Cam A: a new dwarf low-surface-brightness galaxy on the Local Group outskirts?

I. D. Karachentsev, L. N. Makarova and M. I. Andersen

1 Special Astrophysical Observatory, Russian Academy of Sciences, N. Arkhyz, KChR 357147, Russia
2 Nordic Optical Telescope, Observatorio del Roque de los Muchachos, Apartado 474, E-38700 Santa Cruz de La Palma, Spain

Accepted 1999 June 8. Received 1999 June 8; in original form 1999 March 18

ABSTRACT

We present a deep I-band image of the nearby dwarf irregular galaxy Cam A obtained with the Nordic Optical Telescope with 0.6-arcsec seeing (FWHM). The distance to Cam A, $D_{\text{MW}} = 1.9$ Mpc, is estimated from the tip of the red giant branch seen at $I = 22.8 \pm 0.2$ mag. The youngest stellar population of the galaxy seems to be of age about 100 Myr. Relying on its barycentric distance, $D_{\text{LG}} = 1.6$ Mpc, Cam A may be considered as a new probable peripheral member of the Local Group, or a member of the small group situated between the IC 342/Maffei group and the Local Group.

Key words: galaxies: individual: Cam A – Local Group – galaxies: stellar content.

1 INTRODUCTION

A new low-surface-brightness galaxy with an angular diameter $\sim 3$ arcmin was found in the constellation Camelopardalis on the POSS-I prints by Karachentsev (1994). This exemplified the incompleteness of existing catalogues, particularly the Uppsala General Catalogue of Galaxies (UGC) (Nilson 1973, 1974). This object, called Cam A, is included in the list of nearby dwarf galaxy candidates by Karachentseva & Karachentsev (1998). Karachentsev et al. (1997) have noted Cam A as a probable member of the IC 342/Maffei group. A detailed surface photometry of the galaxy in the $B$ and $V$ bands was carried out by Karachentseva et al. (1996) at the Observatoire de Haute-Provence (OHP) 1.2-m telescope. In 1994 Cam A was observed with the 6-m telescope CCD camera, which allows us to resolve its central part into stars. A reproduction of Cam A from the Digital POSS-I is presented in Fig. 1. The galaxy has a rather asymmetric shape, which is also seen on its isophotes presented by Karachentseva et al. (1996).

2 OBSERVATIONS

Cam A was imaged on 1995 February 6 at the Nordic 2.56-m telescope with a seeing of 0.9 arcsec (FWHM). Two exposures were obtained in the $V$ (600-s) and $I$ (600-s) bands. The observations were carried out with a 1k×1k CCD, which provided a 3.0×3.0 arcmin$^2$ field of view and a resolution of 0.176 arcsec pixel$^{-1}$. Standard stars from Landolt (1992) were used for calibration.

The next observations were obtained in 1998 September 28 at the same telescope, but with the High Resolution Adaptive Camera (HiRAC) CCD camera providing a 3.8×3.8 arcmin$^2$ field of view with a 0.11 arcsec pixel$^{-1}$ scale. 8 600-s exposures in the $I$ band with a seeing of 0.6 arcsec were obtained. Fig. 2 shows the resulting composite image of the galaxy. The central (55×55 arcsec$^2$) part of Cam A is reproduced from this frame in Fig. 3. As one can see, the galaxy appears well resolved into numerous faint stars. Automatic search and photometry of these stars was performed with the DAOPHOT-II package (Stetson 1987).

