $-0.10 \leqslant$ [Cu/Fe] $\leqslant +0.00$, and $-0.05 \leqslant$ [Zn/Fe] $\leqslant +0.18$. The main result is that apart from Mn I, the other iron-group elements studied have typical average ratios near (within ± 0.15) the solar value. Comparisons with literature data are displayed in Fig. 1. This figure shows that mean [Mn/Fe] values for 47 Tucanae, NGC 6553, and NGC 6528 resemble those of the metal-rich stars in the Sagittarius dwarf spheroidal galaxy (Sgr dSph) by McWilliam *et al.* (2003a) and McWilliam *et al.* (2003b), while those for M71 ([Fe/H] = − 0.70,

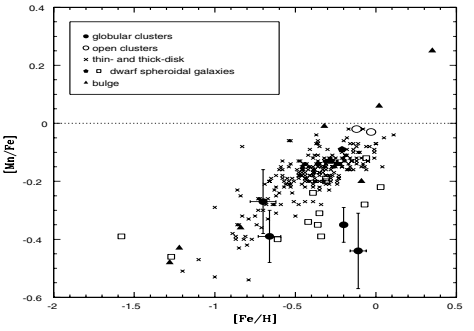

Figure 1. [Mn/Fe] vs. [Fe/H] for a sample of stars: (i) mean abundance ratios from Galactic globular clusters in this work and from M71 data by Ramírez & Cohen (2002) (*filled circles*). The error bars quoted correspond to the dispersion of each abundance from the mean value (rms); (ii) Open cluster stars analysed by Carretta *et al.* (2005) and Bragaglia *et al.* (2006) (*open circles*); (iii) disk stars from Reddy *et al.* (2003), Reddy *et al.* (2006) (*crosses*); (iv) Sgr dSph stars with data from Bonifacio *et al.* (2000) (*filled pentagons*) and from McWilliam *et al.* (2003a), McWilliam *et al.* (2003b) (*open squares*), and (v) bulge field stars from McWilliam *et al.* (2003a), McWilliam *et al.* (2003b) (*filled triangles*).

Ramírez & Cohen (2002)), which were obtained from the Mn I line at 5537 Å and from the Mn I triplet at 6000 Å, follow the other populations presented in Fig. 1.

When we compare the iron-peak elements abundance pattern of the individual stars in the metal-rich Galactic globular clusters analysed and those obtained of the Galactic disk stars the results match each other very well. An interesting point is that the iron-peak abundance ratios derived in this work for NGC 6553 and NGC 6528 help to confirm that these red globular cluster sub-population is chemically connected to the bulge/disk component, as previously pointed out by Ortolani *et al.* (1995). All final results will be discussed in terms of chemical enrichment of the Galaxy in Alves-Brito *et al.* (2007, *in preparation*).

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