The PNLF distance to the Sculptor Group galaxy NGC 55

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Abstract. We identified 21 new Planetary Nebula (PN) candidates in the Sculptor Group galaxy NGC 55. We determined a most likely distance of 2.45 ± 0.4 Mpc using the Planetary Nebulae Luminosity Function (PNLF) method. The distance to NGC 55 is larger than previously determined distances, which means that the Sculptor Group is further away from the Local Group than previously thought. The distance to NGC 55 is again comparable to the distance of NGC 300, adding support to the suggestion that these galaxies form a bound pair.

1 NGC 55

NGC 55 is a highly inclined (i=85±5°) late type galaxy (SB(s)m) in the Sculptor Group. Its Holmberg radius is $20\farcm2$ and blue magnitude m_B=8.42. Sculptor is a very loosely concentrated and almost freely expanding aggregate of galaxies of prolate shape which we view pole-on. It stretches from the outskirts of the Local Group at 1.5 Mpc out to 5 Mpc. Besides the 5 main spiral galaxies, the Sculptor Group contains several dwarf galaxies (Jerjen et al. [1998]).

NGC 55 is one of the 5 bright spiral galaxies of the Sculptor Group, which could be the one nearest to the Milky Way. Distance estimates for NGC 55 range from 1.34 Mpc based on carbon stars (Pritchet et al. [1987]) to 1.8 Mpc based on the Tully-Fisher relation (Karachentsev et al. [2003]). The two bright spiral galaxies NGC 55 and NGC 300 are both at the near side of the Sculptor group and it has been suggested that NGC 55 and NGC 300 form a bound pair (Graham [1982]; Pritchet et al. [1987]; Whiting [1999]). The distance to NGC 300 is well determined via Cepheids (Freedman et al. [1992]: 2.1 ± 0.1 Mpc) and via the PLNF method (Soffner et al. [1996]: 2.4 ± 0.4 Mpc). NGC 55 has remained without a reliable distance estimate.

2 Observations

The observations were done with the Wide Field Imager (WFI) on the 2.2-m telescope at the La Silla Observatory of the European Southern Observatory on the 4 and 5 July 1999. The weather was photometric. WFI consists of a 4 times

2 mosaic of 2k x 4k CCDs. The pixel scale is 0.″238 and the total field of view is 34′ x 33′, which covers the entire galaxy. NGC 55 was observed through the [O III]/8 (FWHM 80.34 Å) and the off-band filter 518/16, and the Hα/7 filter for a total of 3120 sec, 1620 sec, and 3600 sec respectively. On the first day the galaxy was offset to the east and south by 3′ to fill in the CCD gaps. The seeing was 1.″4.

3 Data reduction and results

The ESOWFI external package in IRAF was used to convert the ESO headers to suit the MSCRED package and to set the instrument files and astrometry solution. Next the reductions were done using the MSCRED mosaic reduction package in IRAF according to the guide by Valdes ([1998]).

We followed the survey technique as described in e.g. Jacoby et al.[1989] and Ciardullo et al. [1989]. The on- and off-band images were aligned. The off-band images were then scaled to the level of the on-band images and subtracted from them to produce the difference image. We identified the PNe by blinking this difference image with the off-band image, and the Hα+[N II] images. In order to discriminate PNe from other emission-line sources, we used the following critieria (Feldmeier et al. [1997]): (1) PN candidates had to have a point-spread function (PSF) consistent with that of a point source as all PNe are expected to be unresolved at the distance of NGC 55; (2) PN candidates had to be invisible on the off-band image to exclude bright OB stars exciting H II regions; and (3) PN candidates had to be significantly fainter in Hα+[N II] image than [O III], in order to reduce further the possibility of contamination from H II regions. With all these constraints, only compact, H II regions that have high nebula excitation and faint central OB associations will have been mistaken for PNe. However, even these will be faint and hence cannot significantly affect the PNLF. In total we identified 21 candidate planetaries in NGC 55.

The PN candidates were measured photometrically in the off-band image using PHOT in IRAF and flux calibrated using standard stars and the procedures outlined in Jacoby et al. [1987]. In order to determine the filter transmission for the PNe we need to take the redshift into account and the bandpass shift of the interference filter to the blue. The systemic velocity of NGC 55 was taken to be 116 km/s (Puche & Carignan [1991]). The percentage of transmission is about 88% across the filter for the [O III] line and about 87% for the Hα filter at the location of our objects. The difference in transmission across the field has negligible effect on the derived flux values and magnitudes.

The resulting monochromatic [O III] flux values F_{5007} were converted to [O III]λ5007 magnitudes using (Jacoby [1989]) :

$$m_{5007} = -2.5\ log(F_{5007}) - 13.74. \qquad (1)$$

4 The PNLF distance

[O III] magnitudes were corrected for the interstellar extinction. We consider only the foreground Galactic extinction towards NGC 55 and adopt E(B-V)=0.013 mag (Schlegel et al. [1998]).