3 RESULTS

Fig. 4 shows the colour–magnitude (CM) diagram derived from the first pair of images ($V$ and $I$). The stars located inside and outside the apparent boundary of the galaxy are indicated by squares and crosses, respectively. Because Cam A lies at a low Galactic latitude, $b = 16^\circ 2$, foreground stars dominate among the

Table 1. Properties of Cam A.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cam A</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA (1950.0)</td>
<td>$04^h19^m26^s7$</td>
</tr>
<tr>
<td>Dec. (1950.0)</td>
<td>$+72^\circ17'27''7$</td>
</tr>
<tr>
<td>Morphological type</td>
<td>Irr (LSB)</td>
</tr>
<tr>
<td>Angular diameter, $a_{26.5}$</td>
<td>2.6 arcmin</td>
</tr>
<tr>
<td>Axial ratio</td>
<td>0.57</td>
</tr>
<tr>
<td>Central surface brightness, $\mu_{0,B}$</td>
<td>24.2 mag arcsec$^{-2}$</td>
</tr>
<tr>
<td>$(B - V)_T$</td>
<td>14.84 mag</td>
</tr>
<tr>
<td>$0.83$ mag</td>
<td></td>
</tr>
<tr>
<td>Galactic latitude</td>
<td>$16^\circ 2$</td>
</tr>
<tr>
<td>Extinction, $A_B/A_I$</td>
<td>0.93 mag/0.42 mag</td>
</tr>
<tr>
<td>$(B - V)_T$</td>
<td>0.62</td>
</tr>
<tr>
<td>$I_{\text{RGB}}$</td>
<td>22.6 mag $\pm 0.2$</td>
</tr>
<tr>
<td>$(m - M)_0$</td>
<td>26.38 mag</td>
</tr>
<tr>
<td>Distance, $D_{\text{MW}}$</td>
<td>1.9 Mpc</td>
</tr>
<tr>
<td>Linear diameter, $A_{26.5}$</td>
<td>1.43 kpc</td>
</tr>
<tr>
<td>Absolute magnitude, $M_B$</td>
<td>$-12.47$ mag</td>
</tr>
<tr>
<td>Heliocentric velocity, $V_h$</td>
<td>$-127(?)$ km s$^{-1}$</td>
</tr>
<tr>
<td>Corrected velocity, $V_0$</td>
<td>$+79(?)$ km s$^{-1}$</td>
</tr>
</tbody>
</table>
Figure 1. Reproduction of Cam A from the Digital Palomar Observatory Sky Survey. The field size is \(6 \times 6\) arcmin\(^2\); north is to the top and east to the left.

Figure 2. \(I\)-band image (4800-s) of Cam A obtained with the HiRAC CCD camera on the Nordic 2.56-m telescope in 1998 September. The frame size is \(3.8 \times 3.8\) arcmin\(^2\). The seeing is 0.6 arcsec. The measured stars are indicated with squares.
A new nearby dwarf galaxy

bright \((I < 21\) mag) stars. On the CM diagram one can distinguish a group of bluish stars with \((I) = 22\) mag and \((V - I) = +0.35\), which obviously belong to the brightest population of the galaxy. According to Schlegel, Finkbeiner & Davis (1998), the Galactic reddening in the Cam A direction is \(E(B-V) = 0.21\) or \(E(B-V) = 0.26\), which leads to a corrected colour of these stars, \((B-V)_0 = +0.08\), typical for the blue supergiant branch. However, the scanty statistics do not allow a distance estimate to Cam A from these data.

The recently obtained composite image of the galaxy in the \(I\) band with FWHM = 0.61 arcsec reaches a deeper limit. Over the whole field, \textsc{daophot} detected more than 1400 stars, and about

\[1.33\] from Bertelli et al. (1994).

\[2.19\]

\[2.35\]

\[2.42\]

\[2.57\]

\[2.72\]

\[2.88\] from Bertelli et al. (1994).

\[2.10\]

\[2.10\]

\[2.10\]

\[2.10\]

\[2.10\]
3/4 of them are concentrated within the apparent boundary of Cam A. Their differential number counts are shown in Fig. 5. The dots correspond to the star numbers obtained by a running average with a window of 0.15 mag, while the dashed line represents the number of foreground stars normalized to the same area. The data show that the galaxy luminosity function rises steeply at \( I = 22.8 \pm 0.2 \). Assuming that this rise is caused by the red giant branch, which appears at \( M_I = -4.0 \) (Lee, Freedman & Madore 1993), we derive the distance modulus \((m - M)_0 = 26.38 \pm 0.2\), adopting an extinction \( A_I = 0.42 \).

