Boletim da Sociedade Astronômica Brasileira, **30**, no. 1, 132-133

Chemical analysis of eight giant stars of the globular cluster NGC 6366

A. A. Puls & A. Alves Brito

[1] Instituto de Física, Universidade Federal do Rio Grande do Sul. e-mail: puls.arthur@gmail.com

Abstract. The metal-rich Galactic globular cluster NGC 6366 is the fifth closest to the Sun. We present a detailed chemical analysis of eight giant stars of NGC 6366, using high resolution and high quality spectra obtained at the VLT (8.2 m) and CFHT (3.6 m) telescopes. We attempted to characterize its chemistry and to search for evidence of multiple stellar populations. The atmospheric parameters were derived using the method of excitation and ionization equilibrium of Fe I and Fe II lines. None of the measured elements presents star-to-star variation greater than the uncertainties. We determined a mean [Fe/H] = −0.60 ± 0.03 for NGC 6366. The Na-O anticorrelation extension is short and no star-to-star variation in Al is found. The presence of second generation stars is not evident in NGC 6366.

Resumo. O aglomerado globular rico em metais NGC 6366 é o quinto mais próximo do Sol. Nós apresentamos uma análise química detalhada de oito estrelas gigantes de NGC 6366, usando espectros de alta resolução e alta qualidade obtidos nos telescópios VLT (8.2 m) e CFHT (3.6 m). Tentamos caracterizar sua composição química e procuramos por evidências de múltiplas populações estelares. Os parâmetros atmosféricos foram derivados usando o método de equilíbrio de ionização e excitação de linhas de Fe I e Fe II. Nenhum dos elementos medidos apresenta variação estrela-a-estrela maior que as incertezas. Nós determinamos o [Fe/H] médio igual a −0.60 ± 0.03 para NGC 6366. A extensão da anticorrelação Na-O é curta e nenhuma variação em Al foi encontrada. A presença de estrelas de segunda geração não é evidente em NGC 6366.

Keywords. stars: abundances – Galaxy: abundances – globular clusters: individual: NGC 6366

1. Introduction

Globular clusters (GCs) were, for many years, viewed as the prototypes of simple stellar populations, that is, all their stars would have the same age and metallicity in a first approximation. As of today, the consensus is that some of the light elements studied in GCs present star-to-star abundance variations. In this context, NGC 6366, one of the least massive Galactic GCs, is an interesting object to be investigated. It is the fifth closest GC according to the catalogue of Harris (1996, 2010 edition, 2010 edition), and its distance from the Sun is 3.5 kpc. Also, this GC still had no measurements based on high resolution spectra of chemical elements widely studied in the context of Galactic and GC chemical evolution, such as Al and Eu.

2. Data and Method

Our sample consists of eight bright giant stars observed with UVES@VLT (Dekker et al. 2000) and ESPaDOnS@CFHT, the former for a study of metal-rich Galactic GCs (Feltzing et al. 2009). ESPaDOnS data are reduced through the software Upena/Libre-Esprit pipeline, provided by the instrument team (Donati et al. 1997). The spectra have high resolution (R ≥ 40000) and high signal-to-noise ratio (S/N ≥ 60).

The stellar atmospheric parameters – effective temperature ($T_{\rm eff}$), surface gravity (log g), metallicity ([Fe/H]), and microturbulent velocity (ξ_t), were obtained by photometric and spectroscopic methods.

The spectroscopic stellar parameters for each object were determined by traditional methods. Equivalent widths (EW) of Fe I and Fe II lines were measured by hand using IRAF *splot* task. For each star, a LTE 1D plane-parallel atmospheric model was created, and used as input in the *abfind* driver of MOOG. The effective temperature ($T_{\rm eff}$) was found by excitation equilibrium of Fe I lines. Microturbulent velocity ξ_t was found removing trends between abundance of Fe I lines and reduced EW. The surface gravity log g was found by ionization equilibrium of Fe I and Fe II. Finally, the metallicity [Fe/H] was determined by equalizing the value used in the model and the value given by MOOG in the output. The adopted stellar parameters were found when all the conditions were satisfied simultaneously.

To obtain the abundance of elements with atomic number Z ≤ 28 we adopted EW measurements, except for Mn. For heavier elements and Mn, the spectral synthesis method was used.

3. Results

The mean heliocentric radial velocity for our sample is −121.2 ± 0.7 km s^{-1} (σ = 2.0 km s^{-1}), without outliers. The result is consistent with those found in the literature. From radial velocities, we assume cluster membership for all the eight stars.

The values found for $T_{\rm eff}$, microturbulence and log g are typical for giant stars. As for metallicities, we found a mean [Fe/H] = −0.60 (σ = 0.08). The mean metallicity is consistent with that found by Johnson et al. (2016) and studies based upon low-resolution data.

As for the chemical abundances, the Na-O anti-correlation extension is short and no star-to-star variation in Al is found. The presence of second generation stars is not evident in NGC 6366. Among the species measured, no element present star-to-star abundance variations greater than mean uncertainties.

