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Characterization of the open cluster NGC 2645

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Abstract. Hetem & Gregorio-Hetem (2019) suggested the presence of possible substructures in NGC 2645, which were previously considered a single entity. This study investigates the evolution of the young star cluster, focusing on its structure, star distribution, and filamentary substructures. The near-infrared images were obtained with the Spartan camera on the SOAR telescope, using the H_2, $Br\gamma$, and *Cont*3 filters. These images allowed for the acquisition of coordinates for the stars and the extraction of Point Spread Function photometry. Additionally, the images provided insights into the environment of NGC 2645 and suggested the possible presence of dense molecular knots, which may be associated with H_2 emission. A comparison between the Spartan data and the 2MASS catalog was also conducted, of the Spartan H_2 filter to the 2MASS K_s band, enabling a conversion of magnitudes between the two datasets. This study contributes to the understanding of the structure and dynamics of NGC 2645, exploring the relationship between the stars and the molecular environment.

Resumo. Hetem & Gregorio-Hetem (2019) sugeriram a presença de possíveis subestruturas em NGC 2645, que anteriormente eram consideradas uma única entidade. Este estudo investiga a evolução do aglomerado estelar jovem, com foco na sua estrutura, distribuição de estrelas e subestruturas filamentares. As imagens no infravermelho próximo foram obtidas com a câmera Spartan no telescópio SOAR, utilizando os filtros H_2, $Br\gamma$ e *Cont*3. Essas imagens permitiram coordenadas das estrelas e realizar fotometria PSF para determinar as magnitudes das estrelas nos filtros H_2, $Br\gamma$ e *Cont*3. Além disso, as imagens forneceram informações sobre o ambiente de NGC 2645 visando investigar a possibilidade de presença de condensações moleculares, que podem estar associados a emissões de H_2. Foi realizada também uma comparação entre os dados do Spartan e os do catálogo 2MASS, dada a proximidade entre o filtro H_2 da Spartan e o filtro K_s dO 2MASS, permitindo uma conversão das magnitudes entre os dois conjuntos de dados. Este estudo contribui para a compreensão da estrutura e dinâmica de NGC 2645, explorando a relação entre as estrelas e o meio ambiente molecular.

Keywords. Stars: formation – Infrared: stars – Open clusters and associations: individual

1. Introduction

Young star clusters provide critical insights into the processes of star formation and early stellar evolution, serving as laboratories to study the interactions between stars and their molecular environments. Among these clusters, NGC 2645 has emerged as an intriguing target due to its potential structural complexity. Hetem & Gregorio-Hetem (2019) proposed that the cluster, previously regarded as a single entity, might host filamentary substructures. These substructures could be linked to ongoing star formation, offering an opportunity to study both the cluster's evolutionary state and its interaction with surrounding material.

In this study, we investigate the structure of NGC 2645 using near-infrared imaging from the Spartan camera on the SOAR telescope and Gaia astrometric data. This combination of datasets allows us to explore the cluster's environment, identify potential substructures, and analyze the spatial distribution of stars. Additionally, a comparison with the 2MASS catalog helped calibrate photometric measurements.

2. Identification of substructures

The identification of multiple stellar groups within NGC 2645 was carried out to investigate the cluster's members and potential substructures. Using histograms, revised parameters for the subgroups were defined, allowing for a clearer understanding of their distribution.

Cluster membership was assessed through an analysis of the surface spatial distribution of stars shown in Figure 1 and their proper motions shown in Figure 2. This approach provided a detailed view of the astrometric and kinematic properties of the stars, enabling the separation of distinct subgroups within the cluster. Table 1 summarizes the mean values of the parameters identified for each subgroup, offering a quantitative characterization of their properties.

Table 1. Parameters of NGC 2645 subgroups.

Subgroup	N (stars)	RA (J2000)	Dec (J2000)	pmRA	pmDec
1	114	129.84 ± 0.08	−46.25 ± 0.06	−5.86 ± 0.07	5.13 ± 0.06
2	38	130.19 ± 0.08	−46.60 ± 0.09	−5.74 ± 0.06	5.03 ± 0.06
3	25	130.41 ± 0.06	−46.27 ± 0.03	−5.64 ± 0.05	4.96 ± 0.05

3. Photometry

3.1. Spartan Images

The images obtained from the SOAR telescope in the infrared, as shown in Figure 3, are crucial for several aspects of our study of NGC 2645. These images allow us to gather precise positional data for the stars, which can then be correlated with other astronomical catalogs to enhance our understanding of the region. Additionally, these images are essential for performing Point Spread Function (PSF) photometry, a method that enables the determination of the magnitudes of stars in the H_2, Brγ, and *Cont*3 filters.

