A&A 384, 72–80 (2002)
DOI: 10.1051/0004-6361:20020006

Astronomy & Astrophysics

Surface photometry of new nearby dwarf galaxies⋆,⋆⋆

L. N. Makarova[1,2], I. D. Karachentsev[1], E. K. Grebel[3], and O. Yu. Barsunova[4]

[1] Special Astrophysical Observatory of the Russian Academy of Sciences, Nizhnij Arkhyz 369167, Karachaevo-Cherkessia, Russia
e-mail: lidia@sao.ru; ikar@luna.sao.ru
[2] Isaac Newton Institute of Chile, SAO Branch, Russia
[3] Max-Plank-Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany
e-mail: grebel@mpia-hd.mpg.de
[4] Astronomical Institute, St. Petersburg State University, 198904 St. Petersburg, Russia
e-mail: monoceros@mail.ru

Received 29 August 2001 / Accepted 19 December 2001

Abstract. We present CCD surface photometry of 16 nearby dwarf galaxies, many of which were only recently discovered. Our sample is comprised of both isolated galaxies and galaxies that are members of nearby galaxy groups. The observations were obtained in the Johnson B and V bands (and in some cases in Kron-Cousins I). We derive surface brightness profiles, total magnitudes, and integrated colors. For the 11 galaxies in our sample with distance estimates the absolute B magnitudes lie in the range of $-10 \gtrsim M_B \gtrsim -13$. The central surface brightness ranges from 22.5 to 27.0 mag arcsec^{-2}. Most of the dwarf galaxies show exponential light profiles with or without a central light depression. Integrated radial color gradients, where present, appear to indicate a more centrally concentrated younger population and a more extended older population.

Key words. galaxies: dwarf – galaxies: photometry – galaxies: fundamental parameters – galaxies: irregular – galaxies: evolution

1. Introduction

Dwarf irregular (dIrr) and dwarf spheroidal (dSph) galaxies account for 80–90% of the total population of galaxies. While there are common trends in their global characteristics such as luminosity, surface brightness, and metallicity, dwarf galaxies may differ significantly in the details of their star formation histories and evolutionary state. Nearby dwarf galaxies out to about 5 Mpc have the advantage that we can study both their integrated properties through medium-sized ground-based telescopes, and their detailed stellar content through high-resolution observations with the Hubble Space Telescope or the new 8 m to 10 m-class telescopes. We are carrying out a large project to study both the integrated properties and the resolved stellar content of dwarf galaxies in the Local Volume ($V < 500$ km s^{-1}), a necessary precondition for the understanding of the evolution of unresolved dwarf galaxies at larger distances. Hopp & Schulte-Ladbeck (1995), Karachentseva et al. (1996), Bremnes et al. (1998, 1999), Makarova (1999), and Jerjen et al. (2000) presented the results of surface CCD photometry of many nearby dwarf galaxies within and outside of groups out to a distance of 10 Mpc. Despite this considerable observational progress, for more than 3/4 of the dwarf galaxies of the Local Volume neither surface brightness profiles nor magnitudes and colors have been measured yet, nor have these galaxies been imaged with modern CCD detectors or reliably classified by morphological type.

Over the last three years Karachentseva and Karachentsev with their co-workers have carried out a search for new nearby dwarf galaxies on the basis of the POSS-II and ESO/SERC sky surveys, covering 97% of the sky. Their survey resulted in detection of about 600 dwarf systems more than half of which were missing in the catalogues of known galaxies. Subsequent follow-up observations of these galaxies in the 21 cm hydrogen radio line (Huchtmeier et al. 2000) confirmed that many of these objects are nearby with a median radial velocity of ∼1200 km s^{-1}. It should be emphasized that during the last two decades the total number of probable Local Volume dwarf galaxies has increased by a factor of two due to new detections and amounts to ∼360.

Send offprint requests to: L. N. Makaova, e-mail: lidia@sao.ru
⋆ Based on observations obtained with the Apache Point Observatory 3.5-meter telescope, which is owned and operated by the Astrophysical Research Consortium.
⋆⋆ Figure 1 is only available in electronic form at http://www.edpsciences.org

Table 1. General parameters of the studied galaxies.

Object	α_{2000}	δ_{2000}	A_B mag	A_V mag	Type*	a arcmin	$V_{\rm LG}$ km s^{-1}
KKH23	$03^{\rm h}42^{\rm m}53\overset{\rm s}{.}5$	$38°37'00''$	1.17	0.89	Irr, L	1.1	
KKH35	05 57 07.8	15 25 28	1.71	1.30	Irr, EL	1.3	
KK65	07 42 32.0	16 33 39	0.14	0.11	Irr, H	0.9	168
KKH46	09 08 36.6	05 17 32	0.20	0.15	Irr, L	0.6	409
KKH51	09 30 12.9	19 59 30	0.19	0.15	Irr, L	0.7	438
KKH54	09 45 03.9	32 14 17	0.08	0.06	Irr, L	0.9	479
FM1	09 45 10.0	68 45 54	0.34	0.26	Sph, VL	1.0	
KK78	09 50 19.6	31 27 24	0.09	0.07	Irr, H	0.5	466
Arp-loop	09 57 29.0	69 16 20	0.37	0.28	Irr, EL	1.8	
KKH57	10 00 16.0	63 11 06	0.10	0.08	Sph, VL	0.6	
KKSG19	10 24 28.3	−12 25 57	0.30	0.23	Irr, VL	0.7	373
KKH67	11 23 03.5	21 19 37	0.10	0.08	Irr, EL	1.2	
KKH70	11 39 26.9	60 10 18	0.06	0.05	Irr, H	0.9	
KKSG25	11 45 17.8	−17 16 26	0.17	0.13	Irr, VL	1.2	982
UGC 7242	12 14 07.3	66 05 32	0.08	0.06		1.5	213
KKH86	13 54 33.5	04 14 35	0.12	0.09	Irr, L	0.7	205

