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Characterization of the young stellar cluster Collinder 205 with Spartan/SOAR

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Abstract. The evolution of star clusters can be better understood based on the study of dynamic conditions of the gas associated with the parental molecular cloud, the clustering properties and by the evaluation of the effects due to the presence of ionization sources. In order to compare the characteristics of the cluster members with the conditions of the molecular gas in the cloud where the young stars are associated, our group conducted near-infrared imaging towards the Galactic young cluster Collinder 205, using the SOAR telescope and the Spartan camera. We aim to extract the sources detected in such images and correlate them with complementary data from public catalogs (optical and infrared), such as *Gaia* DR3, 2MASS and AllWISE, following the example of previous studies perfomed by our group in the CMa region and extended to clusters in different regions of the Galaxy.

Resumo. A evolução dos aglomerados estelares pode ser melhor compreendida com base no estudo das condições dinâmicas do gás associado à nuvem molecular parental, das propriedades de *clustering* e pela avaliação dos efeitos causados pela presença de fontes de ionização. Com o objetivo de comparar as características dos membros do aglomerado com as condições do gás molecular na nuvem onde as estrelas jovens estão associadas, nosso grupo realizou imagens no infravermelho próximo em direção ao aglomerado Galáctico jovem Collinder 205, utilizando o telescópio SOAR e a câmera Spartan. Nosso objetivo é extrair as fontes detectadas nessas imagens e correlacioná-las com dados complementares de catálogos públicos (óptico e infravermelho), como *Gaia* DR3, 2MASS e AllWISE, seguindo o exemplo de estudos anteriores realizados por nosso grupo na região de CMa e estendidos para aglomerados em diferentes regiões da Galáxia.

Keywords. Stars: formation – Stars: evolution – Stars: pre-main sequence

1. Introduction

In this work we make use of the $5' \times 5'$ observed field from SOAR/Spartan of the open cluster Collinder 205, in the filters H2, Cont.3 and Brγ. Our objectives are to review the literature for recent results on the cluster, determine the PSF (point spread function) and extract the photometric data in the Spartan images (using the StarFinder software), perform astrometric calibration to determine the equatorial coordinates of the stars and finally cross-match the data with public data bases aiming to construct a photometric catalog of the members containing data from other IR bands.

In Sect. 2 we present the recent results found for the Collider 205 cluster. In Sect. 3 and 4 we describe the methodology developed for extracting the cluster data and the cross-match between different catalogs.

2. Literature Review

Firstly, we revised recent studies on Collinder 205, in order to compare the cluster parameters determined in different works. Table 1 gives the number of members, age, distance and color excess, while Table 2 presents the equatorial coordinates (J2000), proper motion, cluster radius (R) and core radius (r_c).

3. Identifying Stars in the Observed Fields

In order to identify the stars in the observed field, we performed a PSF photometry using the software StarFinder for each SOAR/Spartan image (H2, Cont.3 and Brγ). Later, we combined the use of the software Aladin to perform an astrometrical calibration through the 2MASS (Skrutskie et al. 2006) image (See Fig. 1). By deriving the physical positions of these stars through this method, we achieved their transformation into astronomical coordinates (RA, DEC) utilizing the XYAD task in IDL.

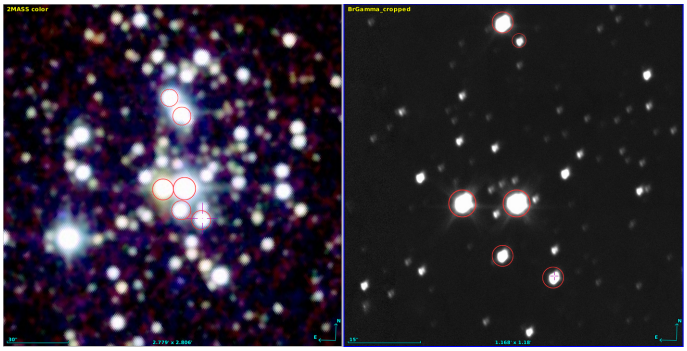

Figure 1. The position of the cluster stars on the 2MASS image (left panel, $2.8' \times 2.8'$) compared with their distribution on the Spartan image (right panel, $1.2' \times 1.2'$). The red circles represent the same stars in both fields.

