

# ON THE APOGEE DR14 SODIUM SPREAD IN THE GALACTIC OPEN CLUSTER NGC 188

Andrés E. Piatti<sup>1,2</sup>

<sup>1</sup>*Consejo Nacional de Investigaciones Científicas y Técnicas, Godoy Cruz 2290, C1425FQB, Buenos Aires, Argentina*

<sup>2</sup>*Observatorio Astronómico de Córdoba, Laprida 854, 5000, Córdoba, Argentina*

## OVERVIEW AND DATA COLLECTION

[Na/Fe] is a flagship among chemical abundances as a good indicator of the existence of multiple populations in globular clusters, with spreads of up to 0.6 dex and more; no globular cluster having a null spread (Gratton et al. 2004; Bastian & Lardo 2018). As far as Galactic open clusters are considered, no multiple populations have been found yet (see, Bragaglia et al. 2012; Carrera & Martínez-Vázquez 2013). Enter NGC 188 (age =  $6.3 \pm 0.2$  Gyr, Bonatto 2019).

I made use of the publicly available Sloan Digital Sky Survey IV, in particular of APOGEE DR14 (Abolfathi et al. 2018) through the APOGEE Stellar Parameters and Abundances pipeline (ASPCAP, García Pérez et al. 2016), to search for stellar parameters and element abundances of stars in the field of NGC 188. As a result, I gathered 758 stars distributed within a radius of  $\sim 1.6^\circ$  from the cluster center and with 2MASS  $K_s$  mag down to  $\sim 12.5$  mag. In order to disentangle *bonafide* cluster members from field stars I used the diagnostic plane [Fe/H] vs. RV (see Fig. 1), which clearly highlights a group of stars tightly distributed around the known cluster with  $RV = 42.4 \pm 0.1$  km/s (Chumak et al. 2010) and metal content  $0.12 < [\text{Fe}/\text{H}] \text{ (dex)} < 0.20$  (Bonatto 2019). They are red giant stars with  $4100 \lesssim T_{\text{eff}}$  (K)  $\lesssim 5000$  and  $1.5 \lesssim \log(g) \lesssim 3.5$ , distributed within a circle with a radius of  $25'$ , which is nearly half of the cluster tidal radius ( $44.78'$ , Wang et al. 2015).

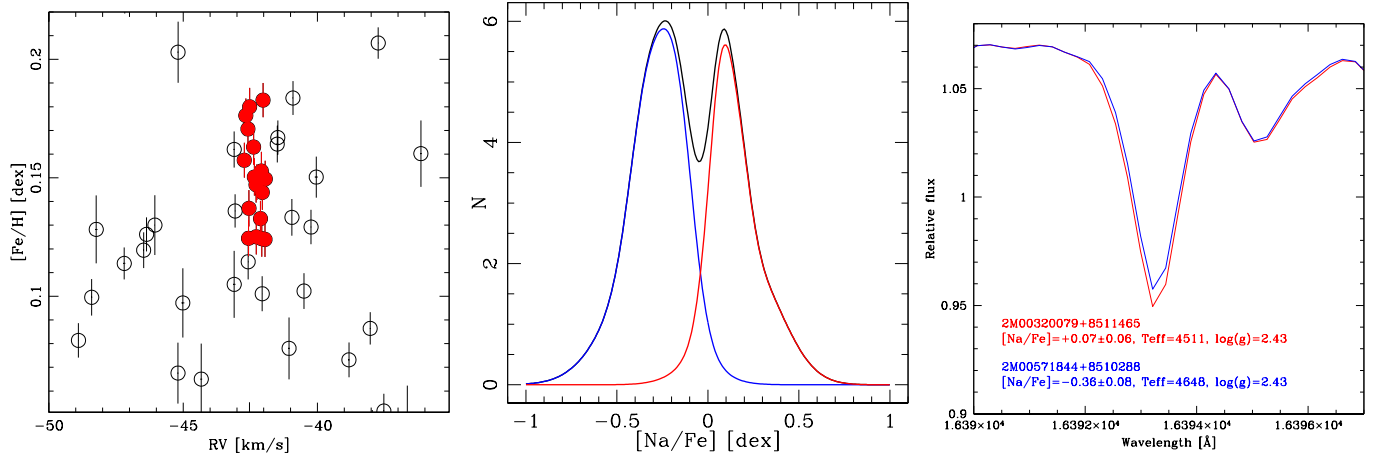
## ANALYSIS AND DISCUSSION

In order to quantify the [Na/Fe] spread, I used the maximum likelihood approach proposed by Pryor & Meylan (1993) (see also Walker et al. 2006) and obtained a mean value of  $\langle [\text{Na}/\text{Fe}] \rangle = -0.04 \pm 0.01$  dex with an intrinsic spread  $W = 0.16 \pm 0.04$  dex. I then built the [Na/Fe] distribution by representing each [Na/Fe] value by a Gaussian function with center and full-width half maximum equal to the [Na/Fe] value and 2.355 times the associated error, respectively, and assigned to each Gaussian the same mean intensity. Fig. 1 depicts the resulting [Na/Fe] distribution. As can be seen, the [Na/Fe] dispersion derived from the maximum likelihood statistics is indeed bimodal, with two prominent peaks differing by  $\simeq 0.3$  dex.