* Estimated by I. D. Karachentsev.
Irr – irregular.
Sph – spheroidal.
EL – extremely low surface brightness.
VL – very low surface brightness.
L – low surface brightness.
H – high surface brightness.

Dwarf galaxy candidates from the latest surveys were included in our ongoing program of ground-based imaging follow-up observations. For these galaxies we adopt the following naming convention: "KK" (Karachentseva & Karachentsev 1998), "KKSG" (Karachentsev et al. 2000), and "KKH" (Karachentsev et al. 2001a), followed by a running number corresponding to the line in each of the respective catalogues. This sample was supplemented by several low-surface-brightness (LSB) dwarfs located in the M 81 group detected in other surveys.

2. Observations

From the catalogs mentioned in the preceding section we selected a sample of 35 most likely nearby galaxies in the appropriate coordinate range. The choice was based on their low radial velocity (<500 km s^{-1}) or their visual impression on the photographic plates (size, granulation). A subset of 16 galaxies were observed successfully. The observations of these nearby dwarf galaxies were made by I. D. Karachentsev and E. K. Grebel on 2000 February 3 and 9 at the 3.5-m telescope of Apache Point Observatory (APO) in New Mexico, USA. We carried out direct imaging using the Seaver Prototype Imaging camera (SPIcam), which is equipped with a backside-illuminated SITe CCD (2048×2048 pixels, pixel scale $0.14''$ pixel^{-1}, field of view $4.78' \times 4.78'$). During the read-out a 2 by 2 binning was applied, resulting in a pixel scale of $0.28''$ pixel^{-1}.

The basic parameters of the observed galaxies are listed in Table 1. The first column contains the galaxy name, the second and third columns its coordinates for the epoch J2000, the forth and fifth columns specify the Galactic extinction in the B and V filters according to Schlegel et al. (1998), the sixth column contains the angular size of the semimajor axis of the galaxy, the seventh column the galaxy's morphological type, and the eighth gives the radial velocity reduced to the Local Group centroid.

The observing log is presented in Table 2. Most of our data were obtained using the standard Johnson B and V filters for SPIcam. In a few cases we used the Kron-Cousins I filter. Detailed filter data are available from the APO web site at `http://www.apo.nmsu.edu/Instruments/filters/broad.html`

The seeing ranged from $1''$ to $1.8''$. Bias frames and twilight flats were obtained every night. Also, several Landolt (1992) standard fields were observed every night covering a range of airmasses.

Only one of the galaxies (Arp-loop) observed on 2000 February 9 was included in Table 2, since the other galaxies observed during this night were too heavily affected by clouds or no galaxy was visible in the field (false detection).

3. Data reduction

The images were processed using the MIDAS package developed at ESO. After bias subtraction and flat-fielding, we removed cosmic ray hits using the FILTER/COSMIC task in MIDAS. Then images obtained in the same filter were

Table 2. Observational log of the nearby dwarf galaxies.

Object	Date	Filter	Exposure s	Airmass
KKH23	03022000	V	300	1.146
		I	2×300	1.168
KKH35	03022000	V	2×300	1.078
		I	2×300	1.077
KK65	03022000	B	300	1.392
		V	300	1.440
KKH46	03022000	B	2×300	1.204
		V	2×300	1.182
KKH51	03022000	B	300	1.250
		V	2×300	1.309
		I	2×300	1.307
KKH54	03022000	B	2×300	1.185
		V	2×300	1.184
FM1	03022000	B	2×300	1.396
		V	2×300	1.418
KK78	03022000	B	300	1.070
		V	300	1.079
Arp-loop	09022000	B	300	1.334
		V	4×300	1.371
KKH57	03022000	B	2×300	1.456
		V	3×300	1.398
KKS19	03022000	B	2×300	1.460
		V	2×300	1.483
KKH67	03022000	B	2×300	1.298
		V	2×300	1.294
KKH70	03022000	B	2×300	1.131
		V	2×300	1.136
KKS25	03022000	B	2×300	1.561
		V	2×300	1.558
UGC 7242	03022000	B	300	1.199
		V	300	1.198
KKH86	03022000	B	2×300	1.158
		V	2×300	1.170

Table 3. Measurement results for the galaxies of the sample.

