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Detection of AGB stars in the IC 10 dwarf irregular galaxy

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Abstract. Amongst the dwarf galaxies in the Local Group, the isolated irregular one, IC 10 is one of the most interesting galaxies, with strong star forming activity and the highest density of Wolf-Rayet stars. Undergoing a starburst phase, having numerous HII regions and being bright in all wavebands, makes it an exquisite galaxy to study the internal and external processes that continue to affect dwarf galaxies 14 Gyr since the Big Bang. In this study, we present a new deep and precise optical monitoring survey of IC 10 using the Isaac Newton Telescope (INT) with the wide field camera (WFC). We performed observations at nine epochs spaced between three to four months apart between 2015 and 2017. We identified Long Period Variable stars (LPVs), Asymptotic Giant Branch stars (AGBs) and Red Super Giant stars (RSGs) to determine the star formation history and chemical evolution of IC 10.

Keywords. stars: formation, stars: variables: other, galaxies: dwarf

1. Introduction

The Local Group is most populated by dwarf galaxies. Star formation history (SFH) and chemical environment are the most important factors to characterizing the dwarf galaxies (Rezaeikh *et al.* 2014). IC 10 is identified as one of the most massive and luminous galaxies (Tehrani *et al.* 2017) with the high density of Wolf-Rayet stars (Crowther *et al.* 2003) and classified as the fifth in luminosity in the Local Group. Asymptotic giant branch stars (AGBs) and red supergiants are identified as the last phase of stellar evolution post main-sequence. AGB stars are distinguishable as Long Period Variables (LPVs) due to the strong radial pulsations of their cool atmospheric shells with the period in the range of several months to years (Javadi *et al.* 2011). The existence of a large amount of bright young stars and extended H II regions of IC 10 reveal the high star forming activity. IC 10 is a starburst galaxy contains of huge amounts of carbon dust which produced by AGB stars (Dell'Agli *et al.* 2018).

2. Observation details

Between June 2015 and October 2017, we exploited the Wide Field Camera (WFC) to conduct a survey of the majority of dwarf galaxies in the Local Group. The WFC is an optical mosaic camera at the 2.5 m Isaac Newton Telescope (INT) of the observatorio

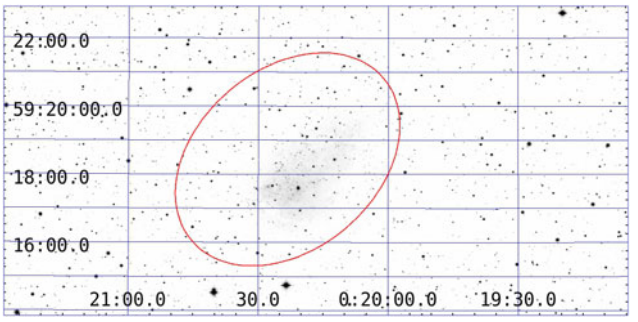

Figure 1. Median i-band mosaic image of the IC 10 dwarf galaxy. The red ellipse is marked as the half-light radius of the galaxy.

del Roque de los Muchachos (La Palma). It contains of four CCDs with a pixel size of 0.33 arcsec / pixel. We used Transforming Heavenly light into Images (THELI) for the automated reduction of astronomical images to combination, calibration and correction (Erben *et al.* 2005). The period of AGB stars which are LPVs is about 100 days and 1300 days for low mass and dustiest massive AGB stars, respectively. To identify the LPVs we need to monitor several epochs, spaced by a month or more. Although the observations were done in Sloan i and Harris V filters, we selected i-band as the peak of Spectral Energy Distribution (SED) of cool AGB stars that is located around 1μm (Javadi *et al.* 2017).

3. Photometry process and results

The photometry is done with DAOPHOT/ALLSTAR software package for all stars in each frame by fitting a point-spread function (PSF) model (Stetson *et al.* (1987)). We combined the individual images to create median image by using the MONTAGE routine. We also performed photometry with DAOPHOT/ALLSTAR on the median image to obtain the master list. We used the ALLFRAME routine to apply PSF-fitting photometry on stars in the master list on each image. The final list of stars has 72937 stars. The median i-band mosaic image of the IC 10 is shown in Fig. 1.

Aperture photometry is done to measure the zero-points of the images by transformation equations (Jordi *et al.* 2006). The master list was calibrated by using standard stars measurements for each night. We used the average of zero-points for the nights without standard stars observations. Furthermore, the relative calibration is applied to each frame against another one by selecting the 50 stars in common with magnitudes in the range of 18 to 22 mag. We used the extinction coefficients which had been obtained at La Palma. The stars at the end of their evolution, inject their mass to the interstellar medium (ISM). The intense death of massive stars and the stellar winds are two most important agents to inject the energy to the ISM. The total dust production (DPR) for the massive and low-mass AGB stars is negligible in comparison with the carbon dust (Javadi *et al.* 2013). Fig. 2 Shows the luminosity distribution in IC 10. The red and green vertical dashed lines indicate the tip of the RGB and the tip of the AGB, respectively. Since The AGB stars are brighter than the RGB stars, they can be separated by indicating the RGB tip. Based on the number of stars below and above the RGB tip luminosity, The number of the AGB stars and RSGs has been obtained 10618 and 450, repectively. According to our results, we identify the LPVs in the galaxy to describe the star formation history and chemical enrichment of IC 10 dwarf galaxy.

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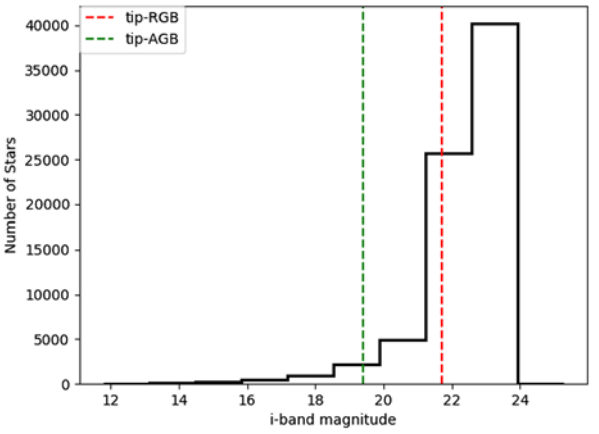

Figure 2. Luminosity distribution in IC 10.

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