Chemical analysis of the Small Magellanic Cloud Main Body

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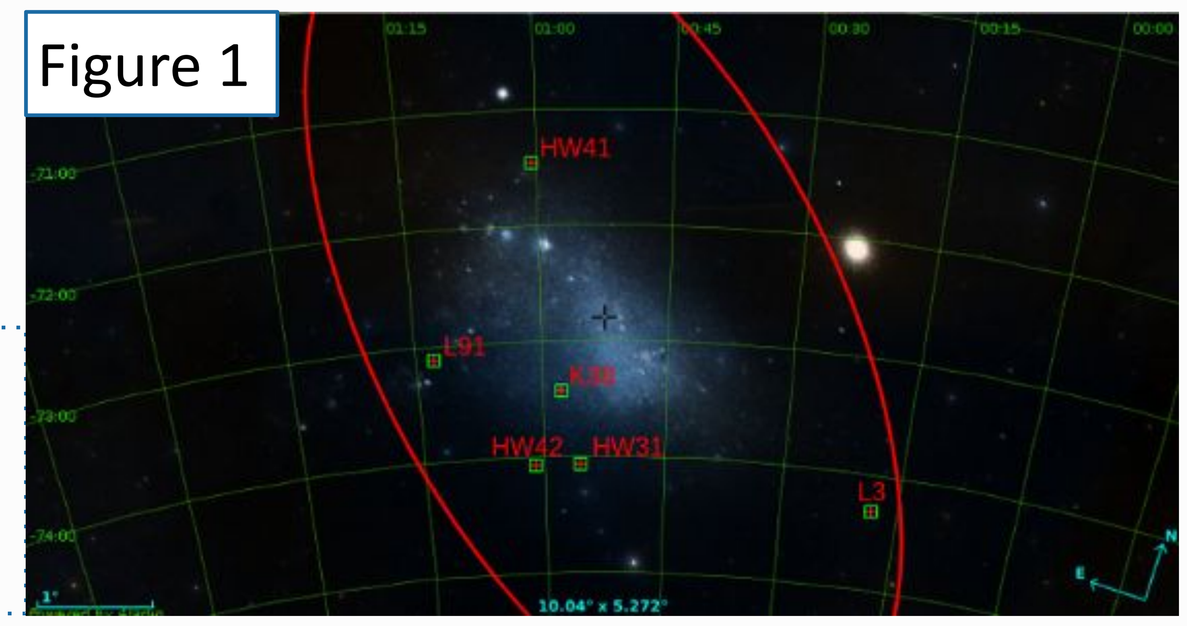

Spatial distribution
DSS2 image of the SMC superimposed with the ellipse of a = 3.4°, centred on SMC centre. The SMC centre is marked with a cross and squares indicate our cluster sample. Arrows show the North and East direction and the spatial scale is shown at the lower left corner.