Object	V_{T}	$(B-V)_{\mathrm{T}}$ $(V-I)_{\mathrm{T}}$	$\mu_B(0)$	M_B
KKH23	16.00 :			
		0.93 :		
KKH35	15.87			
KK65	14.72	0.54	22.5	−11.78
KKH46	16.67	0.38	24.3	−11.98
KKH51	16.48	0.54	24.5	−12.15
		0.77		
KKH54	15.50	0.56	23.8	−13.20
FM1	16.62	0.88	25.4	−10.64
KK78	17.28	0.40	22.6	−10.21
Arp-loop	16.08 :	0.72 :	26.9	−11.41
KKH57	17.12	0.75	25.3	−9.98
KKSG19	16.19	0.60	25.4	−12.14
KKH67	16.82 :	1.05 :	25.7	
KKH70	15.87	0.60	23.5	
KKSG25	17.27	0.54	25.5	−13.10
KKH86	16.21	0.67	24.3	−10.51

co-added. The resulting V-band images are displayed in Fig. 1 (the galaxy KKH 23 is given in the I filter).

Background stars were removed from the frames by fitting a second-degree surface in circular pixel area. The sky background on the image was approximated by a tilted plane, created from a 2-dimensional polynomial, using the least-squares method (FIT/FLAT_SKY). The uncertainties of the sky background determination were about 0.7% of the background level. The value of the surface brightness of the sky is about 22 mag arcsec^{-2} in the B band. Thus, the mean uncertainty introduced by the inaccuracy of the sky background determination is $\leq 0\overset{\mathrm{m}}{.}15$. The size of this uncertainty is primarily caused by the background variations across the frame due to some difficulties of flat-fielding.

The greater part of the sample is comprised of galaxies of extremely low surface brightness. Many objects are characterized by an irregular, clumpy structure. For this reason, we did not approximate the galaxies by ellipses, but used circular apertures. The center of each galaxy was determined interactively.

For the photometric calibration standard stars from the list of Landolt (1992) were used. The observations of the two nights were complicated by the appearance of clouds for 2–3 hours. However, for the rest of the time the conditions were quite photometric judging from APO's 10μ all-sky camera, which continuously monitors the sky above APO. To transform our instrumental magnitudes to the standard Johnson-Cousins system, zero points and color coefficients were determined. We used the extinction coefficients measured by Ted Wyder (`http://www.apo.nmsu.edu/Instruments/Apozeropts.html`). The uncertainties of the transformation to the standard system are $0\overset{\mathrm{m}}{.}05$ in the B filter, $0\overset{\mathrm{m}}{.}07$ in the V filter, and $0\overset{\mathrm{m}}{.}10$ in the I filter.

4. Total magnitudes and surface brightness profiles

To measure total galaxy magnitudes in each band, integrated photometry was performed in increasing circular apertures from a pre-chosen center to the faint outskirts of the galaxies. The total magnitude was then estimated as the asymptotic value of the obtained radial growth curve. The uncertainties of the total magnitude determination were $0\overset{\mathrm{m}}{.}04$ in B, $0\overset{\mathrm{m}}{.}06$ in V, and $0\overset{\mathrm{m}}{.}09$ in I. The measurement results are presented in Table 3. The first column contains the galaxy name, the 2nd and 3rd columns give its total magnitude in the V filter and the color index $B-V$ (in the case of KKH 51 also $V-I$), without correction for the Galactic extinction, the 4th and 5th columns show the central surface brightness, the 6th column gives the absolute stellar magnitude of the galaxies in the B filter corrected for the Galactic extinction according to Schlegel et al. (1998). To calculate the distance, the radial velocity was used, and the Hubble constant was assumed to be 70 km s^{-1} Mpc^{-1}. For the galaxies FM 1, Arp-loop, and KKH 57 the distance modulus of M 81 of to 27.80 mag was taken, since their location makes it highly probable that the given objects belong to the M 81 group. The measurements of some galaxies (marked with a colon) have low accuracy because of light clouds or because of the presence of extremely bright stars in the image. It does not seem possible to determine the parameters of UGC 7242 because of a bright star projected onto it.

For the investigation of dwarf galaxies azimuthally averaged surface brightness profiles have been widely used (Karachentseva et al. 1996; Papaderos et al. 1996; Bremnes et al. 1998). They allow one to improve the accuracy of surface photometry in galaxies of low surface brightness and irregular structure. Azimuthally averaged surface brightness profiles for our galaxies were obtained by differentiating the galaxy growth curves with respect to radius (Bremnes et al. 1998). The resulting profiles in the B (or I) and V colors are displayed in Fig. 2. Most of the galaxies were measured up to the level of 28 to 29 mag arcsec^{-2} in the B filter. Mean uncertainties of the measurements were estimated by intercomparison of individual profiles for the same objects obtained from different frames in the same passband. They amount to about $0\overset{m}{.}05$ at the 23 mag arcsec^{-2} isophotal level and about $0\overset{m}{.}3$ to $0\overset{m}{.}4$ at the 27 mag arcsec^{-2} isophotal level in each of the filters.

By summing up the intrinsic errors indicated above, we derive the final uncertainties of estimating total magnitudes: $0\overset{m}{.}16$ in the B filter, $0\overset{m}{.}18$ in V, and $0\overset{m}{.}20$ in I. The final uncertainties in estimating of surface brightness depends on the SB level of the galaxy itself. The errors at the level of 23 mag arcsec^{-2} are $0\overset{m}{.}16$ in the B filter, $0\overset{m}{.}17$ in V, $0\overset{m}{.}19$ in I. They rise to about $0\overset{m}{.}25$ in B and V at the level of 25–26 mag and amount to about $0\overset{m}{.}35$ to $0\overset{m}{.}55$ at the level of 27–28 mag arcsec^{-2}. The uncertainties in the I filter are higher, and reach to about $0\overset{m}{.}4$ at the level of 26 mag arcsec^{-2}.

