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Characterization of the young star cluster CMa05

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Abstract. This study provides an in-depth analysis of the young stellar cluster CMa05, part of the Canis Major OB1/R1 association, focusing on the identification of internal substructures. Using astrometric, kinematic, and photometric data from public catalogs such as Gaia, 2MASS, and AllWISE, the study analyzed proper motion distributions, parallax, and color-magnitude diagrams. Results confirmed the spatial separation of subgroups CMa05a and CMa05b, both with an average age of 10 million years, and identified 10 objects with circumstellar disks. These findings offer new insights into the study of star formation processes and stellar disk evolution, advancing the understanding of the structural complexity of this region.

Resumo. Este trabalho apresenta um estudo detalhado do aglomerado estelar jovem CMa05, pertencente à associação Canis Major OB1/R1, com foco na identificação de subestruturas internas. Utilizando dados astrométricos, cinemáticos e fotométricos de catálogos públicos como Gaia, 2MASS e AllWISE, foram analisadas distribuições de movimento próprio, paralaxe e diagramas cor-magnitude. Os resultados confirmaram a separação espacial entre os subgrupos CMa05a e CMa05b, ambos com idade média de 10 milhões de anos, além da identificação de 10 objetos com discos circunstelares. Esses resultados contribuem para o estudo dos processos de formação estelar e evolução de discos estelares, ampliando o entendimento sobre a complexidade estrutural desta região.

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

1. Introduction

The Canis Major OB1/R1 (CMa) association is particularly notable for the study of the evolution of stellar cluster structures, as it presents a scenario of star formation influenced by supernovae (Fernandes et al. 2019). Several young clusters are associated with CMa, exhibiting characteristics that may have been shaped by different episodes of star formation.

A recent study by Lima (2022) identified that the young stellar cluster CMa05, belonging to the CMa OB1/R1 association, may actually contain two smaller substructures with spatial distinction, called CMa05a and CMa05b.

This work presents the progress of a Scientific Initiation project aimed at identifying and characterizing cluster members through astrometric, kinematic, and photometric analyses, as well as comparing the results with previous studies to assess the cluster's structure.

2. Identification of Substructures

The study aimed to validate the existence of substructures in the cluster, previously identified by Lima (2022). Public catalog data covering different ranges of the electromagnetic spectrum were used, refining the sample with astrometric and kinematic criteria.

The initial search was conducted in catalogs such as GAIA, 2MASS, and AllWISE, which cover different portions of the electromagnetic spectrum. Using the Gaia catalog data, a characterization of the sample was made, employing diagnostic plots based on the distributions of proper motion, position, and parallax (ϖ). The validation of the cluster membership was also carried out with criteria based on the parallax uncertainty fraction $f = \sigma_\varpi/\varpi$ (See Tab. 1).

Two subgroups with spatial separation were identified in the CMa05 cluster region. These subgroups, CMa05a and CMa05b, showed similar proper motion but have a significant angulas separation (See Fig. 1), exhibiting variations of 1.04 degrees in right ascension and 0.31 degrees in declination.

Table 1. Criteria for selecting cluster member and candidate objects.

Position	Proper Motion	Quality	Status
$\leq 3\sigma$	$\leq 2\sigma$	$f < 0.1$	**Member**
$\leq 3\sigma$	$\leq 2\sigma$	$0.1 < f < 0.33$	**Candidate**
$> 3\sigma$	$\leq 1\sigma$	$f < 0.1$	**Candidate**
$\leq 1\sigma$	$> 2\sigma$	$f < 0.1$	**Candidate**

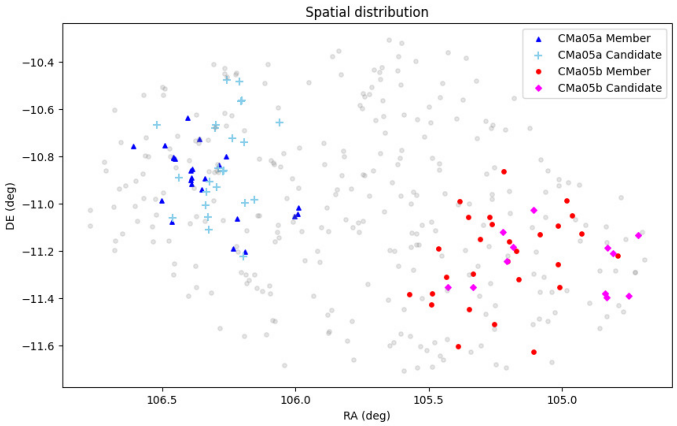

Figure 1. Subclusters identified in the CMa05 region. Gray objects represent field stars in the area.

3. Characterization of Members and Structure

The characterization of members and member candidates for each subgroup was performed through Gaussian fits to the distri-

Table 2. The results from this work compared with the literature.