4. Conclusions

Our analysis confirms NGC 6366 as a metal-rich GC, with no internal [Fe/H] variation. None of the elements measured spread beyond uncertainties in NGC 6366. Being considered a GC with halo kinematics, NGC 6366 has a chemical abundance pattern which can be consistent with both the bulge and the α-rich, metal-rich halo. We have not found any unambiguously second generation star. It can be assumed that our entire sample, or at

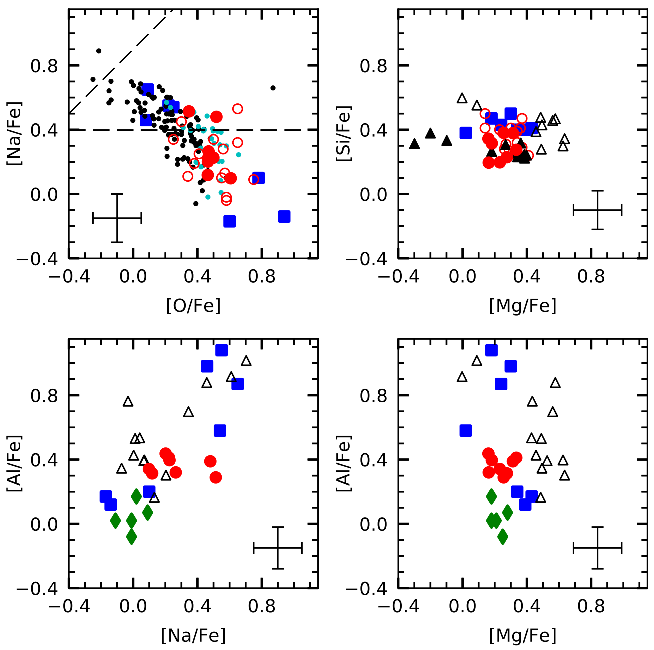

Figure 1. [X/Fe] abundance ratios for light elements. *Red filled circles*: this work. *Red open circles*: NGC 6366 from Johnson et al. (2016). *Blue squares*: NGC 6266 (Yong et al. 2014). *Green diamonds*: NGC 6558 (Barbuy et al. 2007). *Black dots*: 47 Tuc (Alves-Brito et al. 2005; Carretta et al. 2009a). *Cyan dots*: M 71 (Carretta et al. 2009a) *Black filled triangles*: NGC 2808 and *Black open triangles*: NGC 7078 (Carretta et al. 2009b) The error bars are typical for this work. The dashed lines are the borders between P, I and E components defined in Carretta et al. (2009a).

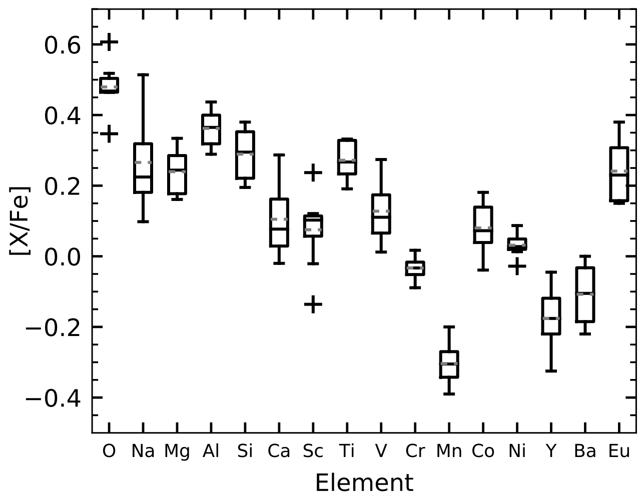

Figure 2. Star-to-star abundance spread for all elements measured in this work, except Fe. *Boxes*: the interquartile ranges (IQR). *Whiskers*: data inside 1.5*IQR limits. *Black horizontal lines*: medians. *Grey dashed lines*: means. *Crosses*: outliers.

least most of it, is from the first generation. If NGC 6366 contains a simple stellar population, which is possibly the case, it enters the list of Galactic GCs without detection of multiple populations, adding evidence that, at least in the Galaxy, such phenomenon occurs only in GCs brighter than $M_V \approx -7$.

Acknowledgements. Partial financial support for this research comes from BIC-UFRGS institutional program and CNPq. IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation. Based on observations collected at the European Organisation for Astronomical Research in the Southern Hemisphere under ESO programme 69.B-0467. Based on observations obtained at the Canada-France-Hawaii Telescope (CFHT) which is operated by the National Research Council of Canada, the Institut National des Sciences de l'Univers of the Centre National de la Recherche Scientique of France, and the University of Hawaii.

References

Alves-Brito, A., Barbuy, B., Ortolani, et al., 2005, A&A, 435, 657A
Barbuy, B., Zoccali, M., Ortolani, et al., 2007, AJ, 134, 1613B
Carretta, E., Bragaglia, A., Gratton, R. G., et al., 2009a, A&A, 505, 117C
Carretta, E., Bragaglia, A., Gratton, R. and Lucatello, S., 2009b, A&A, 505, 139C
Dekker, H., D'Odorico, S., Kaufer, A., et al., 2000, Proc. SPIE Vol. 4008, p. 534-545
Donati, J.-F., Semel, M., Carter, B. D., et al., 1997, MNRAS, 291, 658D
Feltzing, S., Primas, F. and Johnson, R. A., 2009, A&A, 493, 913F
Harris, W. E.,1996, AJ, 112, 1487
Johnson, C. I., Caldwell, N., Rich, R. M., et al., 2016, AJ, 152, 21J
Yong, D., Alves Brito, A., Da Costa, G. S., et al., 2014, MNRAS, 439, 2638Y