We found photometric data in the literature for only one galaxy from our sample: KK 78. The photometry was done by Hopp & Schulte-Ladbeck (1991). The agreement between the two sets of measurements ($B_{\rm our} - B_{\rm HS91} = -0.08$) and ($\mu_B(0)_{\rm our} - \mu_B(0)_{\rm HS91} = 0.1$) is satisfactory.

5. Short description of the galaxies observed

KKH 23. This irregular dwarf galaxy of low surface brightness has not been detected in H I (Karachentsev et al. 2001a). The brightness profile in the V band is well represented by an exponential. The photometry in the I band is unreliable because of the residual background inhomogeneities.

KKH 35. This is an object of extremely low surface brightness at a low galactic latitude ($-4\overset{\circ}{.}6$), showing no structural details. It is utterly invisible in the I band and remains undetected in H I (Karachentsev et al. 2001a). This is probably a faint planetary nebula in the Milky Way or Galactic cirrus.

KK 65. According to Huchtmeier et al. (2000), the radial velocity of this irregular dwarf with respect to the Local Group centroid is only $V_{\rm LG} = +168$ km s^{-1}. This object is located at a distance of $20'$ from another irregular galaxy, UGC 3974, which has nearly the same radial velocity (+161 km s^{-1}). The color index $B-V$ of KK 65 increases slightly from center towards periphery.

KKH 46. The galaxy looks like a group of blue star-like condensations embedded in a common envelope of low surface brightness. It has a corrected radial velocity of +409 km s^{-1} (Karachentsev et al. 2001a). There are no other galaxies with close radial velocities within a projected separation of ∼1.5 Mpc. KKH 46 can be treated as an example of a very isolated dwarf system, where the ongoing star formation process is not initiated by external tidal perturbations.

KKH 51. Judging by the corrected radial velocity $V_{\rm LG} = 438$ km s^{-1} (Karachentsev et al. 2001a) this galaxy is a companion of the giant spiral NGC 2905, which has $V_{\rm LG} = 443$ km s^{-1}. The angular distance between them is $25'$.

KKH 54 = UGC 5209. The galaxy has a radial velocity of +479 km s^{-1} (Karachentsev et al. 2001a). Together with UGC 5186 and UGC 5272 this galaxy is likely to be a member of a very loose group of irregular dwarf galaxies whose radial velocities lie in the interval $V_{\rm LG} = 460$–500 km s^{-1}. The mean color index of the galaxy increases from $B-V = 0\overset{m}{.}48$ at the center to $0\overset{m}{.}60$ at the periphery, which may point to the presence of a more centrally concentrated young population and a more extended old stellar population in the galaxy.

FM 1. This dwarf spheroidal galaxy of very low surface brightness was recently discovered by Froebrich & Meusinger (2000) in searching for new dwarf members of the M 81 group. Karachentsev et al. (2001b) have resolved it into stars with the HST WFPC2 and estimated the distance to be 3.5 Mpc, which confirms the membership of FM 1 in the M 81 group. Photometry of this galaxy is affected by the presence of a bright star $2'$ to the northwest from its center.

KK 78 = UGC 5272b. This blue compact galaxy is located $2'$ southwest of another brighter dwarf system, UGC 5272, with $V_{\rm LG} = 460$ km s^{-1}. From the spectroscopic measurements made by Makarov (private communication) its radial velocity $V_{\rm LG} = 466$ km s^{-1}, which may suggest that the two galaxies are physically related.

A0952+69 = Arp-loop. This is the brightest part of the diffuse circular structure (Arp 1965) that embraces the northern part of M 81. Efremov et al. (1986) have detected quite a few bluish stars and condensations whose origin may be due to the tidal interaction of M 81 with M 82 and NGC 3077. In our CCD frame, two groups of faint objects can be distinguished: one in the east and one in the west with angular sizes of $1\overset{'}{.}0$ and $0\overset{'}{.}6$, respectively. The photometric center was chosen to lie at the eastern spot. As one can see from the brightness profiles, the details of Arp-loop

