CCD imaging of twenty nearby isolated irregular galaxies

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Abstract

B, V and I CCD stellar photometry for a sample of 20 field irregular dwarf galaxies is presented. Most of them have been resolved into stars for the first time. Based on photometry of their brightest blue stars we have derived distances to the objects. Our sample exhibits diverse morphological properties evidently caused by their different starburst activity.

1 Introduction

The data presented here forms part of our general program aimed at the measurement of photometric distances for a complete sample of the nearest galaxies with radial velocities within 500 $\mathrm{km\,s^{-1}}$. Being completed recently, this program will yield a representative atlas of detailed images for about 150 dwarf irregular galaxies. The availability of such a volume-limited "gallery" allows the structural properties of dwarf galaxies to be classified in connection with diverse conditions of star formation in high and low density regions of the Local universe.

Now we will consider 20 mainly isolated dwarf galaxies. Most of them have been resolved into stars for the first time. For an objective description of isolation we used a quantitative approach with a so-called "tidal index" introduced in the work of Karachentsev, Makarov & Huchtmeier (1999). According to this approach the tidal index is equal to zero, when the Keplerian cyclic period of the galaxy with respect to its disturber equals the cosmic Hubble time. And galaxies with tidal index less than zero may be considered as well isolated objects.

2 Observations and photometry

All the galaxies were observed at the 2.56-meter Nordic telescope (La Palma, Canary Islands, Spain). A CCD camera with a 1k×1k chip provided a field of view of 3×3 arcmin The exposure times in filters of the B,V,I Johnson-Cousins system were from 300 to 600 sec. Stellar photometry was carried out with the DAOPHOT package (Stetson, 1987). Besides the detailed photometry of starlike objects, we made a surface photometry of the galaxies in concentric circular apertures, measuring their total apparent magnitudes, V_T, and integral colour indices, $(B-V)_T$ or $(V-I)_T$.

3 Distance estimates

The photometric limit of our CCD frames was about $V = 23$ mag, which allowed us to reveal only the brightest stars (supergiants) in the galaxies. Following Sandage & Tammann (1974) and de Vaucouleurs (1978) we selected blue supergiant candidates under the condition $B-V < 0.4$, and

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Table 1: Basic parameters and distance estimates for 20 dwarf galaxies.

Name	a_{25}	B_T	$(B-V)_T$	V_h	<B(3B)>	μ_0(3B)	D	M_B	Θ
	(′)	(mag)	(mag)	(km/s)	(mag)	(mag)	Mpc	(mag)	
UGC 685	1.4	14.44	0.54	+155	21.33	28.89	5.95	−14.56	−1.1
UGC 1281	4.5	13.26	0.71	+157	20.83	28.68	5.44	−15.67	−1.4
UGC 3303	3.6	13.0:	–	+521	21.42	29.27	7.16	−16.85	−2.0
UGC 3476	1.0	15.38	0.73	+469	22.45	29.23	7.01	−14.83	−1.7
UGC 3600	1.1	15.58	0.58	+403	22.2:	29.3:	7.3:	−14.1:	−1.2
UGC 3698	1.0	15.16	0.56	+423	22.0:	29.3:	7.2:	−14.5:	−1.2
NGC 2337	2.0	13.10	0.57	+434	21.46	29.48	7.88	−16.76	−1.8
UGC 3817	1.8	15.96	0.71	+438	22.53	29.66	8.55	−14.06	−1.3
UGC 3860	1.3	14.96	0.41	+354	21.53	28.79	5.73	−14.06	−1.4
UGC 4426	2.0	15.27	0.45	+394	22.78	30.62:	5.6R	−13.6:	−0.6
F 565-v1	0.7	16.95	0.47	+491	22.5:	29.5:	7.9:	−12.5:	0.3
UGC 5086	1.0	15.94	0.71	+543:	–	[29.36]	[7.45]	−13.49	–
UGC 5272	2.0	14.45	0.31	+520	21.54	29.26	7.10	−14.85	−0.8
UGC 5340	2.5	14.60	0.18	+502	21.32	28.85	5.89	−14.28	−1.1
UGC 5427	1.2	14.89	0.44	+495	21.67	29.26	7.14	−14.37	−0.8
UGC 5456	1.6	13.84	0.42	+535	19.94	27.19:	2.74:	−13.4:	−1.4
NGC 3274	2.1	13.25	0.40	+537	21.03	29.08	6.55	−15.89	−0.3
UGC 5889	1.8	14.25	0.60	+572	21.87	29.85	9.33	−15.64	0.0
NGC 5238	1.3	13.80	0.40	+233	20.84	28.57	5.18	−14.77	−0.6
UGC 9405	1.9	14.65	0.57	+221	22.00	<29.52>	8.02:	−14.9:	0.1

used the mean apparent magnitude of three brightest stars, <B(3B)>, as a distance indicator to a galaxy.

