Boletim da Sociedade Astronômica Brasileira, **36**, no. 1, 87-88

Resolved stellar populations in low metallicity galaxies: II Zw 40

Gabriela N. Lima[1], Eduardo Telles[1], Francisco F.S. Maia[2], & E. Rodrigo Carraso[3]

[1] Observatório Nacional - RJ e-mail: gabrielalima@on.br, etelles@on.br
[2] Univ. Federal do Rio de Janeiro e-mail: ffsmaia@if.ufrj.br
[3] NOIRLab e-mail: rodrigo.carrasco@noirlab.edu

Abstract. The lowest metallicity HII galaxies are the simplest starbursts in the local universe, resembling primeval galaxies. Their star formation history (SFH) remains unclear, as they may be forming their first generation of stars or be old with a prolonged, low-intensity or bursty SFH. We use in this work GeMS/GSAOI on GEMINI-South to identify the starburst entities. The project's primary objective is to test the youth hypothesis by detecting asymptotic giant branch (AGB) and/or red giant branch (RGB) stars from resolved CMD diagrams in the host galaxy. Our pilot project's first target was II Zw 40, a famous young galaxy candidate with Z≈1/5 $Z_\odot$. This paper presents preliminary results, including observed CMD and qualitative comparison with model isochrones. We will show the preliminary interpretation of the observed stellar population mix in this dwarf starburst galaxy.

Resumo. As galáxias HII de menor metalicidade são os starbursts mais simples no universo local, assemelhando-se a galáxias primordiais. Sua história de formação estelar (SFH) permanece incerta, pois elas podem estar formando sua primeira geração de estrelas ou serem antigas com uma SFH prolongada, de baixa intensidade ou periódica. Neste trabalho, utilizamos o GeMS/GSAOI no GEMINI-South para identificar as entidades do starburst. O objetivo principal do projeto é testar a hipótese da juventude detectando estrelas gigantes do ramo assintótico (AGB) e/ou do ramo das gigantes vermelhas (RGB) a partir de diagramas CMD resolvidos na galáxia hospedeira. O primeiro alvo do nosso projeto piloto foi II Zw 40, um famoso candidato a galáxia jovem com Z≈1/5 $Z_\odot$. Este artigo apresenta resultados preliminares, incluindo o CMD observado e a comparação qualitativa com um modelo de isócronas. Apresentaremos a interpretação preliminar da mistura de população estelar observada nesta galáxia starburst anã.

Keywords. Galaxies: dwarf – Galaxies: starburt – Galaxies: stellar content

1. Introduction

The study of low-metallicity HII galaxies provides key insights into the processes driving star formation in the early universe. These galaxies, characterized by their simple starburst nature and resemblance to primordial systems (Telles & Melnick 2018), challenge our understanding of star formation history (SFH). Two competing hypotheses dominate the discussion: these galaxies may represent systems forming their first generation of stars, or they may be older systems with a prolonged, low-intensity or episodic SFH (Legrand, F. et. al. 2000). Stellar population analysis highlights the need for intermediate-age stars (> 1 Gyr) to explain optical spectra or multiwavelength observations, although in some cases, evolved stars remain undetected (Westera et. al. 2004).

Among these intriguing objects, II Zw 40 stands out as a potential candidate for a young galaxy. With a metallicity of approximately one-fifth of the solar value ($Z \approx 1/5 Z_\odot$) (Izotov, Y. I., & Thuan, T. X. (1999)), it offers a unique environment to investigate the nature of star formation in low-metallicity regimes. The core objective of this work is to test the youth hypothesis by resolving the stellar population of II Zw 40 using deep photometry and color-magnitude diagrams (CMDs). Specifically, we aim to identify stars on the asymptotic giant branch (AGB) and red giant branch (RGB), as their presence or absence provides critical constraints on the galaxy's SFH.

Using the Gemini South Adaptive Optics Imager (GSAOI) combined with the Gemini Multi-Conjugate Adaptive Optics System (GeMS), we conducted high-resolution observations of II Zw 40. These data allow us to resolve individual stars in the galaxy and distinguish between star clusters and the field population. Preliminary results presented in this paper include calibrated CMDs and a qualitative comparison of the observed populations with theoretical isochrones. These analyses provide the first steps toward a comprehensive interpretation of the stellar content and star formation processes in this prototypical dwarf starburst galaxy.

2. Data and Methodology

We analyzed II Zw 40 using high-resolution imaging data obtained with the Gemini South Adaptive Optics Imager (GSAOI) in combination with the Gemini Multi-Conjugate Adaptive Optics System (GeMS) on the GEMINI-South telescope. The data reduction was performed using the DRAGONS package, which is optimized for near-infrared adaptive optics datasets.

To improve the photometric calibration of the GSAOI images, we incorporated complementary data from Flamingos-2 in the *J* and *H* bands and from Isaac in the *K* band. These datasets cover a larger field of view, enabling a broader cross-match with the 2MASS catalog. The calibration was conducted in two steps: first, we aligned and matched the Flamingos-2 and Isaac images with 2MASS, ensuring consistency across the photometric system; then, these calibrated images were used as a reference to refine the photometry of the GSAOI images.

