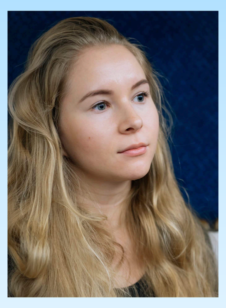

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Chemical composition of a young massive cluster NGC 1569-B

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Introduction

NGC 1569-B is located in a dwarf irregular galaxy NGC 1569 at 3.4 Mpc away. The mass is estimated to be $(4.4 \pm 1.1)\times10^5$ $M_\odot$ and the age 15-25 Myr (Larsen et al. 2008). Such massive clusters are rare in the Milky Way and even in the Local Group. The young star clusters with masses in excess of 10^5 $M_\odot$ offer an excellent opportunity to study large samples of massive stars of the same age.

Integrated light (IL) at high resolution gives us an opportunity to study objects not present in the Milky Way using approaches comparable to that of individual stellar abundances. NGC 1569-B was observed with Keck HIRES providing us with an IL spectrum of the cluster with the wavelength range of 3880-8160 Å and a spectral resolution of R=39000.

Methods

This method splits the cluster Hertzsprung-Russell diagram (HRD), from isochrones or photometry, into bins of different stellar evolutionary stages (Fig. 1). Using Kurucz models, model atmospheres and synthetic spectra are computed for each bin. Then these spectra are scaled to the stellar luminosity with respect to each bin, they are all combined into a single integrated synthetic spectrum. The full description of the method in in Larsen et al. 2012.

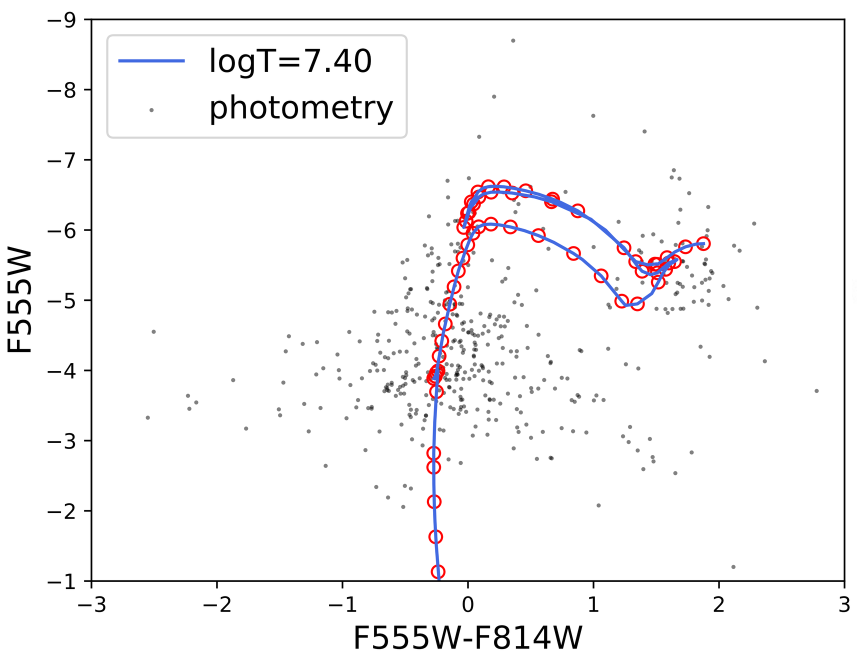

Fig.1: CMD of NGC 1569-B using ACS photometry (black dots), with an isochrone (over plotted in orange) of logarithmic age 7.4 (25 Myrs) and Z=0.008 from the Padua catalogue (Girardi et al. 2000). Red empty circles show the theoretical isochrone bins used for the HRD file.

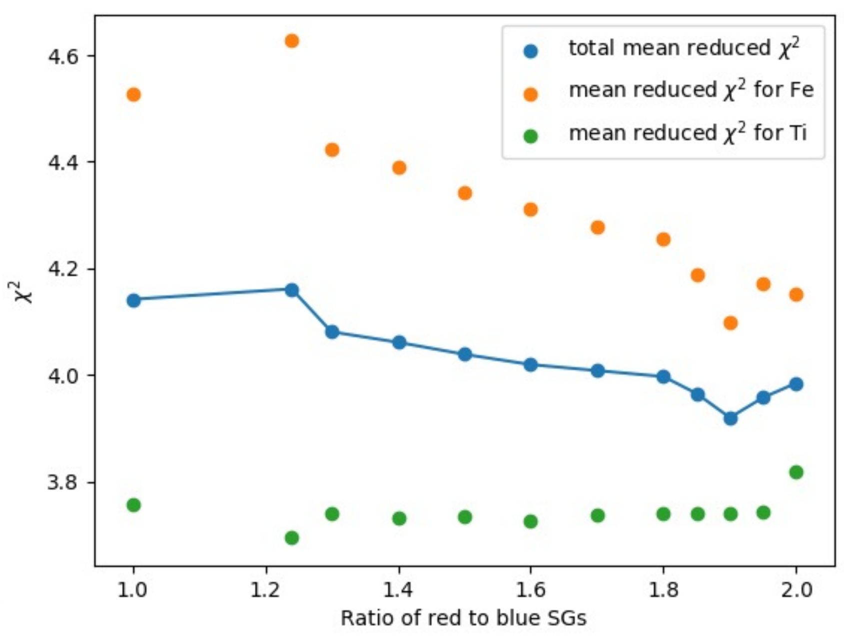

Fig.2: Different ratios of N_{RSG} /N_{BSG} versus the reduced χ^2 values. χ^2 values were summed over all Ti and Fe lines being fitted.