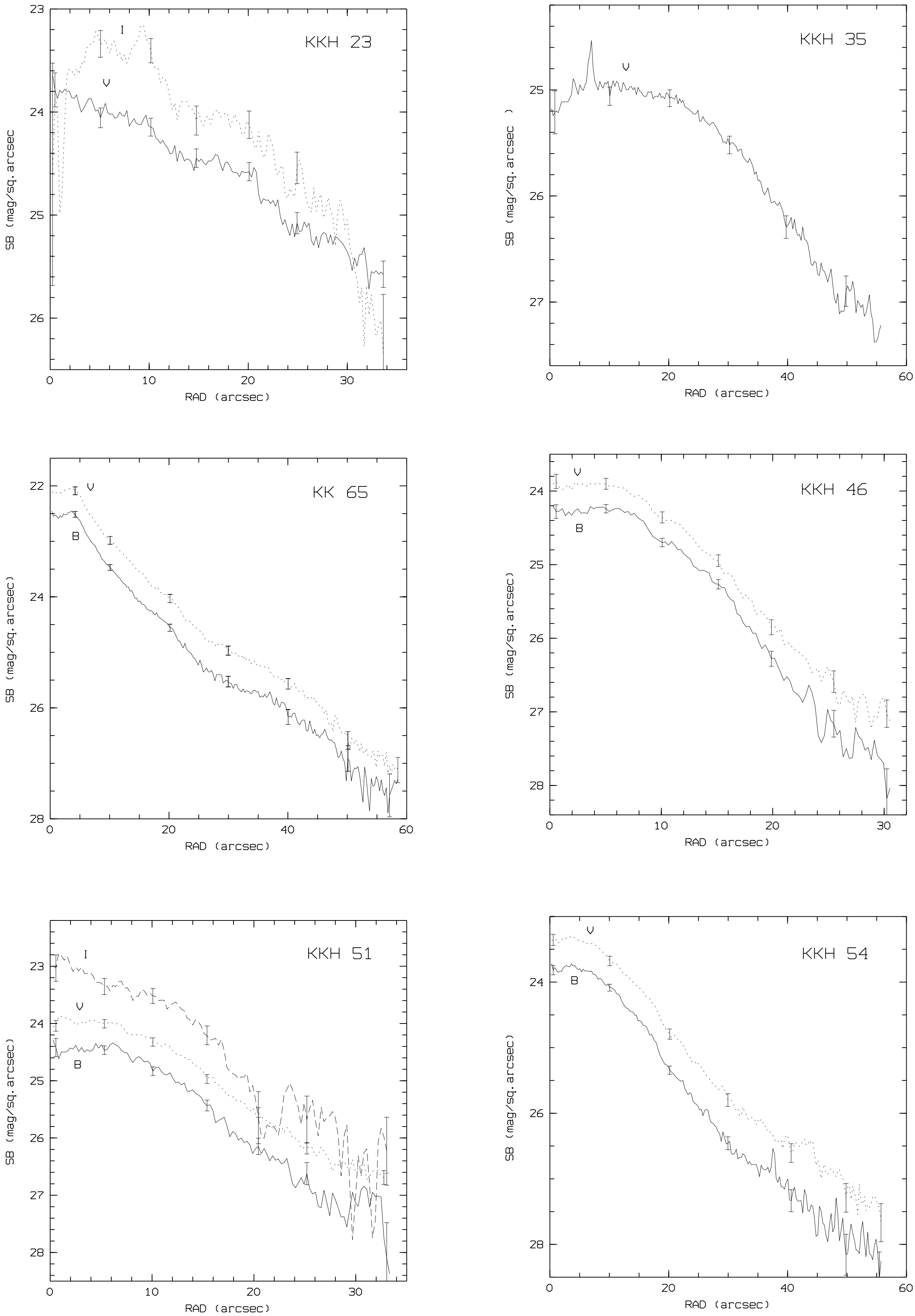

Fig. 2. The azimuthally averaged surface brightness profiles for the nearby dwarf galaxies.

