Stars and their variability observed from space
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FROM MONITORING SURVEY OF VARIABLE RED GIANT STARS TO THE EVOLUTION OF THE GALAXY: ANDROMEDA VII

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Abstract.
We have observed the Andromeda VII dwarf galaxy (And VII) using optical multi-epochs with the Isaac Newton Telescope (INT), in order to identify AGB stars. Among AGB stars, we concentrated on long-period variable stars (LPVs) with the largest amplitudes at optical wavelengths. Because these stars are cool at the end of their evolution and their luminosities reach maxima, their birth mass is directly related to luminosity by employing theoretical evolutionary tracks. Since the periods of LPVs are months to years, we have taken t10 epochs from And VII during the period $2015 - 2017$, spaced by a month or more in the i- and V-bands, plus one epoch in the I-band, to find these variable stars. As a result, a catalogue of $10,000$ stars and 48 LPVs was identified within two halflight radii of And VII. The $i-$band amplitude of variability for our LPV stars ranged from 0.2–1.6 mag. We used the luminosity distribution of those stars to reconstruct their star formation history, employing a method that we have applied in the cases of other Local Group galaxies. By using as well the Spitzer catalogues at mid-IR wavelengths, we constructed a detailed map of the mass feedback into the interstellar medium (ISM).

Keywords: Galaxies: Andromeda VII, stars: variable, AGB, LPV, techniques: photometric

1 Introduction

The low-mass dwarf galaxies are the most abundant and nearest targets in which to study star formation history (SFH) on a galactic scale. For probing the star formation and evolution of the And VII dwarf galaxy, we identified LPV stars that trace stellar populations as young as ~ 30 Myr to as old as ~ 10 Gyr. And VII, also known as the Cassiopeia Dwarf, was discovered 20 years ago (Karachentsev et al. 1999). The distance of And VII was obtained from different photometric methods. From the Padova stellar models and colour–magnitude diagram (CMD), Weisz et al computed $\mu = 24.58$ mag, which we have adopted in this paper (Weisz et al. 2014).

AGB stars with low or medium mass ($0.8-8M_{\odot}$) typically become LPV stars in the final stages of evolution, and reach a high luminosity ($\approx 1000 - 60000L_{\odot}$) and low temperature ($T \approx 3000 - 4500K$) in their lifetime (Yuan et al. 2018; Goldman et al. 2019). They are also prominent in the near-IR, where the effects of dust in the form of extinction and reddening are relatively small. These cool evolved stars start to produce dust through radial pulsations of their atmospheric layers, so they shed their mass (up to 80%) into the ISM (Javadi et al. 2015; Boyer et al. 2017). This paper identified LPVs in And VII and estimated the distribution of their amplitudes in the i-band. That was the first step in obtaining mass–age and mass–pulsation relations for the AGB stars, in order to reconstruct the SFH of this dwarf galaxy.

2 Observation and Data analysis

The Wide Field Camera (WFC) is an optical mosaic camera on the INT (La Palma, Spain). It consists of four 2048×4096 CCDs, with a pixel size of 0.33 arcsec/pixel. We used the WFC between 2015–2017 for identifying LPV stars in And VII. We determined the amplitude and mean brightness of LPVs that are variable on time-scales from ≈ 100 days (for low-mass AGB stars) to ≈ 1300 days for the dustiest massive AGB stars. For this purpose, observations were made over 7 epochs, spaced by one month or more, with the WFC Sloan i filter, one epoch with the WFC RGO I filter and 3 epochs with the Harris V filter, to obtain colour information. The data reduction was performed by the THELI pipeline, and we used DAOPHOT II (Stetson 1987) for Point Spread Function photometry (Saremi et al. 2017, 2019a).

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3 Search of variable stars

To identify variable stars, we used a method similar to the NEWTRIAL programme described by Welch & Stetson (1993) and developed further by Stetson (1996) to derive variability indices (J, K and L) for stars. We found the optimal variability threshold for identifying LPVs from histograms of the variability index L (Javadi et al. 2011a,b; Saremi et al. 2017). Most of the LPVs in And VII have i-band magnitudes between 20–22 mag and are located inside two half-light radii of the galaxy.

