THE DISTRIBUTION OF ATOMIC HYDROGEN AROUND TWO IRREGULAR GALAXIES

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ABSTRACT

We present radio interferometric observations of two irregular galaxies that were candidates for having unusually extended H i emission. The galaxies, UGC 199 and DDO 26, otherwise appeared to be normal, low-luminosity systems with modest star formation rates. To a detection limit of \((2–3) \times 10^{19} \text{ cm}^{-2}\) at a resolution of about 50" , however, the H i around neither galaxy is unusually extended compared with other irregular galaxies. The H i around UGC 199 appears as a regular, symmetric distribution with regular rotation and a maximum rotation speed of about 80 km s\(^{-1}\). By contrast, the H i around DDO 26 shows a concentration into two blobs with an arm in the outer parts to the northwest and some additional emission to the north-west of that. The kinematical major axis is approximately 75° from the H i and optical morphological axis, which is unusual for Im galaxies. In addition the velocity field in the outer parts of the galaxy is messy, and the velocity profiles at the two H i peaks are broad. We suggest that DDO 26 has been perturbed externally or may be two dwarfs in the process of merging.

Key words: galaxies: individual (UGC 199, DDO 26) — galaxies: irregular — galaxies: ISM — galaxies: kinematics and dynamics

1. INTRODUCTION

The atomic hydrogen gas in and around galaxies is the material out of which star-forming clouds are derived, and hence, the H i plays a crucial role in the evolution of galaxies. We have long been intrigued by the gas that extends beyond, and sometimes well beyond, the optical galaxy. In most irregular galaxies, as in most spiral galaxies, the H i extends to about twice the Holmberg radius \(R_{\text{H}}\), defined as the radius at a photographic surface brightness level of 26.7 mag arcsec\(^{-2}\) (see Fig. 13 of Hunter 1997 and references therein for a compilation of H i extents). However, some galaxies have gas extending as far as 7\(R_{\text{H}}\).

To determine the role of this extended gas in the life of irregular galaxies, we began a radio interferometric study of the gas around those with particularly large H i extents at high enough resolution to see interesting structure if it is present. The general questions we are addressing are (1) What is the structure of extended gas disks around irregular galaxies? (2) What role does this potential gas reservoir play in the evolution of the galaxies? and (3) Can large primordial gas disks around irregular galaxies survive without disruption? These questions are important to understand the internal processes and evolution of irregular galaxies, which are the most numerous type of star-forming galaxy. Additionally if, as studies of damped Ly\(\alpha\) systems indicate, the majority of galaxies were larger H i clouds in their youth (Rao, Turnshek, & Briggs 1995), nearby irregular galaxies with large gas envelopes are local examples of high redshift–damped Ly\(\alpha\) systems, and this has been substantiated with observations of one such irregular galaxy that lies directly in front of a quasar object (Bowen, Tripp, & Jenkins 2002). Understanding the state of these envelopes helps us understand the process of galaxy formation.

Two of the galaxies whose extended gas disks we have studied so far turned out to have H i envelopes that are most definitely not regular quiescent disks. NGC 4449 is nearly surrounded by a large arc of gas that spans roughly 80 kpc (Hunter et al. 1998). Interestingly, not only is this gas cold (velocity dispersions of 5–10 km s\(^{-1}\)), but it is also in regular rotation about the center of the galaxy. H i maps of IC 10 show that the extended gas is concentrated in three armlike structures and that IC 10 is merging with a large infalling cloud currently to the south of the disk (Wilcots & Miller 1998). A third galaxy, Sextans A, by contrast does appear to have a smooth outer H i envelope (Wilcots & Hunter 2002).

To increase our sample, we obtained observations of two galaxies that were candidates for having unusually extended H i gas: UGC 199 and DDO 26 (=UGC 2053). UGC 199 was chosen from the Arecibo Observatory mapping of van Zee, Haynes, & Giovanelli (1995). DDO 26 was chosen from the list of Hunter & Gallagher (1985) that was derived from comparing H i fluxes obtained with single-dish radio telescopes with different beam sizes: the NRAO 140 foot and the NRAO 300 foot telescopes with beam sizes of 21' and 10', respectively. We present the results of new interferometric observations of these two galaxies here and show that, in fact, neither of them is likely to have unusually extended H i emission.