PSF photometry models the distribution of light from a point source, such as a star, as it appears on an image. By fitting the PSF to observed stellar images, we can accurately mea-

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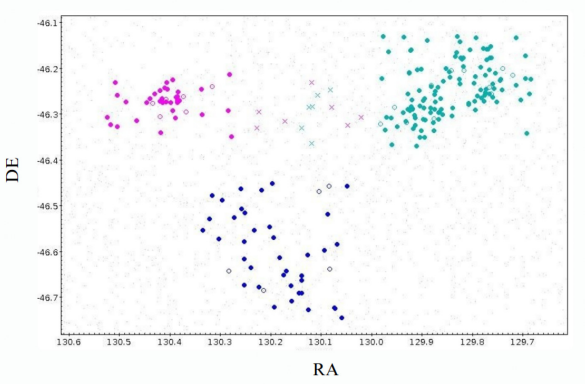

Figure 1. Surface spatial distribution diagram showing member and candidate stars within the cluster. Subgroup 1 members are shown in cyan, Subgroup 2 in blue, and Subgroup 3 in magenta. Filled circles represent confirmed members, open circles indicate candidate members, and 'x' markers show possible candidates.

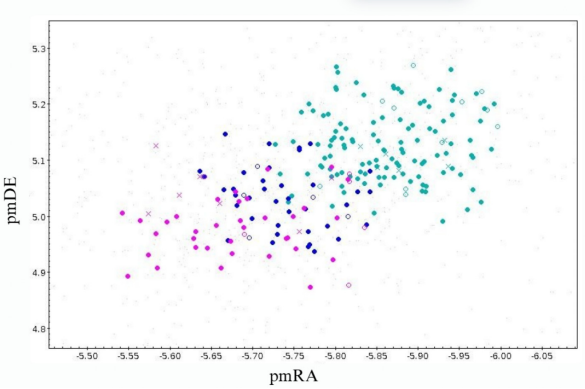

Figure 2. Proper motion diagram of stars in NGC 2645. Subgroup 1 members are shown in cyan, Subgroup 2 in blue, and Subgroup 3 in magenta. Filled circles represent confirmed members, open circles indicate candidate members, and 'x' markers show possible candidates.

sure the flux from individual stars and convert it into magnitudes, improving photometry, especially in crowded regions. Additionally, these infrared images reveal areas of dense molecular knots and H_2 emission. This information is crucial for understanding the physical conditions of molecular gas and dust, as well as their role in star formation within the cluster.

3.2. 2MASS Comparison

Given the proximity of the Ks band (2.159 μm) from the 2MASS catalog (Skrutskie et al. 2006) and the H_2 filter band (2.116 μm) from the Spartan observations, a correlation was performed between the data from both sources. The linear regression, shown in Figure 4, resulted in the following equation:

$$Ks = 0.99 \cdot H_2 + 0.05$$

This equation provides a conversion between magnitudes in the H_2 and Ks bands, enabling a direct comparison of stellar magnitudes from different filters. It ensures consistency between the SOAR infrared data and the 2MASS catalog, facilitating a more comprehensive study of NGC 2645's stellar population and the effects of extinction and other interstellar medium properties.

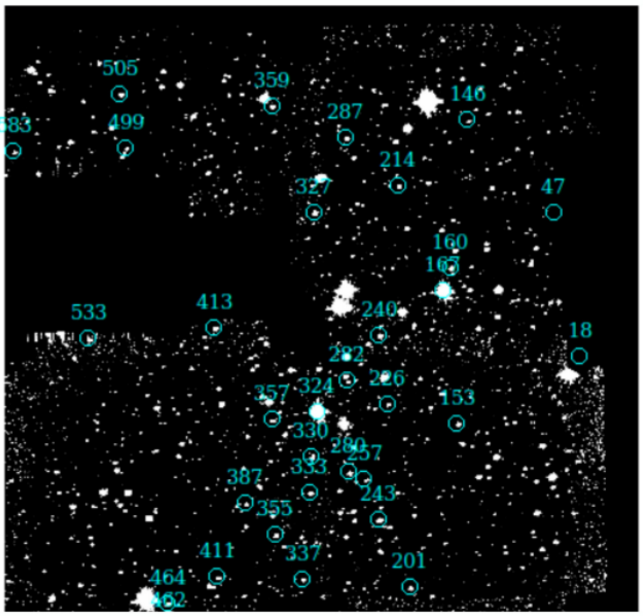

Figure 3. Normalized image of the H_2 filter; Spartan field of 5' × 5'. The cluster member stars are highlighted in cyan.

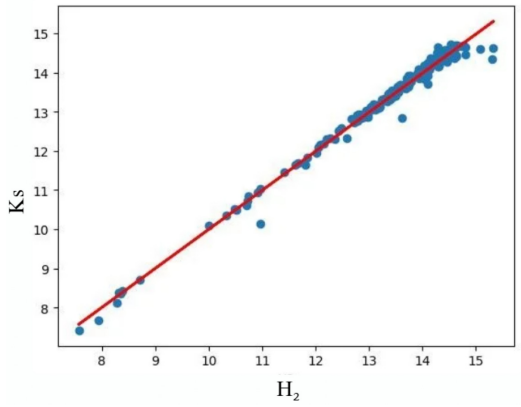

Figure 4. Linear regression of the K_s vs. H_2, illustrating their correlation.

4. Conclusions

The analysis of NGC 2645 reveals its complex structure with distinct subgroups. H_2 emission searches are key to identifying active star formation regions and understanding stellar interactions with molecular gas. The comparison of Spartan data with catalogs such as 2MASS has improved photometric calibration, enhancing the study of the cluster's stellar population, interstellar medium, and evolutionary processes.

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