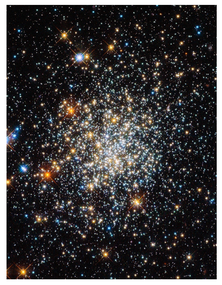
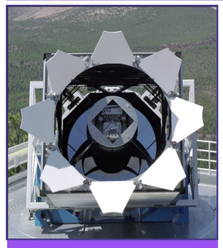


The Open Cluster Chemical Abundances and Mapping (OCCAM) Survey: Optical Extension for Neutron Capture Elements



OCCAM

Open Cluster Chemical Abundance and Mapping

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Abstract: The Open Cluster Chemical Abundance & Mapping (OCCAM) survey is a systematic survey of Galactic open clusters using data primarily from the SDSS-III/APOGEE-1 survey. However, neutron capture elements are very limited in the IR region covered by APOGEE. In an effort to fully study detailed Galactic chemical evolution, we are conducting a high resolution (R~60,000) spectroscopic abundance analysis of neutron capture elements for OCCAM clusters in the optical regime to complement the APOGEE results. As part of this effort, we present Ba II, La II, Ce II and Eu II results for a few open clusters without previous abundance measurements using data obtained at McDonald Observatory with the 2.1m Otto Struve telescope and Sandiford Echelle Spectrograph.

Introduction:

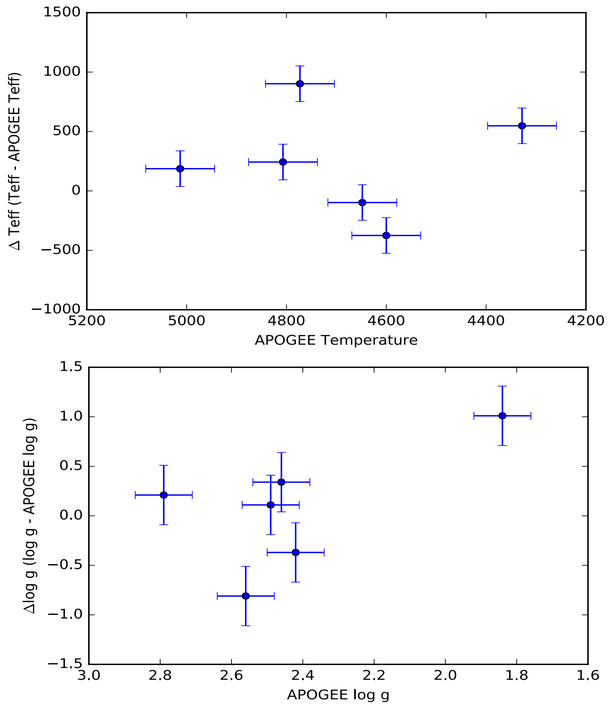
The Open Cluster Chemical Abundance & Mapping (OCCAM, Frinchaboy et al. 2013) survey, has begun a systematic survey of over 100 Galactic open clusters using the Sloan Digital Sky Survey-III/Apache Point Observatory Galactic Evolution Experiment (APOGEE) survey.

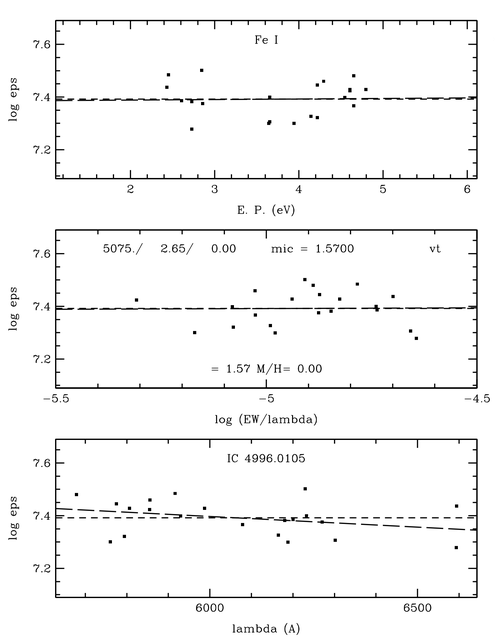
The OCCAM seeks insight into Galactic evolution trends with detailed analysis of light and iron-peak elements determined from the APOGEE infra-red survey. The r- and s- process elements, however, are elusive in the infrared spectra, but critical to our understanding of Galactic evolution. We leverage the APOGEE-based part of the OCCAM survey to provide initial parameters for the abundance analysis of these neutron capture elements for eight stars located in three clusters.