I performed additional checks in order to discard any artifacts in the data which might be responsible of the observed bimodality. I also searched all the ASPCAP flags for peculiarities in our sample stars, and could not find any. The spectra span SNR ranges  $\approx 100$ -600, they have ASPCAPFLAG and NA\_FE\_FLAG values equals to zero, which means that there were no issues in the determination of the stellar parameters, and mean  $\chi^2$  from the ASPCAP fit  $\approx 8.0$ .

However, the [Na/Fe] abundances have been derived from two weak (in GK-giants) and possibly blended lines at about 16378 and 16393 Å, respectively, for which Jönsson et al. (2018) and Holtzman et al. (2018) showed that the Na uncertainty is of 0.16 dex. Furthermore, I directly compared the available spectra for stars with similar atmospheric parameters and it would seem that they look similar (see an example in Fig. 1). Therefore, I warn users of large spectroscopic surveys to be extra careful when finding peculiar abundance results. Analysis pipelines that run in an unsupervised fashion may produce bad results which may not be noticed before publication.

I am deeply indebted to E. Pancino for her contribution to an early version of this Note. I adhere to the official SDSS Acknowledgment at <https://www.sdss.org/collaboration/#publication-policy>.



**Figure 1.** Left, middle and right panels are RV vs. [Fe/H] diagnostic diagram, with red filled circles representing the selected cluster members; their [Na/Fe] distribution with blue and red lines corresponding to values smaller or larger than [Na/Fe] = -0.05 dex; and a comparison of the spectra of two stars with similar atmospheric parameters, respectively.

## REFERENCES

- Abolfathi, B., Aguado, D. S., Aguilar, G., et al. 2018, *ApJS*, 235, 42, doi: [10.3847/1538-4365/aa9e8a](https://doi.org/10.3847/1538-4365/aa9e8a)
- Bastian, N., & Lardo, C. 2018, *ARA&A*, 56, 83, doi: [10.1146/annurev-astro-081817-051839](https://doi.org/10.1146/annurev-astro-081817-051839)
- Bonatto, C. 2019, *MNRAS*, 483, 2758, doi: [10.1093/mnras/sty3291](https://doi.org/10.1093/mnras/sty3291)
- Bragaglia, A., Gratton, R. G., Carretta, E., et al. 2012, *A&A*, 548, A122, doi: [10.1051/0004-6361/201220366](https://doi.org/10.1051/0004-6361/201220366)
- Carrera, R., & Martínez-Vázquez, C. E. 2013, *A&A*, 560, A5, doi: [10.1051/0004-6361/201322048](https://doi.org/10.1051/0004-6361/201322048)
- Chumak, Y. O., Platais, I., McLaughlin, D. E., Rastorguev, A. S., & Chumak, O. V. 2010, *MNRAS*, 402, 1841, doi: [10.1111/j.1365-2966.2009.16021.x](https://doi.org/10.1111/j.1365-2966.2009.16021.x)
- García Pérez, A. E., Allende Prieto, C., Holtzman, J. A., et al. 2016, *AJ*, 151, 144, doi: [10.3847/0004-6256/151/6/144](https://doi.org/10.3847/0004-6256/151/6/144)
- Gratton, R., Sneden, C., & Carretta, E. 2004, *ARA&A*, 42, 385, doi: [10.1146/annurev.astro.42.053102.133945](https://doi.org/10.1146/annurev.astro.42.053102.133945)
- Holtzman, J. A., Hasselquist, S., Shetrone, M., et al. 2018, *AJ*, 156, 125, doi: [10.3847/1538-3881/aad4f9](https://doi.org/10.3847/1538-3881/aad4f9)
- Jönsson, H., Allende Prieto, C., Holtzman, J. A., et al. 2018, *AJ*, 156, 126, doi: [10.3847/1538-3881/aad4f5](https://doi.org/10.3847/1538-3881/aad4f5)
- Pryor, C., & Meylan, G. 1993, in *Astronomical Society of the Pacific Conference Series*, Vol. 50, *Structure and Dynamics of Globular Clusters*, ed. S. G. Djorgovski & G. Meylan, 357
- Walker, M. G., Mateo, M., Olszewski, E. W., et al. 2006, *AJ*, 131, 2114, doi: [10.1086/500193](https://doi.org/10.1086/500193)
- Wang, J., Ma, J., Wu, Z., Wang, S., & Zhou, X. 2015, *AJ*, 150, 61, doi: [10.1088/0004-6256/150/2/61](https://doi.org/10.1088/0004-6256/150/2/61)