One of the major uncertainties we want to understand is the ratio of red to blue supergiants (N_{RSG} /N_{BSG}). For massive clusters, the isochrone and luminosity function cannot predict the number of SGs. Therefore, using the information directly from the isochrones might lead to inaccurate results.

Most of the light of this spectrum comes from the RSG and BSG given that it is a young population, hence there are no AGB or RGB stars. In our method the ratio of RSG to BSG can be varied; the plot shows how χ^2 varies for different ratios (Fig. 2).

Results

The preliminary results can be seen in Tab.1 and an example of a fit is shown in Fig. 4, this is still part of ongoing analysis.
The Tab.1 lists the values of the abundances derived. Three values of N_{RSG} /N_{BSG} shown:

- 1.24 - the original ratio from the isochrone
- 1.53 - the observed ratio (Larsen et al. 2011)
- 1.90 – suggests the best χ^2 values

A trend visible in Fig.2 is that the higher ratios of RSGs to BSGs are favoured by the analysis so far.

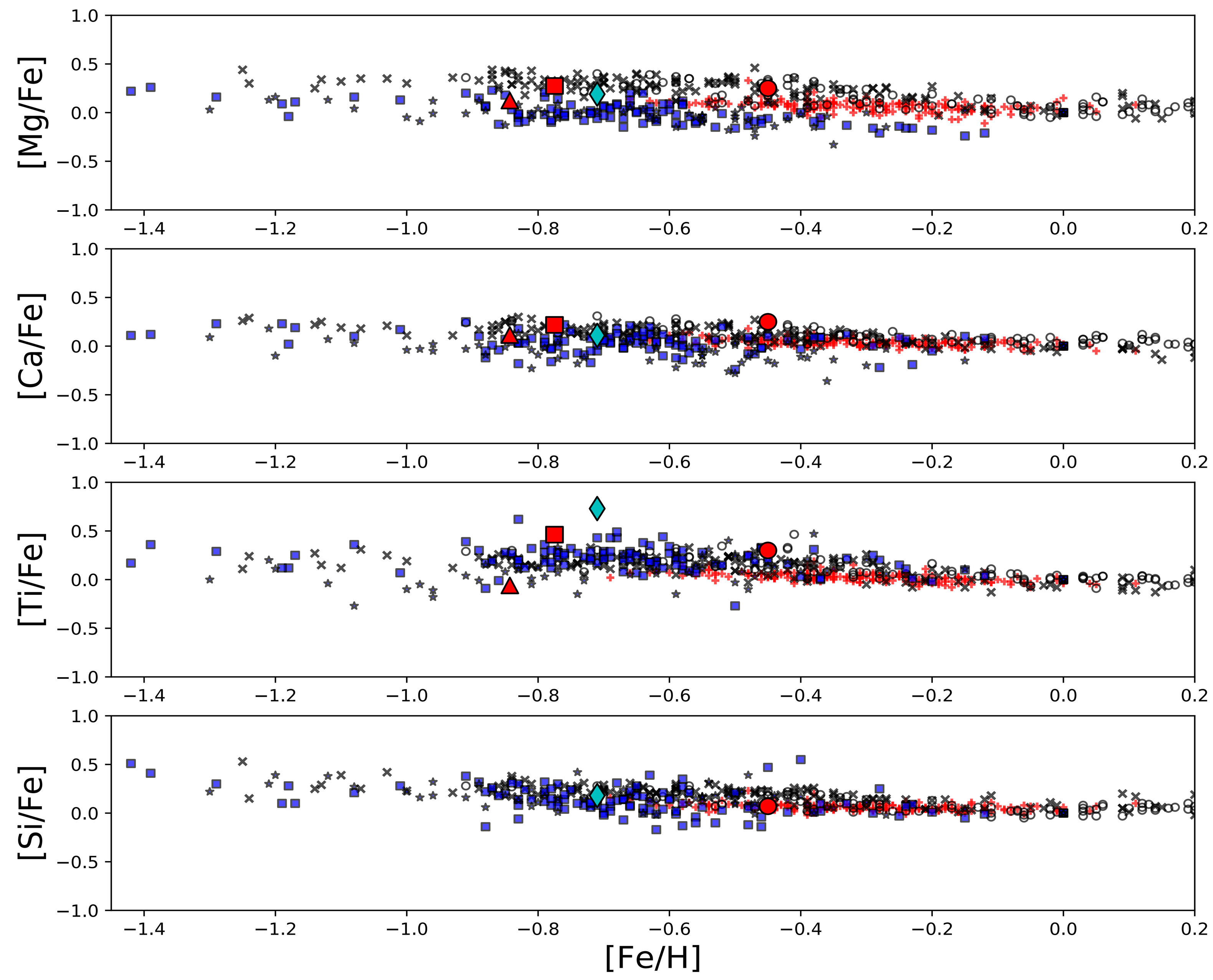

Fig.3: Top: [Mg/Fe] vs. [Fe/H]. Second row: [Ca/Fe] vs. [Fe/H]. Third row: [Ti/Fe] vs. [Fe/H]. Bottom: [Si/Fe] vs. [Fe/H].
- **Turquoise rhombus – this work;**
- **red triangles show the alpha abundances estimated for NGC 1313-379 (Hernandez et al. 2017);**
- **red square display the measurements for NGC 1705-1 (Hernandez et al. 2017);**
- **red circle display the measurements for NGC 6946 (Larsen et al. 2001);**
- **red crosses and black exes present MW disc abundances from (Reddy et al. 2003 and Reddy et al. 2006);**