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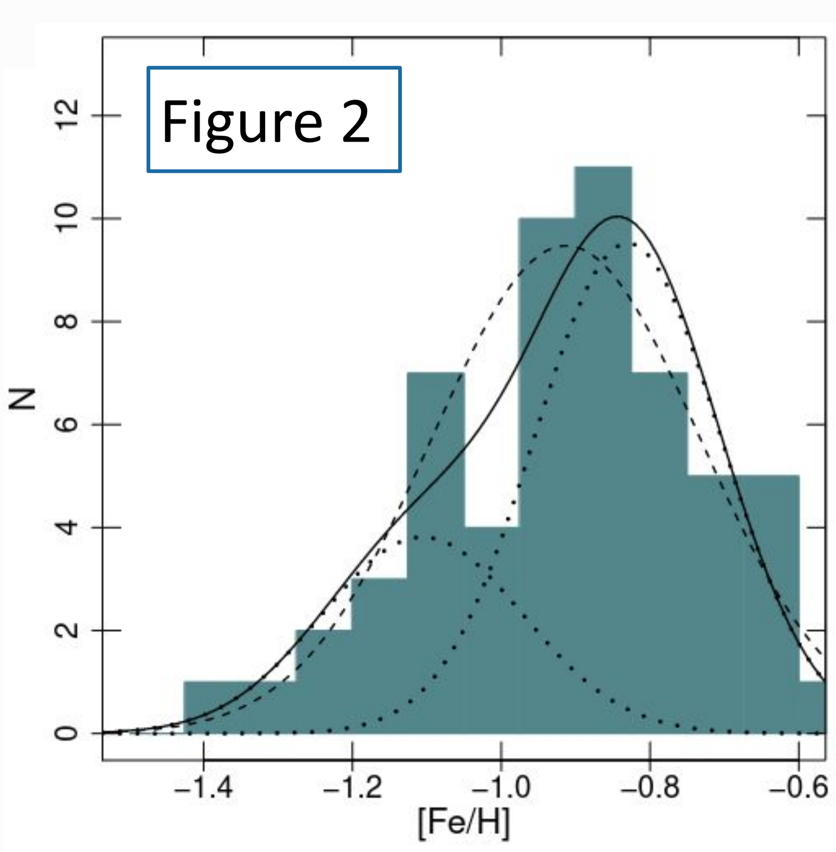
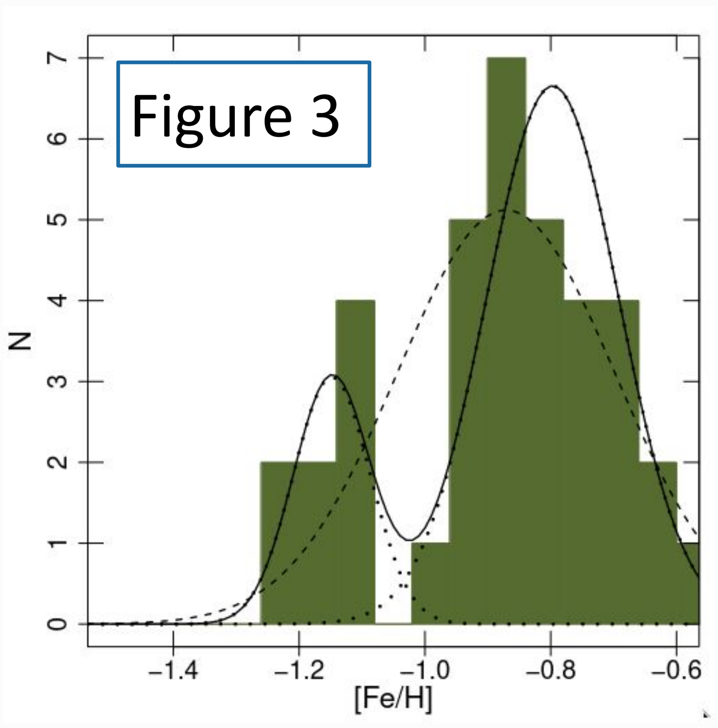
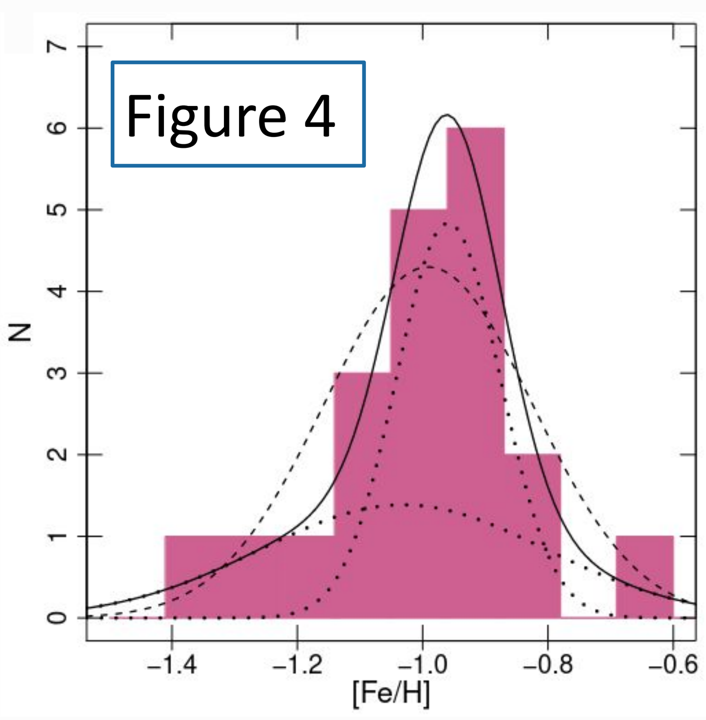
1. Abstract

We derive radial velocities and Ca II Triplet (CaT) metallicity of more than 150 red giants stars in six Small Magellanic Cloud (SMC) star clusters (see Fig. 1) and their surrounding fields, with GMOS on GEMINI-S. We add this information to that available for another 51 clusters and 30 fields with CaT metallicities on the same scale (Parisi et al 2009, 2010, 2015, 2016, 2022, Dias et al 2021, 2022 and Da Costa & Hatzidimitriou 1998). Using this expanded sample we analize the chemical properties of the SMC Main Body (MB), defined as the inner 3.4 degrees in semimajor axis (Dias et al 2016, 2021 and Parisi et al 2022). We found a high probability that the metallicity distribution of the MB clusters is bimodal with a metal-rich and a metal-poor cluster groups, having mean metallicities and dispersion of <Fe/H> = −0.80, σ = 0.06 and <Fe/H> = −1.15, σ = 0.10 dex, respectively. Neither metal-rich nor metal-poor clusters present a metallicity gradient. However the full MB cluster sample and field stars have a negative metallicity gradient consistent with each other, but the one corresponding to clusters has a large error due to the large metallicity dispersion present in the clusters studied in that region. Metal-rich clusters present a clear age-metallicity relation, while metal-poor clusters show no chemical enrichment throughout the life of the galaxy.