The \( V, V - I \) diagram for Cam A was also presented by Gallart et al. (1999) at the recent IAU Symposium 192 in Capetown. Their CMD reaches about \( I = 24 \) and finds the overdensity of red stars with \( (V - I) = 2 \) fainter than \( I \sim 23 \). At the same time, Gallart et al. note the danger of trying to estimate the distance to Cam A when only limited data are available, because recent bursts of star formation in irregulars like Cam A can produce a significant population of stars brighter than usually found at the tip of the RGB.

4 DISCUSSION

With the resulting distance from the Milky Way, \( D_{MW} = 1.9 \pm 0.2 \) Mpc, the dwarf system Cam A is situated slightly further away than known peripheral members of the Local Group: Sex A, Sex B and Antlia. The distance from the Local Group barycentre to Cam A, \( D_{LG} = 1.6 \) Mpc, is even smaller than the distances to these dwarf galaxies. The barycentric distance to Cam A approximately equals the radius of the ‘zero-velocity sphere’ of the Local Group, which is about 1.5 Mpc according to Sandage (1986). It suggests that Cam A is a probable member of the Local Group, where two giant spiral galaxies, M 31 and the Milky Way, govern the kinematics of other galaxies.

A summary of the basic characteristics of Cam A is given in Table 1. The photometric data were taken from Karachentseva et al. (1996). Judging by the rather asymmetric shape of the galaxy, as well as its colour index \((B - V)_0 = 0.62\), Cam A is certainly an irregular dwarf galaxy. The 100-Myr isochrone from Bertelli et al. (1994), which is shown in Fig. 4, shows the presence of bright blue stars with an age of 60–100 Myr. Such galaxies usually have a significant amount of gas and may be detectable in the 21-cm line of neutral hydrogen. A 21-cm line observation with the Effelsberg 100-m radio telescope (Huchtmeier, private communication) shows weak emission at \( V_b = -127 \pm 3 \) km s\(^{-1}\), which corresponds to the velocity \( V_0 = +79 \) km s\(^{-1}\) after correction for the solar motion with respect to the Local Group centroid (Karachentsev & Makarov 1996). The same feature is also seen in the spectrum of Cam A obtained with the Nancay 300-m radio telescope in the velocity range \([-600, +1600]\) km s\(^{-1}\) by Karachentseva et al. (1996). However, H\(_I\) emission at this radial velocity is widespread in this area of the sky (e.g. Hartmann & Burton 1997). A decision about possible H\(_I\) emission from Cam A can only be made with synthesis observations.

We know there is no straightforward boundary between the Local Group and other prominent nearby groups such as the Sculptor, M81, Centaurus and Maffei/IC 342 groups. Within about 8° from Cam A there are two other nearby dwarf galaxies: NGC 1569 and UGCA 92, with corrected radial velocities 102 and \(+89\) km s\(^{-1}\) and distances 1.7 and 1.8 Mpc, respectively (Karachentsev et al. 1997). It is probable that NGC 1569, UGCA 92 and Cam A constitute a small external grouping, just outside the Local Group ‘boundary’, that merges further out with members of the Maffei/IC 342 group. This small group scenario lends strong support to the putative radial velocity for Cam A as well the nearby distance estimate for it.

ACKNOWLEDGMENTS

We thank J. Lequeux, M. Irwin, W. Huchtmeier and N. Tikhonov for valuable discussions. This work is supported by INTAS-RFBR grant 95-IN-RU-1390 and DFG grant KS-9112.

REFERENCES


This paper has been typeset from a \TeX/\LaTeX\ file prepared by the author.