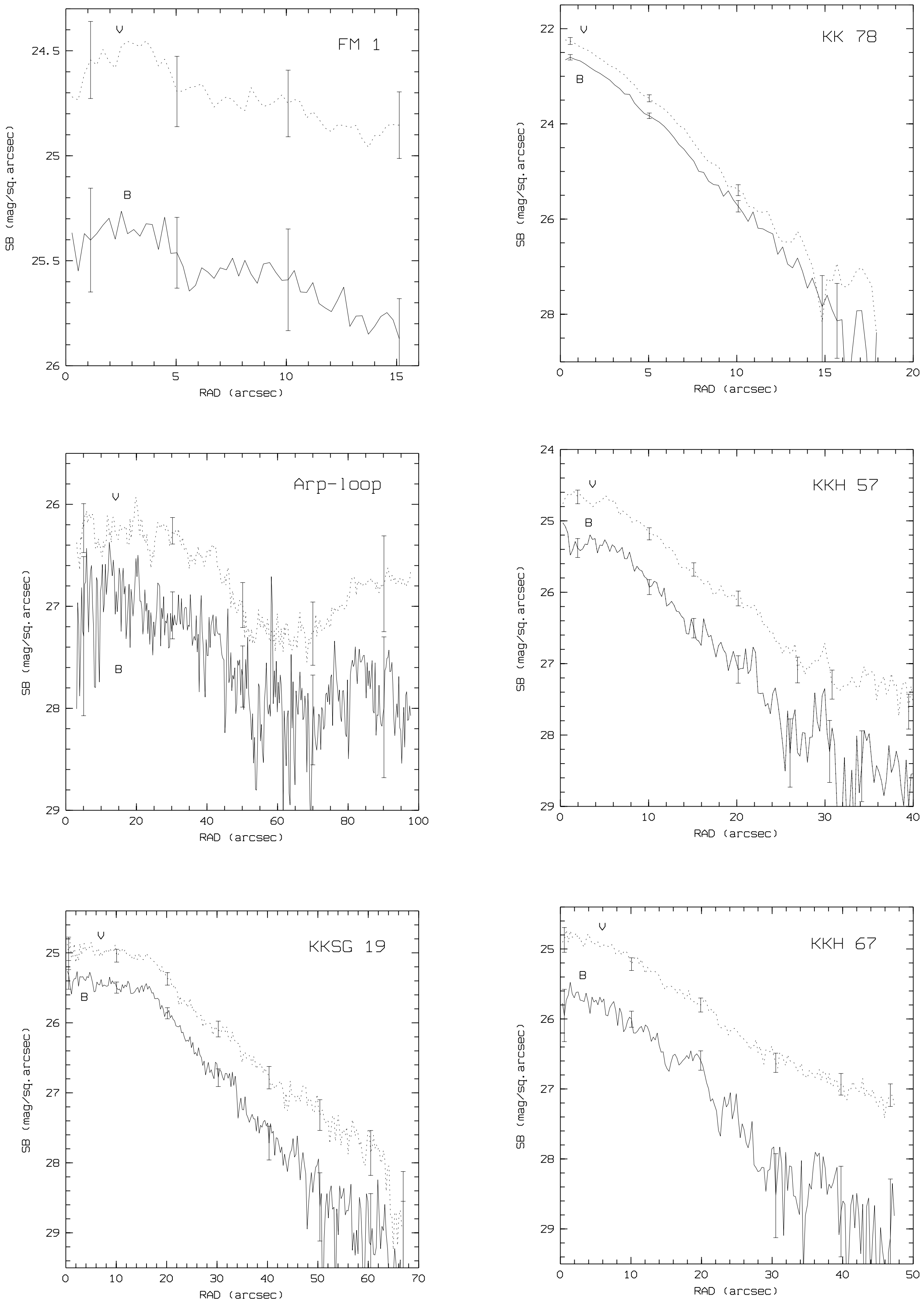

Fig. 2. continued.

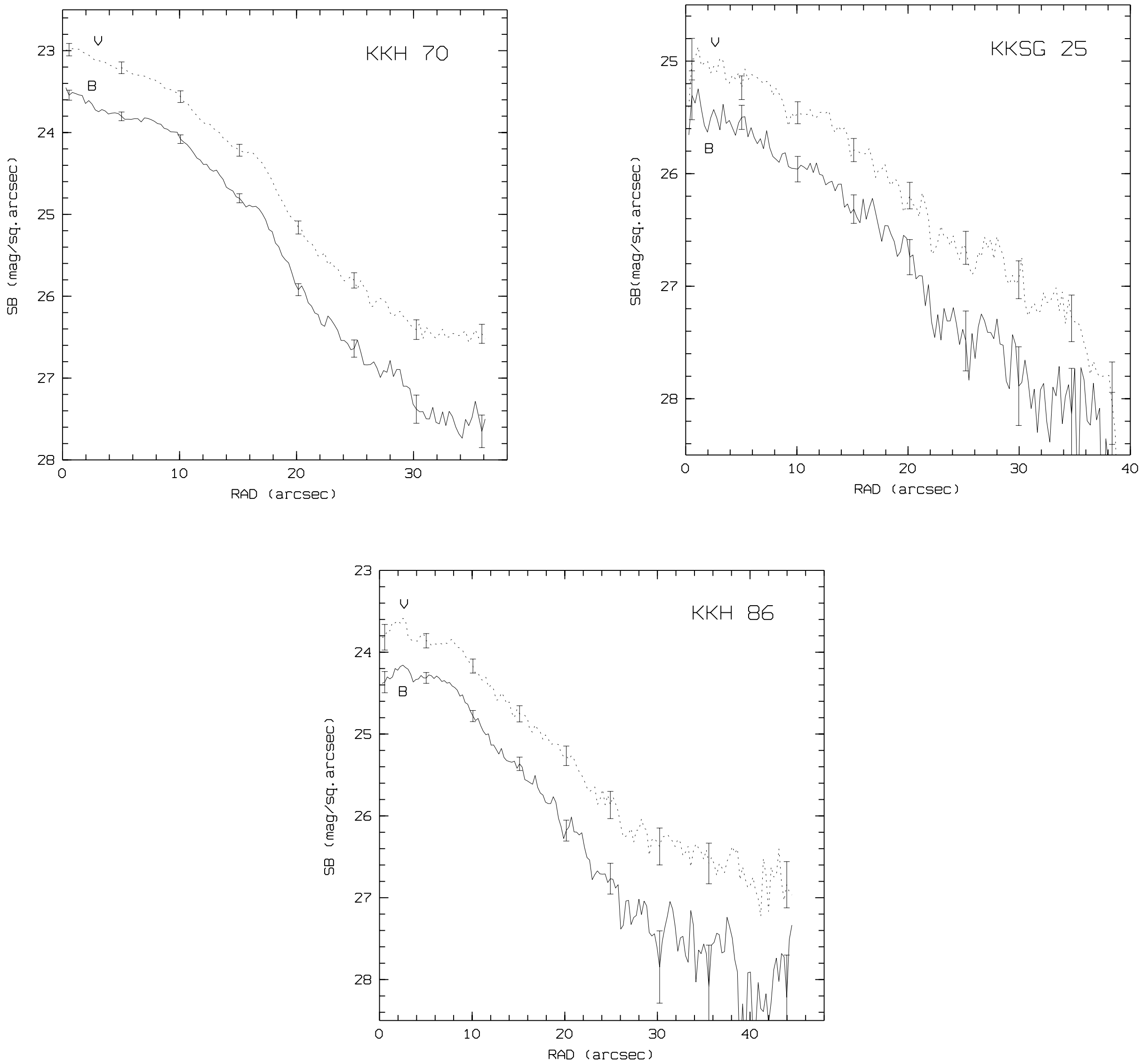

Fig. 2. continued.

have an extremely low surface brightness, which is fainter than 26 mag arcsec^{-2} in the V band. For this reason, the total magnitude $V_{\rm T}$ and the integrated color of the object cannot be determined with satisfactory accuracy.

