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AGB Stars in WLM

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Abstract. We investigate the star formation history and metallicity of the Local Group irregular dwarf galaxy WLM using wide-field JHK near-infrared imaging, spanning a region of approximately 1 sq. degree, obtained with WFCAM on UKIRT. JHK photometry clearly reveals the tip of the red giant branch, allowing a new estimate of the distance, and allows ready identification of C-type and M-type AGB stars. The C/M ratio was used to produce a surface map of the metallicity distribution which is compared to previous studies. Multi-wavelength spectral energy distributions (SEDs) were constructed for some AGB stars.

1. Introduction and Data

WLM (Wolf-Lundmark-Melotte) is a dwarf irregular galaxy and is a member of the Local Group. It is at a distance of 932 ± 33 kpc (McConnachie et al. 2005). In 2007 Valcheva et al. did a photometric study on part of WLM and found a C/M ratio of 0.56 ± 0.12 which differed greatly (by a factor of 20) from previous values. In 2009 Leaman et al. used Ca-II triplet spectroscopy on 78 red giant stars and found a mean [Fe/H] of −1.27 ± 0.04 dex and also found that stars closer to the centre of the galaxy were more metal rich by 0.30 ± 0.06 dex. The data used here is near-infrared (NIR) JHK observations made on October 16$^{\text{th}}$ 2007 using WFCAM on UKIRT in Hawaii.

2. Results

2.1. C/M ratio and Metallicity

The C/M ratio represents the number ratio between carbon rich (C-type) and oxygen-rich (M-type) asymptotic giant branch (AGB) stars. Using a histogram of $J - K$ colour we find a C to M split at $J - K = 1.05 \pm 0.05$ mag which gives ratios of 0.27 to 0.89 for the inner half square degree of data depending on foreground removal methods. In the central area dominated by the galaxy (an ellipse with RA=±0.07° Dec= ±0.15°) we obtain ratios between 0.4 to 0.8. When we correct our C/M ratio using the C-type catalogue of Battinelli & Demers (2004) (to account for flaws in using $J - K$ colour as cut-off) these ratios range from 0.36 to 1.43 and 0.55 to 1.24 for inner and central regions respectively. The lower ratio of the central region compared to the inner region could be due to a metal rich star-forming region within the central part of WLM.

Using the same sky area as Valcheva et al. (2007), we on the whole find our reduced data agrees more with their unreduced data and vice versa which could be due to their adopted foreground having a large number of C-type stars. The C/M ratio is calibrated to [Fe/H] using the equation B.1 from Cioni (2009). By applying this equation to our data we obtain [Fe/H] values from −1.12 to −1.37 dex for original C/M ratios and −1.18 to −1.43 dex for corrected ones for the inner field. For the central field these values are from −1.20 to −1.34 dex and −1.27 to −1.40 dex for original and corrected C/M ratios.

2.2. Distance modulus (m-M)

The tip of the RGB (TRGB) represents the split between the RGB and AGB populations. The TRGB is found at $K = 18.7 \pm 0.1$ mag and is used to calculate the distance modulus once a value for its absolute magnitude is known. We explored two methods of obtaining this value; evolutionary tracks and [Fe/H]. With the tracks by Marigo et al. (2008) we did two calculations, one for age ranges and the other for metallicity giving distance moduli of (m-M)= 24.37 mag at a constant metallicity and varying age, and (m-M)= 24.39 mag at a constant age and varying metallicity. For the calculated [Fe/H] we make use of the relation between [Fe/H] and the absolute magnitudes of RGB stars, by Ferraro et al. (2000). Here, it is assumed the overall metallicity of the galaxy is the same for both the AGB and RGB population. The mean of the values for the different methods explored is (m-M)= 24.89 ± 0.25 mag (∼ 951 kpc). This value agrees with previous measurements.

2.3. Spectral Energy Distribution (SED)

By combining our NIR data with optical data from McConnachie et al. (2005) and mid-infrared data from Boyer et al. (2009) we can investigate the SED of AGB stars in WLM. The SED allows us to obtain bolometric fluxes (and bolometric magnitudes from the distance modulus). We found 1281 matches between all the datasets after applying some small systematic shifts. For the sources to be usable in a SED there needed to be a magnitude present in every band, in total 52 sources met this criteria. When deriving the bolometric flux we found that the most luminous stars were not the C-type AGBs but supergiants. The bolometric fluxes were also converted into bolometric magnitudes giving us additional data to confirm stellar types.

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