Abundance of zirconium in the red giants of Galactic globular cluster 47 Tuc

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Introduction

Research done during the past decade has shown that stars in Galactic globular clusters (GGC) do not share the same chemical composition and may have formed during different star formation episodes (e.g. Bastian et al., 2018). This suggests that globular clusters may consist of two (or more) generations of stars, with the second generation born from the material enriched by the ejecta of the most massive stars (Krause et al., 2013) and/or asymptotic giant branch (AGB) stars (Ventura et al., 2001). Unfortunately, our current knowledge about the GGCs does not allow us to discriminate between the possible pollution scenarios.

Additional valuable information about the evolution of GGCs may be obtained from *s*-process elements. They are synthesized in different environments and, in combination with light element abundances, may shed further light on the possible evolutionary scenarios of the GGCs. Unfortunately, most of such studies until now have been based on small samples of GGC stars. Therefore, to partly fill this gap, in this study we determined the abundances of sodium and the *s*-process element zirconium in 283 RGB stars of Galactic globular cluster 47 Tuc.

Abundance analysis

Abundance analysis was based on the archival spectra of RGB stars that were obtained with the GIRAFFE spectrograph mounted on the VLT UT2 telescope (ESO, Chile). The spectra were obtained during the three observational programmes: 072.D-0777(A) (PI: P. François), 073.D-0211(A) (PI: E. Carretta) and 088.D-0026(A) (PI: I. McDonald).

Three spectral lines of neutral zirconium were used, with their central wavelengths located at 612.7475 nm, 613.4585 nm and 614.3252 nm. Line equivalent widths were determined using *splot* task in IRAF, by fitting Gaussian profiles to the observed spectral lines. Stellar model atmospheres were computed using the ATLAS9 code and were further employed to derive 1D LTE zirconium abundances with the WIDTH9 package.

For sodium, we used two lines at 615.4225 nm and 616.0747 nm. Abundances were determined using NLTE line synthesis performed with the MULTI code (Carlsson 1986; Korotin et al. 1999).

Results

The mean zirconium abundance we obtained for a sample of 283 red giants in 47 Tuc is [Zr/Fe] = +0.37 ± 0.09 (the error here is RMS deviation due to star–to–star abundance variation). This is so far the largest sample of red giant stars analyzed in this cluster for zirconium abundance. In case of sodium, we obtained the mean abundance of [Na/Fe] = +0.43 ± 0.16.

The obtained result shows a weak but statistically significant correlation between abundances of Zr and Na, (Fig. 1), and anti-correlation between abundance of Zr and radial distance from the cluster center (Fig. 2). The obtained results suggest that in this GGC zirconium was produced by the same polluters that enriched the second generation stars with the light chemical elements.