Cluster	[Fe/H]	Error	Number of Stars	[Ba II /Fe]	Error	Number of Stars	[La II/Fe]	Error	Number of Stars
N 103	-0.01	0.11	2	0.29	0.09	2	0.45	0.04	2
N 457	0.07	0.12	3	0.26	0.05	2	0.52	0.07	3
IC 4996	0.01	0.12	3	0.08	0.11	2	0.33	0.09	3

Cluster	[Ce II/Fe]	Error	Number of Stars	[Eu II /Fe]	Error	Number of Stars	r- / s-	Error	Number of Stars
N 103	0.21	0.03	2	0.18	0.02	2	0.19	0.11	8
N 457	0.17	0.04	3	0.27	0.05	3	0.28	0.10	11
IC 4996	0.36	0.02	3	-0.02	0.04	3	0.15	0.15	11

ABOVE: results for the elemental abundances for each cluster. We also show the number of stars that contribute to each calculation.

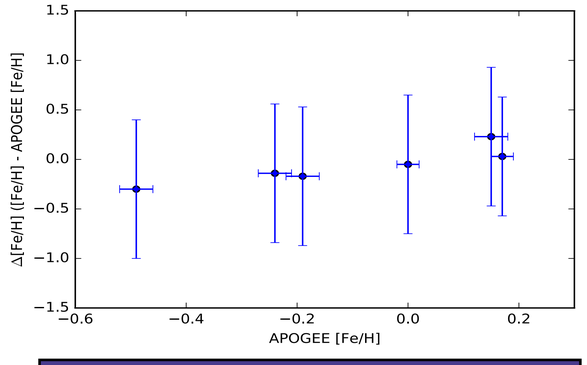




ABOVE: an example of the model atmosphere created in MOOG to constrain our stellar parameters such as effective temperature, log g, and [Fe/H]. This star is IC 4996 0105, the same star in the spectral synthesis graphs to the right.

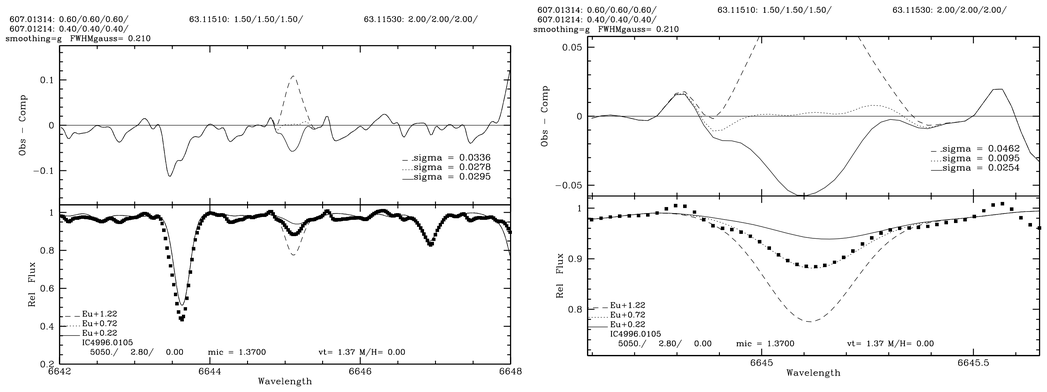
Future Work:

Adding more stars to each cluster, as well as gathering a larger number of clusters to our sample will allow us to be more comfortable in our derived abundances for the clusters. This will also allow us to be more confident in any trends seen in the clusters as both a function of age and, eventually, distance.