Properties of UGC 199 and DDO 26 are given in Table 1. Both systems are classed as Im galaxies and were not known to be interacting systems. DDO 26 has an \(M_B\) comparable to that of the Small Magellanic Cloud (SMC). We do not yet have an \(M_B\) for UGC 199, but an estimate by van Zee et al. (1995) from a photographic magnitude would place UGC 199 as 2 mag fainter than DDO 26. The star formation rates derived from H\(\alpha\) luminosities are also given in Table 1. DDO 26 has a star formation rate per unit area that
TABLE 1
Galaxy Characteristics

| Quantity                      | UGC 199 | DDO 26 | Reference          |
|-------------------------------|---------|--------|--------------------|
| Morphological type            | Im:     | Im     | RC3                |
| $D$ (Mpc)                     | 29.8    | 17.3   | RC3, $H_0 = 65$ km s$^{-1}$ Mpc$^{-1}$ |
| $R_{25}$ (arcmin)             | 0.46    | 1.02   | RC3                |
| $R_{25}$ (kpc)                | 7.9     | 5.15   | RC3                |
| $E(B-V)$                      | 0.038   | 0.093  | Burstein & Heiles 1984 |
| $E(B-V)^t$                    | ...     | 0.50   | Hunter & Hoffman 1999 |
| $M_B$                         | ...     | -16.68 | RC3                |
| log $L_{H\alpha}$ (ergs s$^{-1}$) | 39.23  | 39.50  | Hunter & Elmegreen 2002 |
| log SFR/area ($M_\odot$ yr$^{-1}$ kpc$^{-2}$) | -3.61  | -3.57  | Hunter & Elmegreen 2002 |

- $E(B-V)^t$ is used to correct the $H\alpha$ luminosity for reddening, in conjunction with the reddening law of Cardelli, Clayton, & Mathis 1989. For UGC 199, we assumed an $E(B-V)^t = E(B-V)^f + 0.1$.
- The star formation rate per unit area (SFR/area) is determined from the $H\alpha$ luminosity and a Salpeter (1955) stellar initial mass function integrated from 0.1 to 100 $M_\odot$ (Hunter & Gallagher 1986). The area is $\pi R_{25}^2$. 

Fig. 1.—21 cm continuum map of the region around UGC 199. The map has been corrected for the attenuation by the primary beam. The continuum sources are numbered as in Table 3. The contour near the center is the outer $H\alpha$ emission contour of UGC 199 shown in Fig. 3 and is $2.2 \times 10^{19}$ cm$^{-2}$. The beam size FWHM (55.2 × 46.9) is shown as the elliptical contour at lower left.
is between that of the SMC and LMC. The star formation rate of UGC 199 is 16 times lower and is typical of irregular galaxies (Hunter 1997). Thus, both objects have relatively low luminosity and appear to be fairly typical Im galaxies.

2. OBSERVATIONS

2.1. H\textsc{i}

We obtained 21 cm line emission observations of UGC 199 and DDO 26 with the Very Large Array\(^1\) (VLA) radio interferometer in its D configuration on 2000 August 5. We chose the D configuration to maximize sensitivity to low column density extended emission. Characteristics of the observations and maps are given in Table 2. The total bandwidth was 1.56 MHz with 128 channels and a channel separation of 12.2 kHz (2.6 km s\(^{-1}\)). The data were on-line Hanning-smoothed, and the resulting velocity resolution is 5 km s\(^{-1}\).

We subtracted the continuum emission in the \(uv\)-plane by using line-free channels on either end of the spectrum. To make maps, we employed a routine in the NRAO Astronomical Image Processing System that enables one to choose a sample weighting that is in between the standard “natural” weighting, which gives the highest signal-to-noise ratio but at the expense of long wings in the beam, and

\(^1\)The VLA is operated by the National Radio Astronomy Observatory (NRAO), which is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.
“uniform” weighting, which gives the best resolution but at
the cost of signal-to-noise ratio and the presence of negative
sidelobes. We chose a sample weighting that gives a formal
increase of only 5% in noise yet with a significant im-
provement in beam profile over what would have been achieved
with “natural” weighting. The resulting synthesized beam
profiles (FWHM) are given in Table 2. We also experi-
enced with naturally weighted maps and with maps

| Quantity                      | UGC 199 | DDO 26 |
|-------------------------------|---------|--------|
| R.A. (J2000.0)                | 00 20 51.4 | 00 20 51.4 |
| Decl. (J2000.0)               | 12 51 39 | 29 45 05 |
| Central velocity (km s⁻¹)     | 1800    | 1034   |
| Time on source (minutes)      | 140     | 145    |
| Beam FWHM (arcsec)            | 55.2 x 46.9 | 51.0 x 45.5 |
| Beam FWHM (kpc)               | 8.0 x 6.8 | 4.3 x 3.8 |
| Single channel rms (Jy beam⁻¹)| 0.94     | 0.96    |
| Integrated H I (M₁)           | 8.5 x 10⁹ | 1.1 x 10⁹ |
| R₁₁ to 3 x 10¹⁹ cm⁻² (arcmin) | 1.5      | 2.4     |
| R₁₁/R₂₅                       | 3.3      | 2.4     |

Fig. 3.—Integrated H I map of UGC 199, shown as contours superposed on our V-band image of the galaxy. The H I contour levels are 2.2, 3.3, 14.5, 25.7,
36.9, 48.0, and 59.2 times 10¹⁹ cm⁻². The beam size FWHM (55.2 x 46.9) is shown as the elliptical contour at lower left.