Reference	Group	N (stars)	RA(J2000) (deg)	Dec(J2000) (deg)	pmRA (mas/yr)	pmDE (mas/yr)	Parallax (mas)
Current Work	CMa05a	48	106.31 ± 0.14	-10.87 ± 0.18	-3.07 ± 0.15	0.64 ± 0.16	0.82 ± 0.05
Current Work	CMa05b	40	105.16 ± 0.23	-11.24 ± 0.17	-3.00 ± 0.15	0.76 ± 0.14	0.81 ± 0.05
Lima (2022)	CMa05a	39	106.30 ± 0.14	-10.90 ± 0.12	-3.06 ± 0.17	0.65 ± 0.16	0.82 ± 0.06
Lima (2022)	CMa05b	36	105.19 ± 0.16	-11.20 ± 0.15	-2.97 ± 0.15	0.76 ± 0.14	0.82 ± 0.07
Santos-Silva et al. (2021)	CMa05	31	$105.32^{+0.29}_{-0.14}$	$-11.20^{+0.15}_{-0.21}$	$-2.98^{+0.11}_{-0.15}$	$0.79^{+0.08}_{-0.14}$	$0.78^{+0.10}_{-0.05}$

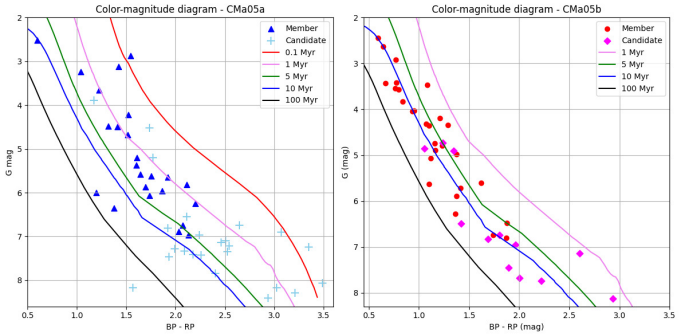

Figure 2. Color-magnitude diagrams showing the distribution of objects compared to isochrone models for CMa05a and CMa05b.

butions of astrometric and kinematic parameters. The results are presented in Tab. 2. Although the parallaxes are similar, more accurate estimates for objects at distances greater than 1 kpc, as indicated by (Luri et al. 2018), suggest a slight difference in the average distances: ≈ 1185 pc (CMa05a) and ≈ 1228 pc (CMa05b), with uncertainties of about 80 pc for both measurements.

Photometric data from the Gaia catalog were used to construct color-magnitude diagrams, analyzed with PARSEC isochrones (Bressan et al. 2012), to estimate the age of the cluster. The results indicate an approximate age of 10 million years for the stellar population of both subclusters, suggesting that the stars in CMa05a tend to be younger than those in CMa05b (see Fig. 2).

Additionally, infrared data from the 2MASS and AllWISE catalogs were used to identify objects with excess of infrared emission, indicative of circumstellar disks, following the method used by Koenig & Leisawitz (2014). Using this data, it was possible to identify 9 Class II objects, which present circumstellar disks, via a color-color diagram (see Fig. 3), 7 of them are members or candidates of CMa05a, and 2 are found in CMa05b.

4. Conclusions

The results were compared (See Tab. 2) with previous studies, such as those by Lima (2022) and Santos-Silva et al. (2021, where the cluster was considered a single structure), showing good agreement in astrometric and kinematic parameters while also highlighting the new findings regarding the cluster's internal substructure. The confirmation of previously unrecognized substructures underscores the importance of detailed and refined methodological approaches in understanding the complexity of star formation processes.

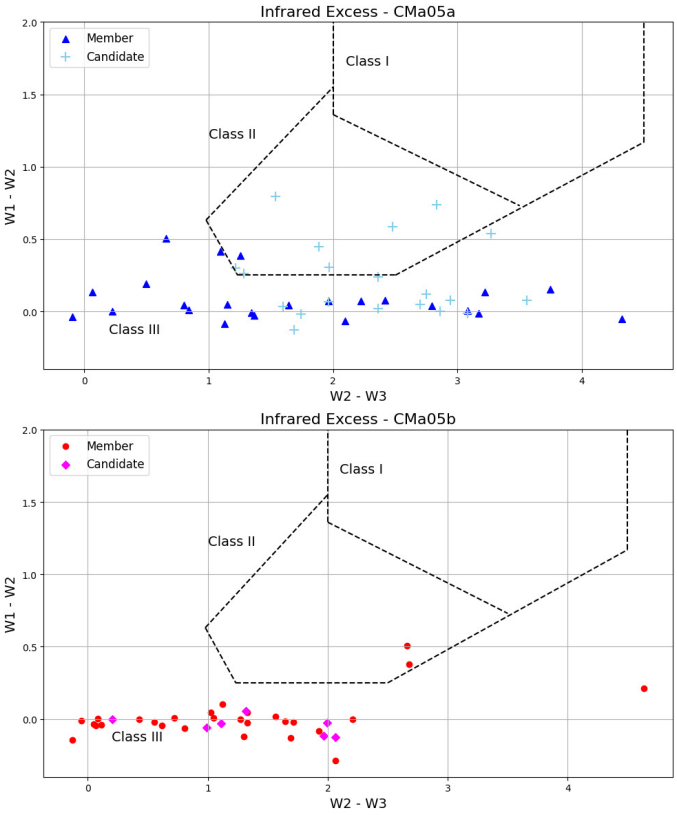

Figure 3. Color-color diagram of WISE displaying the expected regions for Class I and Class II sources, as proposed by Koenig & Leisawitz (2014).

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