Comparisons to APOGEE data:
top left) this figure shows our effective temperatures for each star compared to APOGEE derived effective temperatures; bottom left) this figure shows our calculated log g for each star compared to the APOGEE calculated log g; above) this figure shows our calculated [Fe/H] for each star compared to the [Fe/H] calculated by APOGEE

Note that two of our eight stars (both from cluster IC 4996) do not have APOGEE parameter data, so could not be compared here.

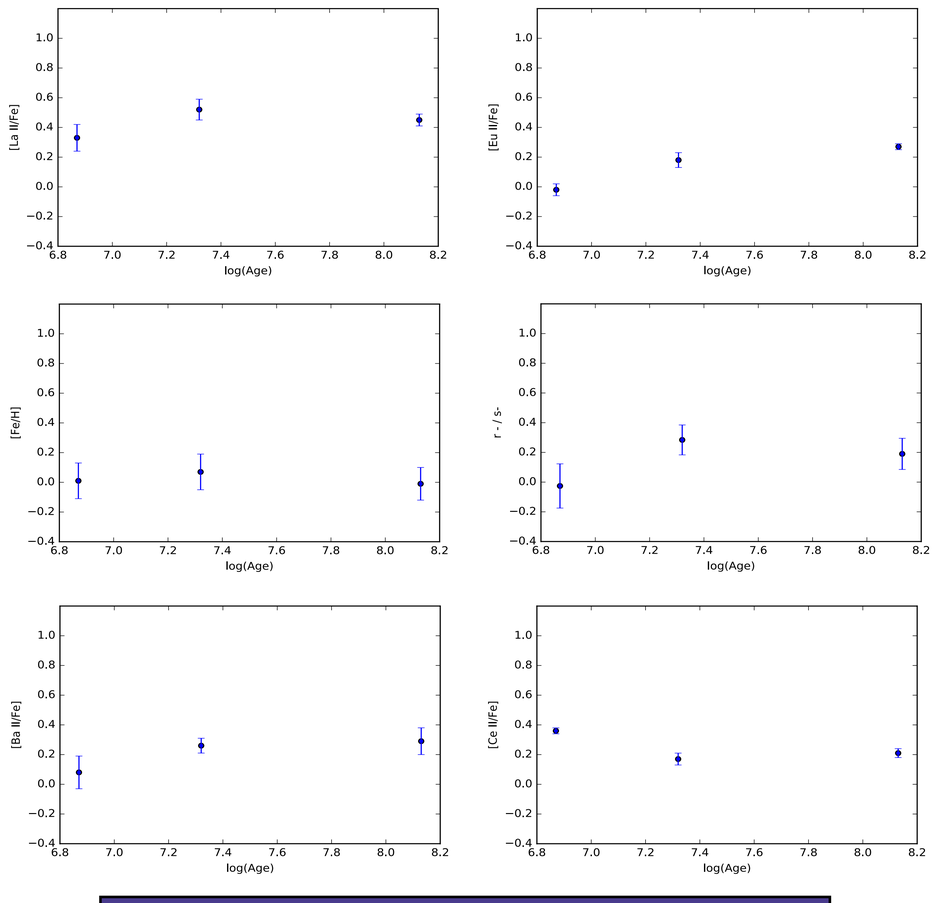


ABOVE: left) sample spectral synthesis from IC 4996 0105, showing the model spectra for the Eu 6645 absorption line; these syntheses are used to derive abundances for the r- and s- process elements in this study. right) a closer view of the europium II 6645 line being modeled.

Analysis:

The abundances for neutron capture elements were determined using two drivers in 2014 version of the line analysis code MOOG (Sneden 1973): *abfind* and *synth*; these were used in conjunction with Kurucz model atmospheres. The *abfind* driver used equivalent width analysis, while the *synth* driver for MOOG relied on spectrum synthesis. APOGEE data provided initial stellar model parameters.
A comparison of our derived stellar parameters to that of the APOGEE data is shown in the two graphs located at the bottom left.

The most widely used line to generate the synthetic spectra of Ce II was λ6043; for Eu II the λ6645 line was used the most; for La II there were many options, and the most used were λ5805, λ6390, and λ6774.



ABOVE: The above figures show each element analyzed in this study, for each cluster, with respect to age.

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