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Characterization of the young star cluster associated with FZ CMa

J. V. Corrêa-Rodrigues[1] & J. Gregorio-Hetem[1]

[1] Instituto de Astronomia, Geofísica e Ciências Atmosféricas da Universidade de São Paulo - IAG/USP
e-mail: joaov.crodrigues@usp.br, gregorio-hetem@usp.br

Abstract. The Canis Major Association OB1/R1 (CMa) is a peculiar star formation scenario that is interesting to study the effects of supernovae (SN) and whose star formation history has not been fully understood. We have studied optical spectra of more than one hundred stars in the region associated with the star FZ CMa, acquired with the Gemini telescope in the multi-object mode. This population is probably mixed, lying between a younger group (<5 Myr) associated with the star Z CMa, and an older one (> 10 Myr), associated with GU CMa. Our goal is to improve the *census* of the young low-mass stars in the region, and, in order to do that, we attempted to identify typical spectral features of this evolutionary phase, such as the absorption Li I line and the Hα emission line. We found 27 stars with the Li I line in absorption and 5 stars with only Hα emission. These numbers are smaller, but comparable with the ones previously reported in the literature for the region associated with Z CMa, despite FZ CMa being more distant from the highest concentration of gas.

Resumo. A Associação Canis Major OB1/R1 é um cenário de formação estelar peculiar, interessante para se estudar o efeito de supernovas e cuja história de formação estelar ainda não está completamente esclarecida. Estudamos espectros ópticos de mais de uma centena de estrelas na região associada à estrela FZ CMa, obtidos com o telescópio Gemini no modo multi-objeto. Esta população é provavelmente mista, estando localizada entre um grupo mais jovem (<5 *Myr*) associado à estrela Z CMa e outro mais velho (> 10 *Myr*) associado à estrela GU CMa. Nosso objetivo é melhorar o levantamento das estrelas jovens de baixa massa da região e para isso buscamos identificar características espectrais típicas desta fase evolutiva, como a linha de absorção do Li I (λ 6708 Å) e a linha de emissão Hα. Encontramos 27 estrelas que apresentam a absorção na linha do Li I e 5 que apresentam apenas a emissão em Hα. Estes números são menores, mas comparáveis aos previamente reportados na literatura para a região associada a Z CMa, apesar de FZ CMa estar mais afastada da maior concentração de gás.

Keywords. Stars: formation – Stars: pre-main sequence – Stars: variables: T Tauri, Herbig Ae/Be

1. Introduction

Investigating star-forming regions is crucial since it provides important clues to Galactic structure and evolution. In this context, the Canis Major Association OB1/R1 is a large ($\sim$ 100 deg^2 — Gregorio-Hetem et al. 2021) conglomerate of molecular clouds, emission, and reflection nebulae. It is located at a distance of d = 1185 ± 25 pc (Pettersson & Reipurth 2019) and is associated with ~200 B type stars and only a few late-type O stars (Shevchenko et al. 1999; Fernandes et al. 2019).

The CMa star-forming region is outlandish and remarkable. Several proposals try to explain its star formation history (e.g. Herbst & Assousa 1977; Reynolds & Ogden 1978) and, more recently, Fernandes et al. (2019) found that three runaway stars have likely been ejected by sucessive events of SN that occurred ~6, ~2 and ~1 Myr ago. Such events affected the environment and evolution processes of young stellar objects in the association, which makes CMa the perfect site to study the interplay between SN and star-forming regions. These authors also showed evidence that this region is in fact part of a structure that could be approximated by an elliptical shell (with a diameter of $\sim$ 60 pc — Fig. 1).

The *census* of the young low-mass stars in the region is still incomplete; however, it is crucial to investigate the possibility of triggering and/or inhibiting star formation by SN or even the early destruction of circumstellar disks. Therefore, our main goal with this ongoing work is to improve this *census*, especially in the region associated with FZ CMa, also known as the "inter-cluster region". Probably, this stellar population is mixed, lying between two clusters in different age ranges: one group associated with the star Z CMa (<5 Myr) and the other associated with the star GU CMa (>10 Myr). The paper is organized as follows: In Sec. 2 we describe the methodology adopted to analyze the stellar spectra; the results are outlined in Sec. 3, and conclusions are summarized in Sec. 4.

2. Methodology

To characterize the stellar population associated with FZ CMa, we analyzed optical spectra with a resolution of $\sim$ 2200. We focused on searching for typical features of this evolutionary phase, such as the Li I absorption line (λ 6708 Å), as an indicator of their youth, and the Hα emission line (which are used to distinguish disk-bearing stars from stars that do not have an active accretion disk). The spectra were acquired with the Gemini South telescope in the multi-object mode (Gemini Multi-Object Spectrograph - GMOS) in 2017 and we obtained data for over a hundred stars distributed in four different fields of 5.5'×5.5' (Fig. 2). Approximately 20% of them are counterparts of X-ray sources. Figure 3 shows a Gemini R-band image of the field ICR-C4 in detail compared with X-ray contours.

3. Results

After careful data reduction of all the spectra, the preliminary results indicate the presence of 27 stars with the lithium absorption line λ 6708 Å (T Tauri stars candidates — spectra in Figure 4, for instance) and 5 stars without Li I line, but showing Hα emission line. These stars could also be young, since the Hα is expected in young intermediate-mass stars, for example. As a consequence, we need to thoroughly investigate these stars.