4. Cross-match with Infrared Catalogs

Positions retrieved from StarFinder were used to perform a cross-match with the infrared catalogs 2MASS (Skrutskie et al. 2006) and AllWISE (Cutri et al. 2012), using the TopCat software. Then, we created new datasets for the counterparts found for the Spartan filters in each catalog. The number of sources

Table 1. Number of members, age, distance and color excess obtained from the literature for Collinder 205.

References	N	log (Age) yrs	d pc	E(B-V) mag
Gregorio-Hetem & Hetem (2024)	108	7.62	1862 ± 70	0.89
Dias et al. (2021)	99	6.95 ± 0.22	1400 ± 224	$(0.81 \pm 0.02)^a$
Cantat-Gaudin & Anders (2020)	81	6.66	2394	0.74^a
Hetem & Gregorio-Hetem (2019)	143	5.70 ± 2.10	2044 ± 209	0.62
Cantat-Gaudin et al. (2018), LP19	102	$(6.90 \pm 0.03)^b$	1953^{+475}_{-319}	...
Kharchenko et al. (2013)	131	7.03	1458	0.87
Santos-Silva & Gregorio-Hetem (2012)	174	$6.70^{+0.43}_{-0.39}$	...	0.56 ± 0.07

Notes. [(a)] Values converted from their visual extinction presented in the literature. [(b)] Results from Cantat-Gaudin et al. (2018) are presented along with log(Age) adopted from Liu & Pang (2019, LP19).

Table 2. Coordinates, astrometric parameters, size and core radius of Collinder 205.

References	α (J2000) deg	δ (J2000) deg	$\mu_\alpha \cos\delta$ mas yr^{-1}	μ_δ mas yr^{-1}	R pc	r_c pc
Gregorio-Hetem & Hetem (2024)	135.116	−48.988	−4.71 ± 0.22	3.98 ± 0.17	3.26 ± 0.15	0.90 ± 0.08
Dias et al. (2021)	135.091	−48.985	−4.67 ± 0.40	3.93 ± 0.27	...	...
Cantat-Gaudin & Anders (2020)	135.119	−48.984	−4.80	3.92	...	...
Liu & Pang (2019)	135.087	−48.969	−4.92 ± 0.26	3.92 ± 0.26	...	...
Hetem & Gregorio-Hetem (2019)	135.123	−48.983	−4.81 ± 0.47	3.94 ± 0.47	3.51 ± 0.19	0.95
Kharchenko et al. (2013)	135.135	−48.990	−3.52	6.88	3.56^a	0.34
Santos-Silva & Gregorio-Hetem (2012)	135.129	−48.983	...	...	3.4 ± 1.2	0.30 ± 0.03

Note. [(a)] Radius converted from the angular size presented in the literature.

detected for each filter are presented in Table 3 and their distribution can be seen in Fig. 2.

Table 3. Number of sources detected with Spartan and respective 2MASS and AllWISE counterparts.

Filter	Spartan	2MASS	AllWISE
H2	562	395	139
Cont.3	520	391	139
Brγ	425	351	138

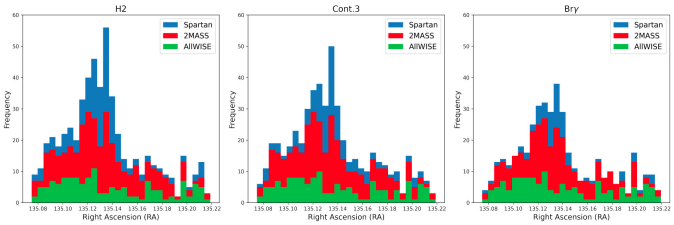

Figure 2. Histograms comparing the frequency of detected sources versus right ascension.

5. Conclusions & Future Work

The literature review was an important step to better understand the techniques currently being used for the characterization of open clusters, and also to group the recent results from the literature regarding the Collinder 205. The methodology used was effective in identifying the infrared counterparts in the Spartan images. The cross-match with infrared catalogs provided us with a final list of sources detected by Spartan and their corresponding counterparts in the 2MASS and ALLWISE catalogs, allowing an expansion of the infrared source list in the study. For next stages of the project we plan to use the 2MASS and Spartan data to perform a photometric transformation from the H_2 band (2.12 μm) to the K_s band (2.159 μm), in order to expand the 2MASS catalog with relative magnitude values in the K_s band for sources that were not previously detected in this catalog. Later, we will begin the cross-match with the Gaia-DR3 catalog (Gaia Collaboration et al. 2023), which will provide astrometric and photometric parameters to complement the study about the dynamical evolution of the cluster.

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