Some basic parameters of the galaxies as well the results of our photometry are presented in Table 1. Its columns contain: (1) — the galaxy name; (2) — the standard diameter from the PGC (Paturel et al., 1992) in arcmin; (3),(4) — the total apparent magnitude and the integrated colour index from our measurements; (5) — the heliocentric radial velocity from the PGC ; (6) — the mean apparent magnitude for the three brightest blue stars in the galaxy, used for its distance estimation; (7),(8) — the distance modulus and the corresponding distance in Mpc, (9) — the galaxy absolute magnitude, (10) — the tidal index.

As an example, we give a few notes on two of the observed galaxies.

UGC 1281 = FGC 195. This edge-on galaxy is listed in the Flat Galaxy Catalogue by Karachentsev et al. (1993). One arcmin to the East, there is a compact elliptical galaxy. The V frame of the galaxy is presented in Fig. 1. UGC 1281 has a high colour index for a Sm, which may be caused by internal extinction in the galaxy. Within its apparent boundary there is a red star with $V = 21.23$ and $V - I = +1.93$. Identifying it with a red supergiant, we derive a distance modulus 28.91, which agrees well with a modulus of 28.68 from the three brightest blue stars.

UGC 5340 = DDO 68 = VV 542. Among other irregular dwarfs this galaxy stands out for its disturbed structure. It is listed by Vorontsov-Velyaminov (1977) in the Atlas of interacting galaxies as #542. However, in the wide surroundings of UGC 5340 there are no other galaxies which could be responsible for the strong tidal disturbance of this system.

UGC 5340 has been resolved into stars for the first time by Hopp & Schulte-Ladbeck (1995). The results of our photometry of the brightest stars are presented in the color-magnitude diagram (Fig. 2). The stars within the apparent boundary of the galaxy are indicated with squares, and crosses are the stars outside the galaxy boundary. The galaxy is mainly populated by blue stars. The three brightest ones, with <B(3B)> = 21.32 yield a distance modulus of 28.85. Here we have ignored the brightest object with $V = 19.37$ and $B - V = 0.03$, whose luminosity exceeds that of

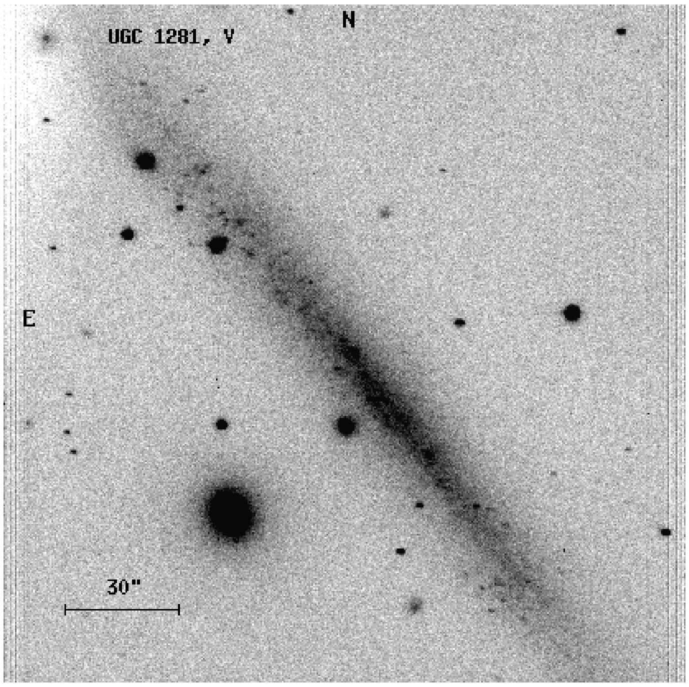


Figure 1: The V frame of UGC 1281. North is top, and East is left.

others by more than two magnitudes. This object may be an unresolved multiple system of young stars. The distance modulus according Hopp & Schulte-Ladbeck is 28.5.

It should be noted that UGC 5340 has an unusually blue integral colour, $(B–V)_T = 0.18$, which agrees well with the colour $(B-R)_T = 0.32$ according to Hopp & Schulte-Ladbeck (1995). This feature, as well as the high hydrogen mass-to-luminosity ratio, $M(\mathrm{HI})/L_B > 1$ $\mathrm{M}_\odot/\mathrm{L}_\odot$, may indicate a young galaxy.