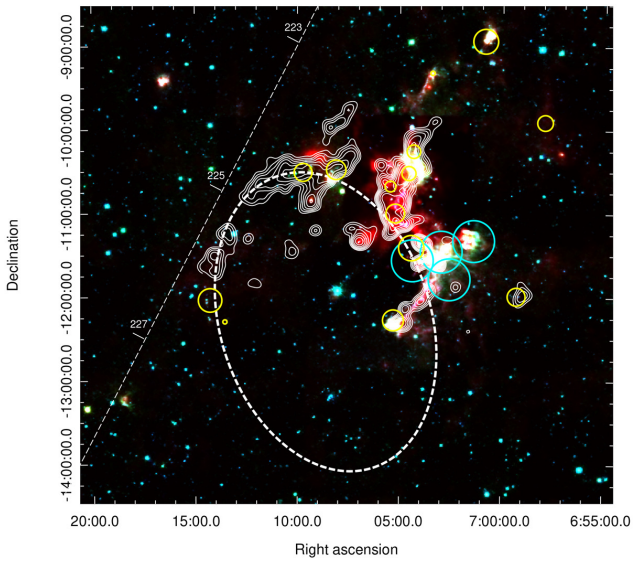

Figure 1. WISE (Wide-field Infrared Survey Explorer) composite color image of the CMa OB1 region. Groups of Young Stellar Objects (YSOs), identified by Fischer et al. (2016) are indicated by small yellow circles. Cyan circles point out observations using XMM-Newton (X-ray Multi-Mirror Newton Satellite — Fields observed by Santos-Silva et al. 2018). The white contours trace ^{13}CO emissions. The coordinates on the galactic plane at $b = 0$ are shown by the dashed line, and the white dashed ellipse represents the CMa shell. Extracted from Fernandes et al. (2019)

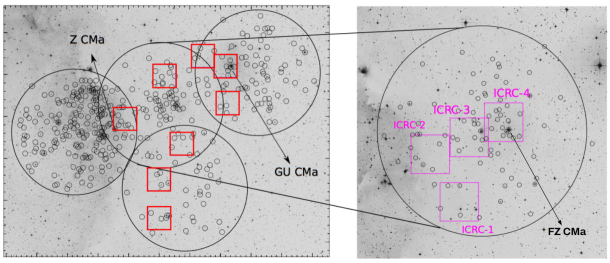

Figure 2. Optical (DSS - Digital Sky Survey) image overimposed by the GMOS fields observed in 2013 and 2017 (red and magenta squares, respectively) and X-ray sources (small circles).

Fernandes et al. (2015) analyzed GMOS spectra of the stellar population in the region associated with Z CMa (see Fig. 2) using the same methodology and found 41 stars with Li I absorption line and 8 stars with Hα emission. Hence, despite the region associated with FZ CMa being more distant from the highest concentration of gas, the rate of detection of young stars is comparable with the region associated with Z CMa.

4. Conclusion

We just established the methodology of GMOS data reduction and calibration that proved to be adequate to identify and measure typical features of T Tauri stars. The number of young stellar objects seems to be comparable to the region associated with Z CMa. The fraction of the disk-bearing stars will be inspected after spectral type determination and classification of the young low-mass stars between Classical T Tauri and Weak-lined T Tauri, however, the preliminary results indicate that this fraction is lower compared to other star-forming regions at the same age.

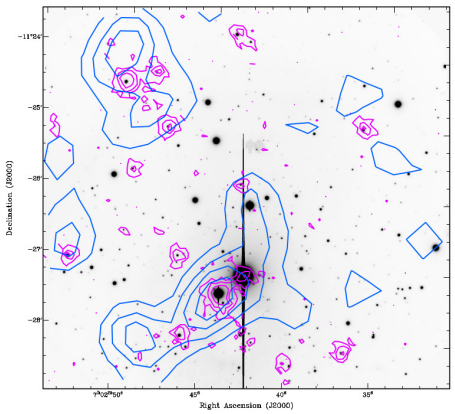

Figure 3. Gemini R-band image of field ICRC-4 observed with GMOS. The bright star is FZ CMa. X-ray sources detected by ROSAT (Röntgen Satellite — Results from Gregorio-Hetem et al. 2009) are indicated by blue contours, which were better resolved with the XMM-Newton observations (magenta contours).

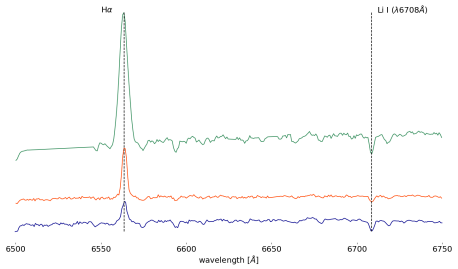

Figure 4. Three examples of the observed spectra highlighting the Hα emission and lithium absorption lines. On the intensity axis, all the spectra are shown on the same scale and in arbitrary units.

As prospects of this project, we also aim to analyze the data from the fields observed with GMOS in 2013 (Figure 2), whose spectra have lower resolution, to complement the characterization of the stellar population in this region. In addition, we intend to explore other surveys, such as 2MASS (Two Micron All Sky Survey) and S-PLUS (Southern Photometric Local Universe Survey).

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