KKH 57. Just as FM 1 this galaxy is also a dSph member of the M 81 group. The HST observations made it possible to resolve the galaxy into stars and yielded a distance of 3.7 Mpc (Karachentsev et al. 2001b).

KKSG 19. This irregular galaxy of very low surface brightness has a radial velocity $V_{\rm LG} = +373$ km s^{-1} (Huchtmeier et al. 2002). The surface brightness profile shows a plateau in the central part. This galaxy shows a pronounced radial color gradient with an increasingly redder color towards the periphery.

KKH 67. This galaxy of extremely low surface brightness is tentatively classified as dIrr. Karachentsev et al. (2001a) have not detected it in H I. From the integrated color index $(B-V)_{\rm T} = 1\overset{\rm m}{.}05$ it looks more like a dSph than a dIrr.

KKH 70. This is a compact irregular galaxy with blue condensations on the northeastern side. The emission line with $V_{\rm hel} = -154$ km s^{-1} is likely to belong to local Galactic hydrogen (Karachentsev et al. 2001a).

KKSG 25. This is a bluish galaxy of very low surface brightness. Judging by its coordinates and radial velocity, $V_{\rm LG} = +982$ km s^{-1} (Huchtmeier et al. 2002), it may be a member of the southern extension of the Virgo cluster.

UGC 7242 = KKH 77. An irregular dwarf galaxy with a radial velocity of $V_{\rm LG} = +213$ km s^{-1} (Karachentsev et al. 2001a). A very bright star is projected onto its northern side, which strongly complicates the photometry of the galaxy. Together with NGC 4236 and DDO 165 this galaxy forms the eastern spur of the M 81 group.

KKH 86. This is a well isolated irregular galaxy with a radial velocity of $V_{\rm LG} = +205$ km s^{-1} (Karachentsev et al. 2001a). Despite the small radial velocity value, it is not resolved into stars and may belong to the periphery of the Virgo cluster.

6. Discussion of results and conclusions

It is well known that broad-band color indices are fundamental for studying stellar populations in galaxies, and the color variations along the radius reflect inhomogeneities of the stellar component. About half of the galaxies under investigation demonstrate a minor increase in the redness of the total color index $B - V$ center to periphery. This is likely to correspond to the increase in the average age of the stellar population towards the edge of the galaxy. This property of many dwarf galaxies was noticed earlier (Makarova 1999). In particular, a more extended old stellar population is a common property of dwarf galaxies in the Local Group (Grebel 2000). The absence of a noted color gradient for half of the galaxies of our sample may be indicative of a more homogeneous spatial distribution of the stellar populations of different age in these dwarf galaxies, or of a small age and metallicity spread.

The median color index of the measured galaxies is $\langle B - V\rangle = 0\overset{\rm m}{.}50 \pm 0\overset{\rm m}{.}10$. This color index is somewhat redder than in typical LSB galaxies, where $\langle B-V\rangle = 0\overset{\rm m}{.}45$ (McGaugh & Bothun 1994; Vennik et al. 1996).

Figure 3 displays the relationship between central surface brightness of the galaxies of the sample discussed and absolute stellar magnitude in the B filter. All the values are corrected for Galactic extinction. For comparison, similar relations for the spiral galaxies from the paper by van der Kruit (1987), and also for the dwarf galaxies and the galaxies of low surface brightness from the paper by Vennik et al. (1996) and for the dwarf galaxies from the article by Makarova (1999) are plotted in the figure. As can be seen from the figure the galaxies of the present study occupy a rather narrow range of absolute B magnitudes, $\sim -10\overset{\rm m}{.}0$ to $\sim -13\overset{\rm m}{.}2$. Their central surface brightnesses are distributed in the interval from 22 to 25.5 mag arcsec^{-2}. The mean value of the central surface brightness in the B filter (corrected for Galactic extinction) for our galaxies is 24.6 ± 1.3 mag arcsec^{-2}. The nearby dwarf galaxies measured by Vennik et al. (1996) and Makarova (1999) have on the average higher absolute magnitudes and central surface brightnesses. The regions of nearby dwarf galaxies and bright spirals are well-separated. Note that there may be a weak correlation of the absolute stellar magnitude and the central surface brightness for the galaxies indicated in the figure. Such a correlation was noted earlier (Binggeli & Cameron 1991; Vennik et al. 1996 and other authors). There is a noticeable separation in the $M - \mu$ diagram between galaxies of different morphological types. It was suggested by Binggeli (1994) that the $M - \mu$ diagram for stellar systems might be the equivalent of the HR diagram for stars (see Fig. 1 of his review).