The final calibrated photometry for the GSAOI data achieves uncertainties of 0.05 mag in the *J* band, 0.08 mag in the *H* band, and 0.11 mag in the *K* band (Fig. 1). This methodology ensures a robust photometric baseline for constructing accurate color-magnitude diagrams (CMDs) and analyzing the stellar population of II Zw 40. Our obsevations achieved a final spatial resolution of 90 mili-arcseconds in the K band.

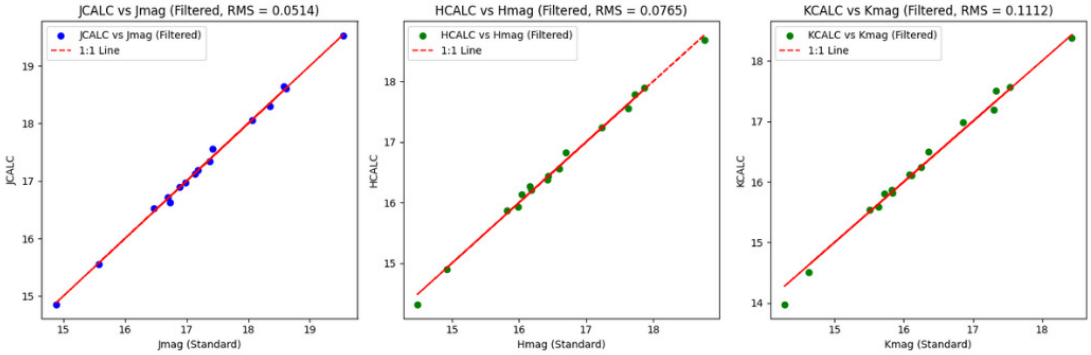

Figure 1. Photometric calibrations of our GSAOI images in the bands J, H and K respectively.

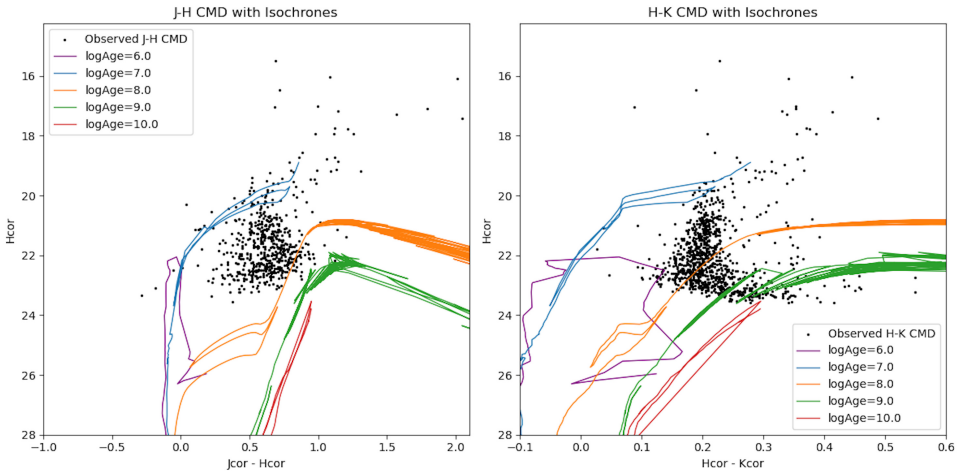

Figure 2. CMD with extinction correction and isochrones superposed. The diagrams suggest that the observed stars belong to a young to intermediate stellar group, with ages between 10^7 and 10^8 years, but with a small presence of older stars. There is evidence of RGB and AGB stars in the diagrams, mainly in regions with: ($J - H > 0.8$ or $H - K > 0.3$) and intermediate magnitudes ($J_{\rm cor}, H_{\rm cor} \sim 20 - 22$). The presence of these stars suggests that the system contains a more evolved population, with stars in the late stages of their evolution. Precise identification between RGB and AGB would require detailed a complementary analysis.

3. Preliminary Results

We constructed a color-magnitude diagram (CMD) for II Zw 40 using calibrated and extinction-corrected photometry in the J, H, and K bands (Fig. 2). The isochrones overlaid on the CMD were derived from PARSEC evolutionary tracks (Bressan et. al. (2012)) computed for a metallicity of $Z = 0.008$[1].

In this preliminary analysis, the detected sources include a mix of individual massive stars and potential unresolved star clusters. This classification highlights the need for further refinement of source separation techniques to better distinguish between these populations and provide a clearer understanding of the stellar content in this low-metallicity dwarf galaxy.

4. Future Perspectives

In the future, we aim to refine the detection methodology to address challenges associated with low signal-to-noise ratios, background contamination, and source blending. Additionally, we plan to analyze the stellar populations across different regions of II Zw 40 to investigate whether they are consistent with a merger-driven scenario or support the hypothesis that star formation in this galaxy occurs in situ despite its disturbed morphology.

Acknowledgements. I would like to express my sincere gratitude to CAPES and the Observatório Nacional for their generous support, which enabled me to participate in the XLVII Annual Meeting of the Brazilian Astronomical Society in Águas de Lindóia.

References

Bressan, A. et al. 2012, MNRAS, 427, 127
Izotov, Y. I., & Thuan, T. X. 1999, ApJ, 511, 639
Legrand, F. et al. 2000, A&A, 355, 891
Telles, E.& Melnick, J. 2018, A&A, 615, A55
Westera, P. et al. 2004, A&A, 423, 133

[1] Generated using the PARSEC CMD tool: `http://stev.oapd.inaf.it/cgi-bin/cmd`