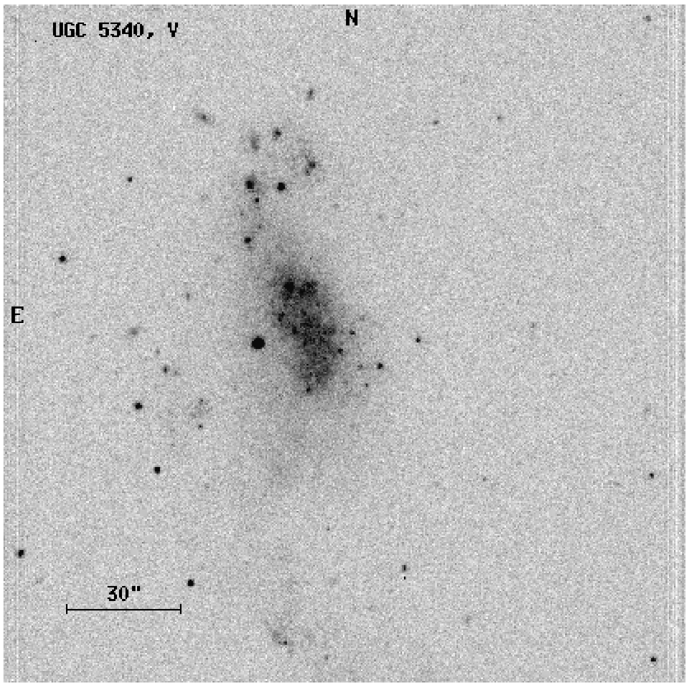
4 Conclusions

Taking advantage of the high quality of the Nordic telescope optics, we carried out a detailed two-colour imaging of 20 irregular galaxies. Most of them were resolved into stars for the first time. We made photometry of the brightest stellar population and also measured the integral magnitudes and colour indices of the galaxies. Based on the magnitudes of the brightest blue stars we estimated distances to the galaxies, which lie in the interval of [5.1 - 9.4] Mpc.

Besides UGC 3698 and UGC 5086, the studied galaxies are well isolated systems, whose crossing time with respect to their nearest massive neighbours is of the order of the cosmological time, $\sim 10^{10}$ years. Evolution of such isolated dwarf galaxies should not be affected by tidal disturbances. Nevertheless, these objects show impressively diverse morphologies, which are likely to result from their starforming activity.

The absolute magnitudes of the galaxies lie in the interval $[-12.5, -16.9]$ with a median of -14.6, and their integral colours, $(B-V)^0_T$, are concentrated within [0.30, 0.70] with a median of 0.47. Outside this colour index interval there is only one galaxy, UGC 5340, with $(B-V)^0_T = 0.17$. It has also a high $M(\mathrm{HI})/L_B$ ratio, being probably a young system.

Because the radial velocities of the considered galaxies can not be much affected by neighbours, one can use them to estimate the local value of the Hubble parameter, $H = V_0/D$. According to the data of Table, individual estimates of H have a median of 65 $\mathrm{km\,s^{-1}/Mpc}$. This value is in



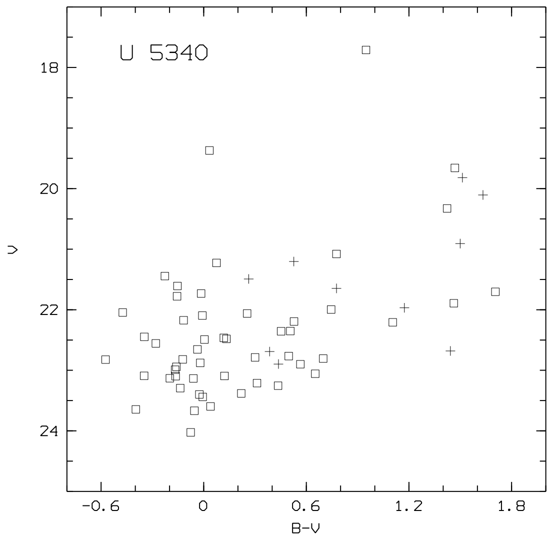


Figure 2: The V frame of UGV 5340 (left). V vs. $(B-V)$ diagram for UGC 5340 (right). Open squares correspond to stars measured within the galaxy boundary and crosses indicate the foreground stars.

reasonable agreement with other estimates of the Hubble parameter.

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