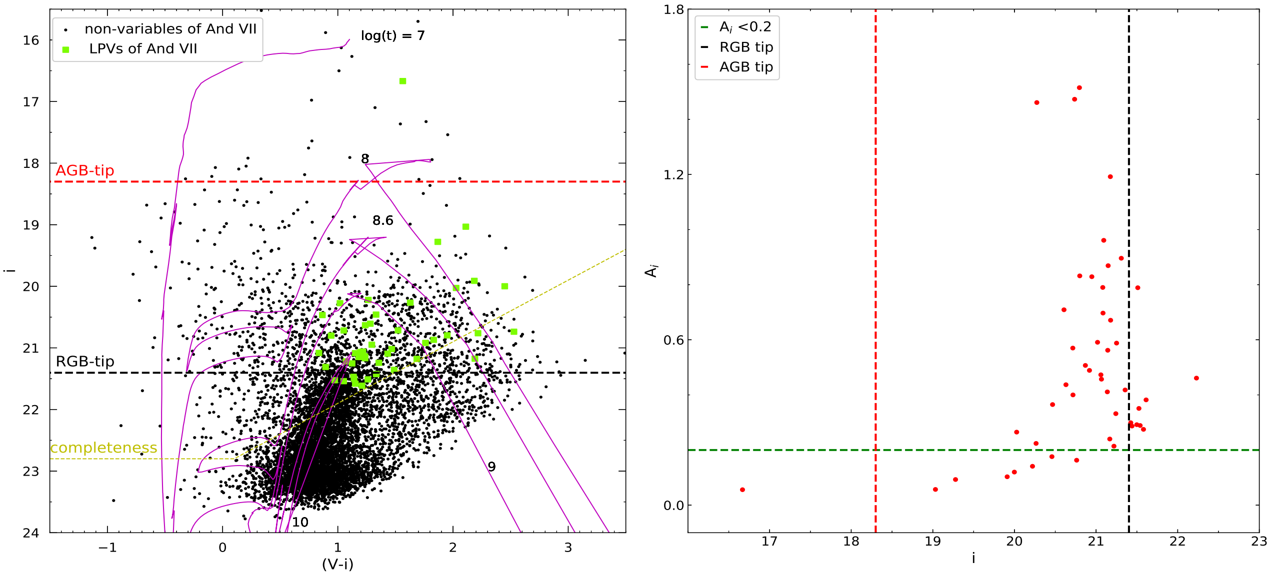

Fig. 1. Left: LPVs are displayed as green points, with isochrones from Marigo et al. (2017) overlaid. **Right:** Estimated A_i of LPVs *vs.* i-band magnitude; dashed lines define the amplitude of $A_i < 0.2$ mag.

Figure 1 (left panel) presents the colour magnitude diagram (CMD) of And VII in the i-band versus $V - i$ colours, with our identified LPV stars in green. Overplotted are isochrones from Marigo et al. (2017). The AGB-tip and RGB-tip are illustrated as red and black dashed lines, respectively. The 50% completeness limit of our photometry is determined from a simple simulation (Saremi et al. 2017). The right panel of Fig. 1 shows that the estimated i-band amplitudes of LPVs are increasing as their brightness decreases, down to near $A_i = 1.6$ mag. We consider only the candidates with $A_i > 0.2$ mag to be LPVs.

4 Ongoing work

We are extending the study of And VII to derive the star-formation history of the dwarf galaxy by applying a method used by Javadi et al. (2011c, 2015, 2017); Rezaeikh et al. (2014); Hamedani Golshan et al. (2017); Hashemi et al. (2019); Saremi et al. (2019b). We will then model the spectral energy distributions of variable stars obtained by a combination of nearIR and optical data (our catalogue) and midIR data (Spitzer catalogues) to estimate the mass-loss rate and chemical enrichment of the galaxy (Javadi et al. 2013).

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