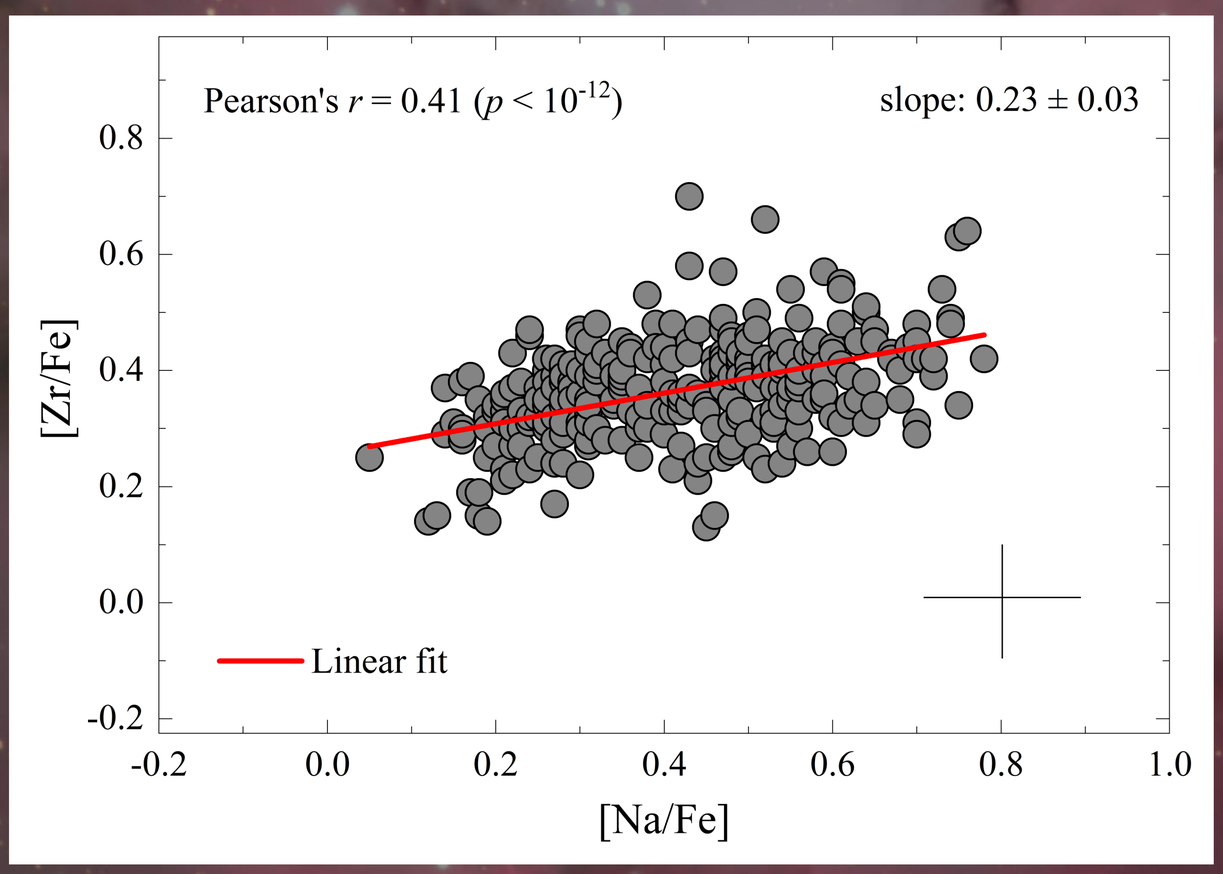

Fig 1. Abundances of zirconium and sodium in the RGB stars of 47 Tuc. Error bars at bottom right show the typical abundance determination error.

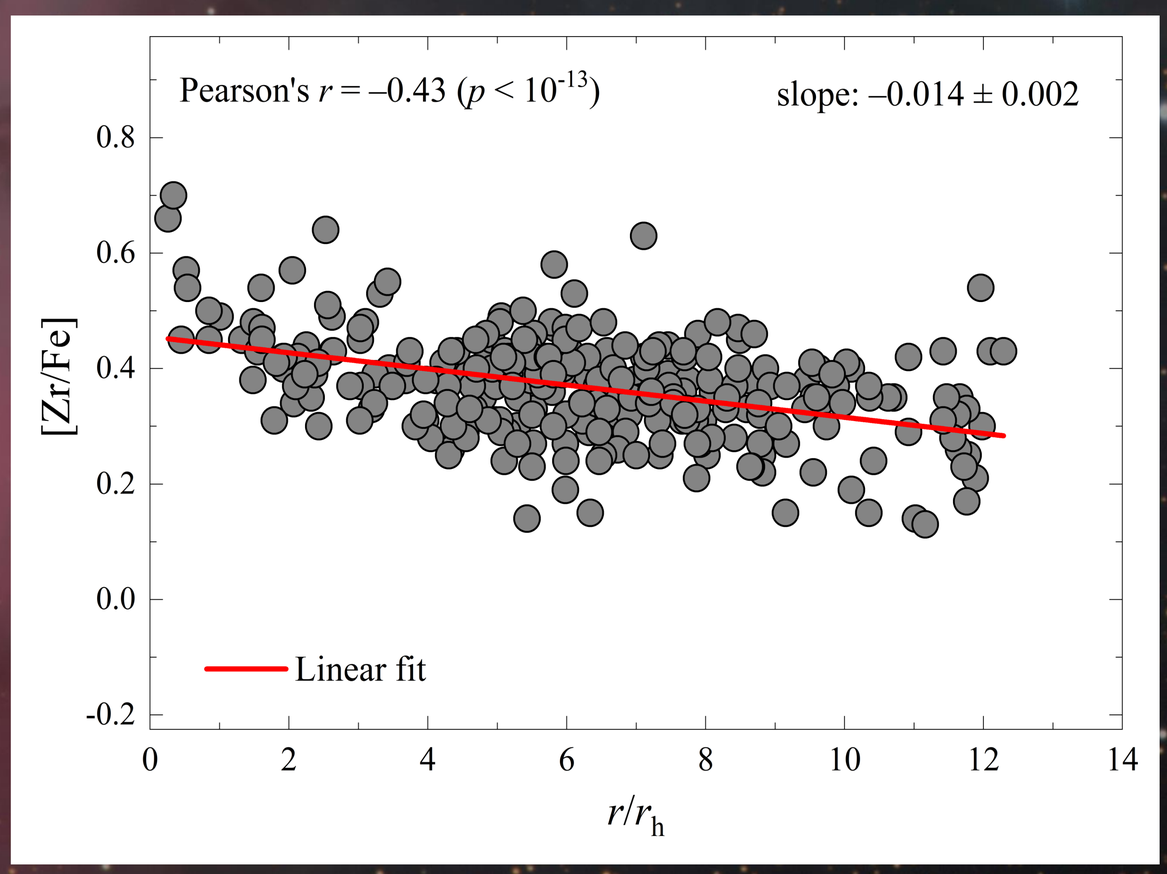

Fig 2. Abundance of zirconium in the RGB stars of 47 Tuc as a function of radial distance from the cluster center.

References

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