Identifications become incomplete beyond $m_{5007} = 23.5$ mag. Besides missing faint PNe, the probability of overlap with a star or with an H II region increases towards the centre, particularly in the Hα+[N II] image. Hence brighter PNe than the ones recovered in the outskirts may have been missed towards the center.

From these data the PNLF distance to the galaxy can normally be derived by convolving the empirical model for the PNLF given by Ciardullo et al. [1989]:

$$N(m) \propto e^{0.307M}[1 - e^{3(M^{*}-M)}] \tag{2}$$

with the photometric error function and fitting the data to the resultant curve via the method of maximum likelihood. This takes into account that the probability of observing PNe near the cutoff magnitude M* decreases for small sample sizes. Fig. 1 plots the PNLF for the sample. Assuming M*= -4.48, based on the calibration to M 31 (Ciardullo et al. [2002]), we obtain a most likely distance modulus (m $-$ M*) = 26.95 $\pm$ 0.35, which corresponds to a distance of 2.45 $\pm$ 0.4 Mpc. Hence we obtain the same distance as the PNLF distance to NG 300 (Soffner et al. [1996]). No PNe with absolute magnitude lower than M* = -4 are expected (Méndez et al. [1993]), thus the distance to NGC 55 would be at least 2.0 Mpc.

5 Discussion

Fig. 2 shows the distance determinations to NGC 55 and NGC 300 over the last 20 years. Our distance determination is larger than previously determined distances to NGC 55, as has also been the case for the Cepheids and PNLF distance determinations to NGC 300. It means that these galaxies at the near side of the Sculptor Group are further away from the Local Group than previously thought. The PNLF distances to NGC 55 and NGC 300 are again similar, which adds support to the fact that they form a bound pair and illustrates the consistency of the PNLF method for distance determination.

6 Conclusions

We identified 21 new PNe candidates in the Sculptor Group galaxy NGC 55. The PNLF method gives us a most likely distance of 2.45 $\pm$0.4 Mpc. The distance to NGC 55 turns out to be comparable to the distance of NGC 300, adding support to the suggestion that these galaxies form a bound pair. It also means that the Sculptor Group is further away from the Local Group than previously thought.

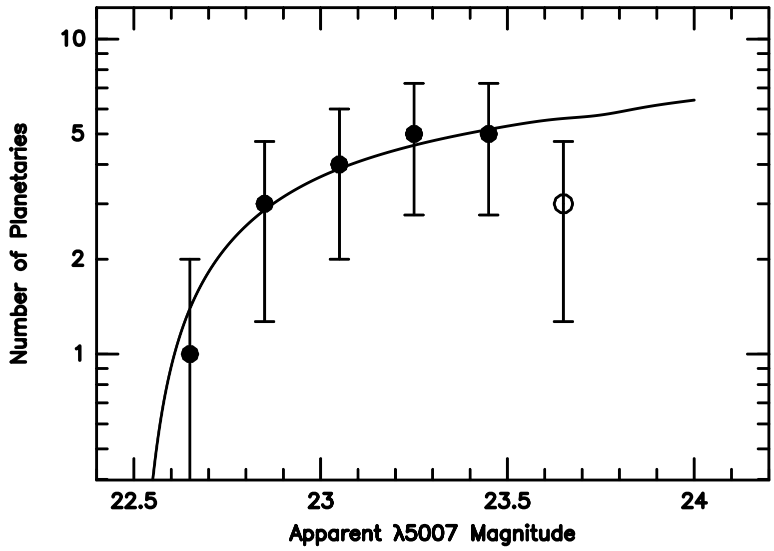

Fig. 1. Observed [O III]λ5007 PNLF of NGC 55. The curve represents the best-fitting empirical PNLF convolved with the photometric error function and shifted to the most likely distance. The open circle represents a point past the completeness limit.

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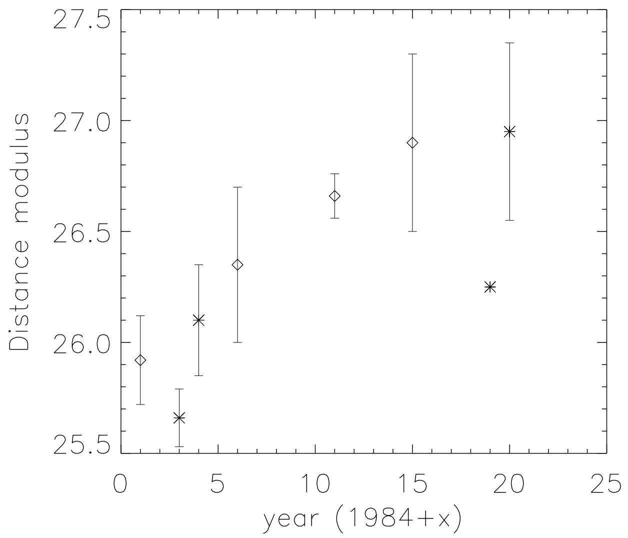

Fig. 2. Estimates of the distance modulus to NGC 300 (diamonds) and NGC 55 (stars) throughout the years as from 1984.

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