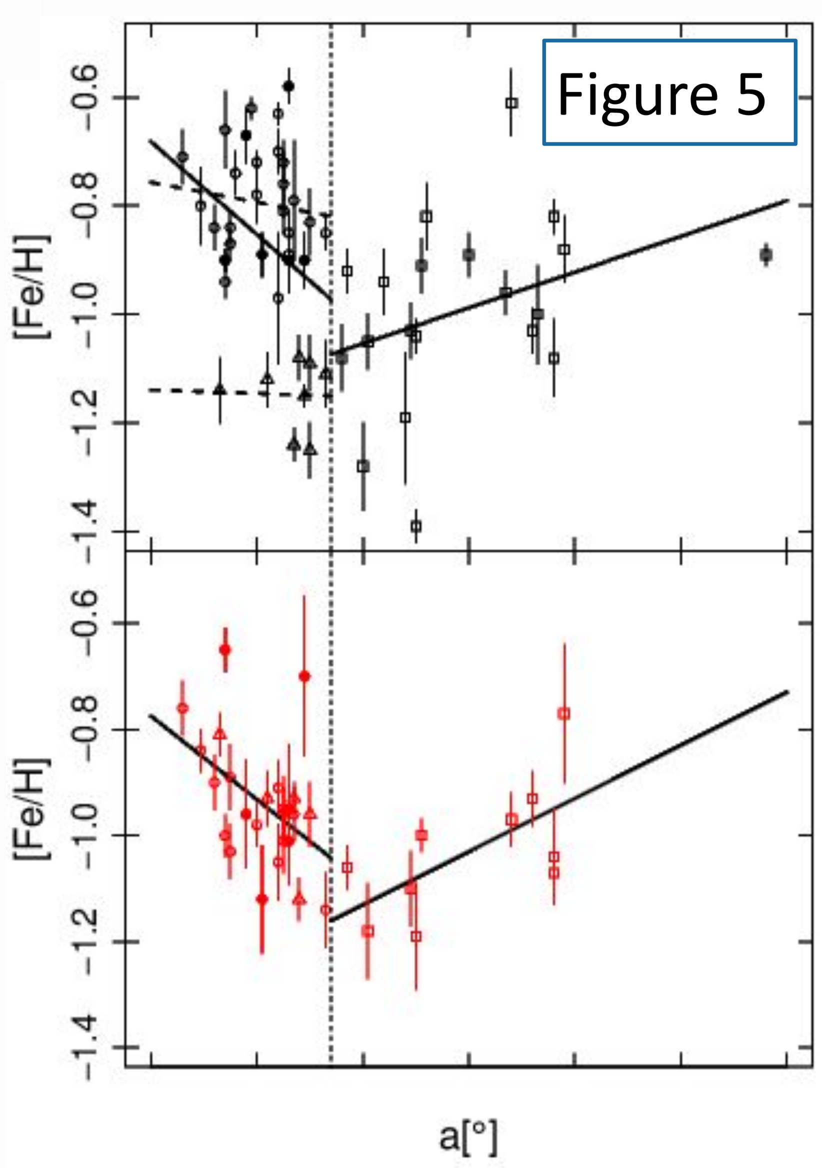


2. Metallicity distribution of the enlarged cluster sample. Dotted lines are the two fitted Gaussian functions according to the results from the Gaussian Mixture Modeling test (GMM Muratov & Gnedin 2010) and the solid line shows their sum. Dashed line shows the fitted Gaussian in the unimodal case. We applied GMM test to the whole sample and found a probability of bimodality of 39%.

