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# Study of red giant stars in Galactic open clusters

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## 1. Introduction

Galactic open clusters are still the only example of single stellar populations: gravitationally bound stars that presents different masses but the same age and chemical composition. Despite multiple stellar populations are found in globular clusters, its existence in open clusters is still widely discussed in the literature. In globular clusters, one of the most common abundance variations found is the anticorrelation between CN and CH, which is the best studied since the molecular bands are easy to be measured using low resolution spectra. However, the sample of open clusters analysed is still small when comparable to that of globular clusters. Therefore, the UFRGS Open Cluster Survey (UOCS) aims to mapp over 500 red giant stars in 30 Galactic open clusters to seach for CN and CH abundance variations.

## 2. Aims

(i) to increase the number of giant stars in open clusters that have been spectroscopically surveyed to date;

(ii) to obtain radial velocities to determine membership for the stars in the survey;

(iii) to analyze their chemical distribution (CN-CH bands), and

(iv) to impose observational constraints on the lower mass needed to start contributing for the formation of multiple stellar populations in clusters.

## 3. Observations and data reduction

Our sample consists of 500 giant stars located in 30 open clusters. Their spectra were acquired with GOODMAN, which is a low resolution spectrograph (R = 2800) mounted at the 4.1m SOAR Telescope.

The observations were carried out on four semesters (2016-2017). The observed wavelength ranges from 350 to 616nm.

Data reduction is being done using the Image Reduction and Analysis Facility (IRAF) software.

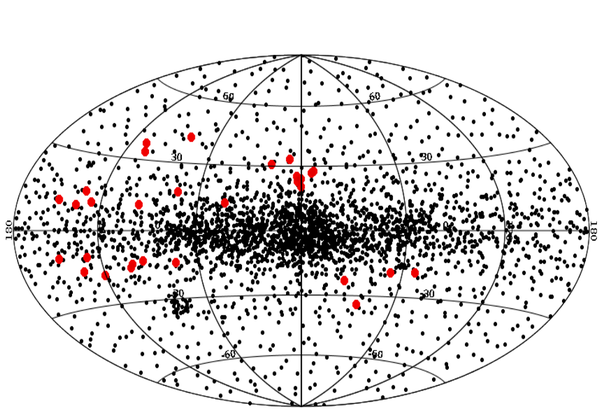

Figure 1: Distribution of UOCS open clusters in the Galaxy.

## 4. Methods

The stellar atmospheric parameters - effective temperature ($T_{eff}$) and surface gravity ($log\ g$) - were obtained by photometric methods. The photometric $T_{eff}$ were calculated using $(V - K_s)$ colour employing the calibrations of Alonso et al. 1999. This calibration was chosen because an error of 0.05 in mag implies mean errors of just 1.0 - 0.7% in temperature. The surface gravity was estimated using the relation

$$log\frac{g_*}{g_\odot} = 4log\frac{T_*}{T_\odot} + 0.4(M_{bol*} - M_{bol\odot}) + log\frac{M_*}{M_\odot}. \quad (1)$$

For the open cluster here presented, NGC2204, we adopted $E(B-V) = 0.13$ and $[Fe/H] = -0.35$.
The heliocentric radial velocities were determined using the IRAF $rvidlines$ task by measuring the position of a large number of absorption lines along each spectrum.

## 5. Preliminary results

For the cluster NGC 2204, the values of effective temperature ($\langle T_{eff} \rangle = 4760K$) and surface gravity ($log\ g \sim 2$) found match those expected for red giant stars, and their radial velocity, despite the low spectral resolution, is within that expected for stars of the disc.

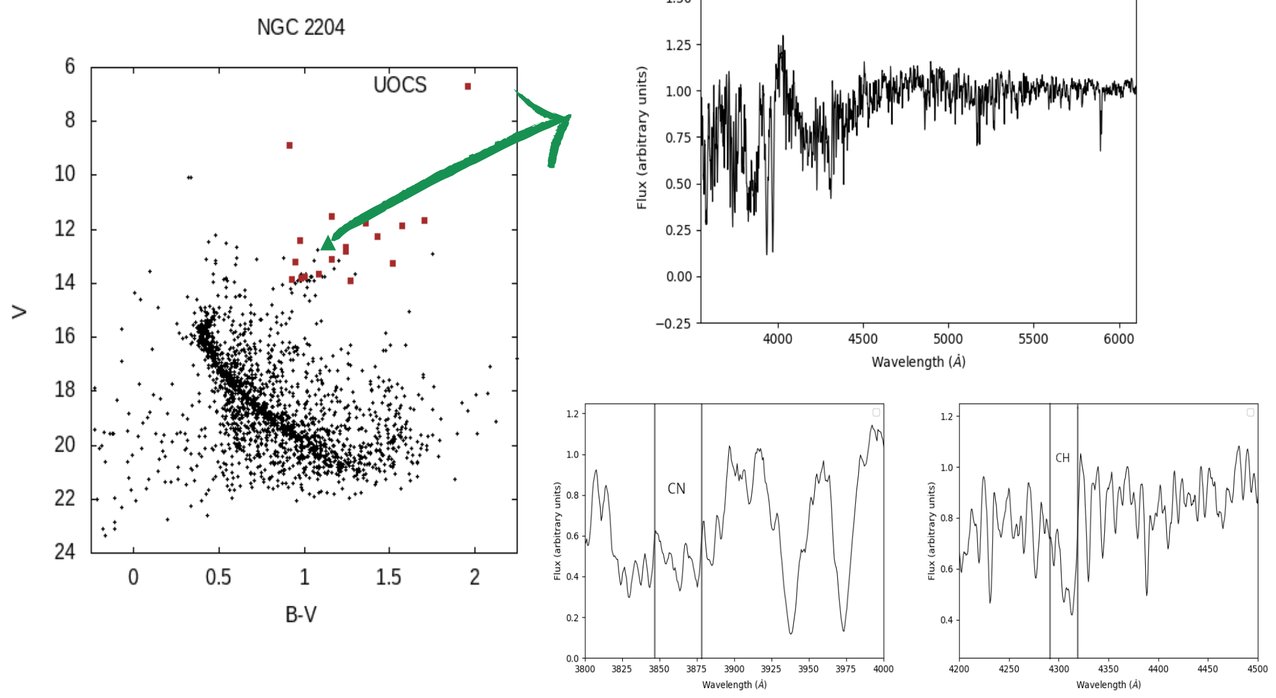


Figure 2: Colour-magnitude diagram of the open cluster NGC 2204 and the spectrum of NGC2204_32 with its CN and CH indices shown.

## 6. Conclusions and perspectives

The results presented in this work are important as a validation mechanism of photometric methods and, in particular, the spectroscopic methods, aiming to determine fundamental stellar parameters of giant stars using low resolution data. The methodology will be applied to other survey stars.

Together with the CN and CH spectral indices that will be measured, the fundamental parameters are essential for characterizing the program stars presented here and answering some of the most fundamental questions about the chemical evolution of stars in star clusters.

## 7. References

[1] Alonso, A. et al., "The effective temperature scale of giant stars (F0–K5)" 1999 A&A, 140, 261.
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[4] Alonso, A. el al., "Erratum: The effective temperature scale of giant stars (F0-K5). II. Empirical calibration of $T_{eff}$ versus colours and [Fe/H]" 2001 A&A, 376, 1039.