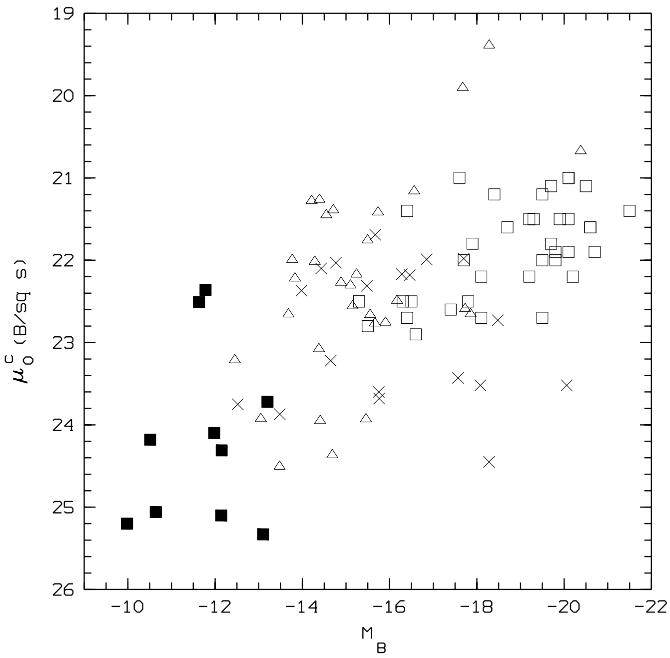

Fig. 3. The central surface brightness in B band versus the absolute B-magnitude. The filled squares are our measured galaxies, the triangles are the galaxies from the paper by Makarova (1999), crosses are the low surface brightness galaxies from the article by Vennik et al. (1996), and open squares are the spiral galaxies from the work of van der Kruit (1987).

McGaugh & Bothun (1994) believe that the distribution of galaxies in the (μ_0, M_B) plane may reflect the initial conditions of formation of these objects. The luminosity corresponds approximately to the mass enclosed in the density fluctuation from which the galaxy formed, while the surface brightness corresponds to the density gradient in this fluctuation.

Acknowledgements. We are very grateful to D. I. Makarov for kindly making available to us the results of the radial velocity measurement of KK 78. IDK and EKG would like to thank the staff at Apache Point Observatory for their support during the on-site and remote observations. The work of LNM was supported by INTAS grant YSF 2001/1-0129. IDK and EKG acknowledge support through the Henri Chrétien International Research Grant administered by the American Astronomical Society, which made it possible to obtain the data presented here. EKG was supported by NASA through grant HF-01108.01-98A from the Space Telescope Science Institute during part of this work.

References

Arp, H. C. 1965, Nature, 148, 363

Binggeli, B. 1994, ESO Conf. Workshop Proc., 49, ed. G. Meylan, & P. Prugniel

Binggeli, B., & Cameron, L. M. 1991, A&A, 252, 27

Bremnes, T., Binggeli, B., & Prugniel, P. 1998, A&AS, 129, 313
Bremnes, T., Binggeli, B., & Prugniel, P. 1999, A&AS, 137, 337
Efremov, Yu. N., Karachentsev, I. D., & Karachentseva, V. E. 1986, PAZh, 12, 434
Froebrich, D., & Meusinger, H. 2000, A&AS, 145, 229
Grebel, E. K. 2000, in 33rd ESLAB Symp., Star formation from the small to the large scale, ESA SP-445, ed. F. Favata, A. A. Kaas, & A. Wilson (Noordwijk: ESA), 87
Jerjen, H., Binggeli, B., & Freeman, K. C. 2000, AJ, 119, 593
Hopp, U., & Schulte-Ladbeck, R. E. 1991, A&A, 248, 1
Hopp, U., & Schulte-Ladbeck, R. E. 1995, A&AS, 111, 527
Huchtmeier, W. K., Karachentsev, I. D., Karachentseva, V. E., & Ehle, M. 2000, A&AS, 141, 469
Huchtmeier, W. K., Karachentsev, I. D., & Karachentseva, V. E. 2002, A&A, accepted
Karachentseva, V., Prugniel, P., Vennik, J., et al. 1996, A&AS, 117, 343
Karachentseva, V. E., & Karachentsev, I. D. 1998, A&AS, 127, 409
Karachentsev, I. D., Karachentseva, V. E., Suchkov, A. A., & Grebel, E. K. 2000, A&AS, 145, 415
Karachentsev, I. D., Karachentseva, V. E., & Huchtmeier, W. K. 2001a, A&A, 366, 428
Karachentsev, I. D., Sharina, M. E., Dolphin, A. E., et al. 2001b, A&A, 375, 359
Landolt, A. 1992, AJ, 104, 340
Makarova, L. 1999, A&AS, 139, 491
McGaugh, S. S., & Bothun, G. D. 1994, AJ, 107, 530
Papaderos, P., Loose, H.-H., Thuan, T., & Fricke, K. 1996, A&AS, 120, 207
Schlegel, D. J., Finkbeiner, D. P., & Davis, M. 1998, ApJ, 500, 525
van der Kruit, P. 1987, A&A, 173, 59
Vennik, J., Richter, G., Thanert, W., & Biering, C. 1996, Astron. Nachr., 317, 289