- **black open circles are MW disc abundances from (Bensby et al. 2005);**
- **blue squares and stars belong to LMC bar and inner disc abundances presented by (Van der Swaelmen et al. 2013).**

Conclusions

It is important to extend the number of studied YMCs; currently the chemical composition of only four extragalactic YMC are studied in detail. NGC1569-B is particularly interesting due to its mass, given that it is impossible to find one in our Local group.

The current results suggest super solar [α/Fe], in particular very high [Ti/Fe], while other α elements seem to correlate with the MW disk. The biggest challenge for analysis of YMC is the numbers of RSGs and BSGs. These stars have the major impact on the spectra of the observed objects, hence must be carefully modelled.

Bibliography

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N_{RSG} /N_{BSG}	[Fe/H]	[Mg/Fe]	[Ca/Fe]	[Ti/Fe]	[Si/Fe]	[Cr/Fe]	[Mn/Fe]	[Sc/Fe]	[Ba/Fe]	[Ni/Fe]
1.24	-0.60 ± 0.06	+0.06 ± 0.10	+0.17 ± 0.17	0.74 ± 0.09	+0.19 ± 0.18	+0.38 ± 0.15	-0.03 ± 0.20	+0.93 ± 0.21	+1.50 ± 0.10	+0.10 ± 0.19
1.53	-0.71 ± 0.07	+0.19 ± 0.08	+0.11 ± 0.18	+0.73 ± 0.09	+0.18 ± 0.21	+0.35 ± 0.15	-0.16 ± 0.15	+0.98 ± 0.23	+1.41 ± 0.11	0.00 ± 0.16
1.90	-0.76 ± 0.07	+0.26± 0.05	+0.02 ± 0.17	+0.67 ± 0.10	+0.32 ± 0.18	+0.30 ± 0.15	-0.22 ± 0.13	+0.94 ± 0.22	+1.34 ± 0.11	-0.08 ± 0.15

Table 1: The chemical element abundances derived for different ratios of N_{RSG} /N_{BSG} .

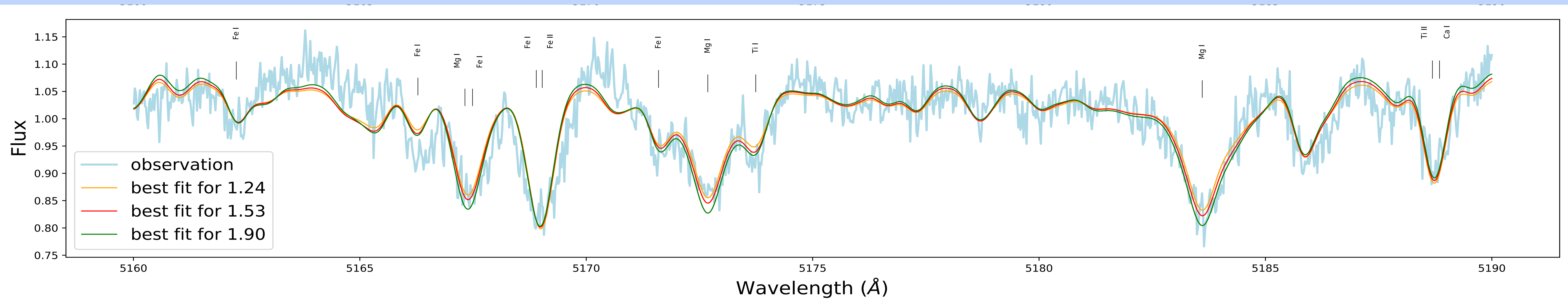

Fig. 4: An example of a fit, the observed spectrum is in blue and the best fit models for 1.24, 1.53, and 1.90 are in orange, red and green, respectively.