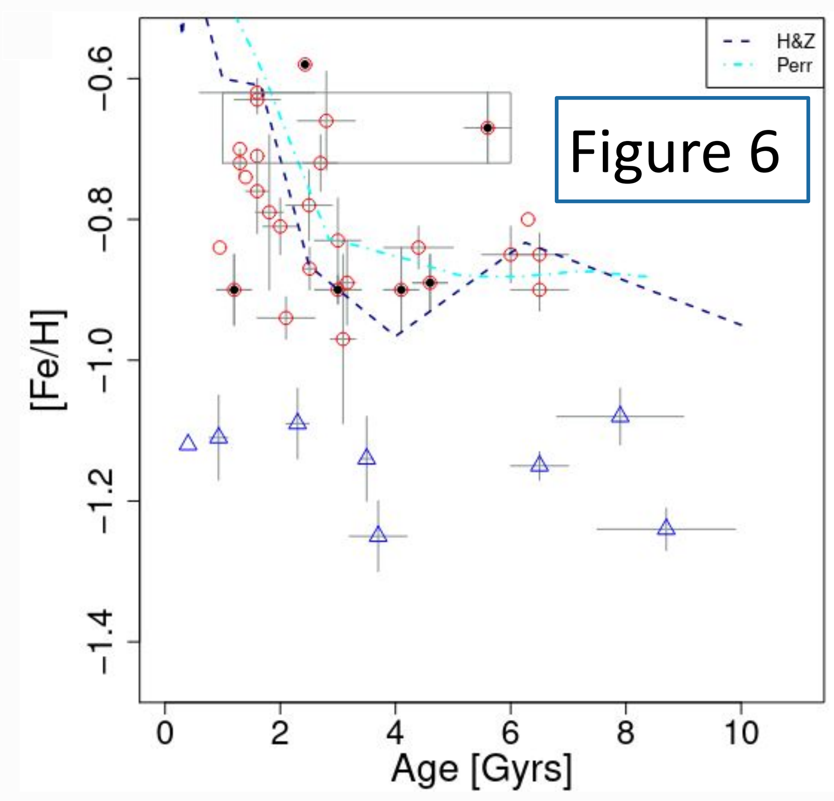




3. Metallicity distribution of the inner (a<3.4°, Fig. 3) and outer (a>3.4°, Fig. 4) regions. Dotted, dashed and solid lines are the same as in Fig. 2. We ran GMM and found that while the outer metallicity distribution presents a probability consistent with that found for the entire sample (~37%), the inner part shows a high probability of a bimodal metallicity distribution (~95%). The existence of bimodality in the inner region suggests the idea of **two possible cluster populations coexisting towards the Main Body** having a mean metallicity smaller and larger (-1.15 and -0.80 dex, respectively) than the typical mean metallicity of field stars (~ -1, Parisi et al 2016).



4. Metallicity gradient of clusters (upper panel) and field stars (bottom panel). Filled and open circles are clusters and fields studied in this work and from the literature, respectively. Circles and triangles show the metal-rich and metal-poor groups in the inner region, respectively. Squares show clusters in the outer region. The vertical line indicates the limit between the inner and outer regions. We determined from our extended samples the metallicity gradients in the inner and outer regions of the galaxy (solid lines). We found values of -0.08 ± 0.04 dex deg^{-1} and 0.03 ± 0.02 dex deg^{-1} for the inner and outer regions of the cluster sample, respectively. With respect to field stars, the linear fits give a metallicity gradient of -0.08 ± 0.03 dex deg^{-1} for the inner part of the SMC and 0.05 ± 0.02 dex deg^{-1} for the outer part. We performed linear fits to the two internal groups separately (dashed lines) yielding values for the metallicity gradients of -0.02 ± 0.03 dex deg^{-1} and -0.003 ± 0.042 dex deg^{-1}, for the metal-rich and metal-poor groups, respectively.



5. Age-metallicity relation in the inner region. Red circles and blue triangles show those clusters corresponding to the metal-rich and metal-poor groups, respectively. The six clusters studied in this work are represented with filled symbols. The chemical evolution of the metal-rich group clusters seems to be well represented by the Harris & Zaritsky (2004, H&Z) and Perren et al. (2017) models. Metal-rich clusters show a chemical enrichment process which increased the metallicity considerably, at least for about half of the younger clusters. On the contrary, metal-poor clusters appear to not have undergone any chemical enrichment.

6. Conclusions

- We find a high probability (95%) that the cluster metallicity distribution is bimodal in the inner region of the SMC but unimodal in the outer region. Thus, we found two groups that correspond to the metal-poor and metal-rich clusters in the inner region.
- The cluster metallicity gradient is negative in the inner region but positive or null in the outer region. However, linear fits for the metal-rich and metal-poor clusters separately are consistent with no metalicity gradient.
- The Age-Metallicity Relation in the inner region shows that the metal-rich clusters appear to follow the chemical enrichment of field stars given by Harris & Zaritsky or the model proposed by Perren et al., but metal-poor clusters do not present any chemical enrichment.

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