Note.—Units of right ascension are hours, minutes, and seconds, and units of declination
are degrees, arcminutes, and arcseconds.
smoothed to twice the beam size to explore possible missed emission at low column densities.

We deconvolved the maps until there were roughly comparable numbers of positive and negative components. To remove the portions of each channel map without emission that are only contributing noise to the map, we used the maps smoothed to twice the beam size for a conditional transfer of data in the unsmoothed maps. The channel maps were blanked wherever the flux in the smoothed maps fell below 2.5 $\sigma$. Flux-weighted moment maps were made from the resulting data cube.

2.2. $V$-Band Images

We obtained $V$-band images of UGC 199 with the Perkins 1.8 m telescope at Lowell Observatory in 1998 December and 1999 January. We used a SITe $2048 \times 2048$ CCD binned $4 \times 4$. The pixel scale was $0\farcs61$, and the seeing was $2\farcs2$. The night was clear. We took three 750 s exposures and combined them to remove cosmic rays.

DDO 26 was observed by P. Massey in $V$ band with the Kitt Peak National Observatory 4 m telescope 1997 October. The exposure was a single 60 s image. The detector was...
a Tektronix 2048 × 2048 CCD. The night was clear. The pixel scale was 0.′42 and the seeing was 1′6.

The electronic pedestal was subtracted using the overscan strip. Images were flat-fielded by using observations of the twilight sky.

3. H I RESULTS

3.1. UGC 199

To examine continuum objects in the field of view of the radio map of UGC 199, we constructed and deconvolved maps from the D configuration $uv$ data before the continuum was subtracted. The 21 cm continuum emission is illustrated in Figure 1. An outer H I contour of UGC 199 is shown superposed to outline the galaxy. We have not detected any continuum emission from UGC 199 itself. Other sources in the field of view of the primary beam are listed in Table 3, along with their fluxes.

Channel maps of the H I line emission in UGC 199 are shown in Figure 2. We detected H I from 1740 to 1870 km

![Graph showing the best-fit rotation curve of UGC 199](image)

Fig. 6.—Best-fit rotation curve of UGC 199. The velocity field was fitted in annuli 20′ wide, spaced every 20′. We held the position angle fixed at −82°. This was determined from Fig. 5. We also held the inclination angle fixed at 42°. This was determined from the minor-to-major axis ratio of the integrated H I (Fig. 3) and assumed an intrinsic ratio of 0.3 (Hodge & Hitchcock 1966; van den Bergh 1988). Determination of the central position and central velocity are discussed in the text.

![Image of the region around DDO 26](image)

Fig. 7.—Map of the region around DDO 26, showing the 21-cm continuum. The map has been corrected for the attenuation by the primary beam. The continuum sources are numbered as in Table 4. The contour near the center is the outer H I emission contour of DDO 26 shown in Fig. 10 and is $3.1 \times 10^{19}$ cm$^{-2}$. The beam size FWHM (51′0 × 45′5) is shown as the elliptical contour at lower left.
The channel maps show an elliptical distribution, which does not change significantly from channel to channel and appears to be similar to the beam shape. There is clear evidence of regular rotation.

The integrated HI map is shown superposed on our V-band image in Figure 3. The distribution is smooth and symmetrical. It is elongated at a position angle of $-77^\circ$, close to that of the optical. The minor-to-major axis ratio of the HI is 0.77. If the intrinsic ratio is 0.3, as found in the optical for other irregular galaxies by Hodge & Hitchcock (1966) and van den Bergh (1988), the observed ratio implies an inclination of 42$^\circ$.

The flux in each channel of the HI data cube was integrated over a square $21\arcmin$ on a side to determine the total HI flux detected in the map. The flux was corrected for attenuation by the primary beam. The integrated profile is shown in Figure 4 and compared with the single-dish profile obtained by Schneider et al. (1990). The beam of that observation detects more gas. We detect a total HI mass of $8.5 \times 10^8$ $M_\odot$. For comparison van Zee et al. (1995) give a total HI mass of $8.1 \times 10^8$ $M_\odot$. Thus, our VLA map includes 5% more HI. Maps of our data made with lower resolution but higher signal-to-noise ratio do not detect any more flux.

Velocity field contours are shown superposed on our V-band image in Figure 5. There is clear and regular rotation at a position angle of $-82^\circ$, close to the major axis of the integrated HI distribution. We have determined a rotation curve in the following manner. We began by allowing all parameters to be variables and fitting the entire field with a

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Fig. 8.—Channel maps of HI line emission in DDO 26 made from VLA D configuration observations, showing the inner $9.75 \times 9.75$. The beam size FWHM ($51\arcsec \times 45\arcsec$) is shown in the final panel. Right ascension is marked along the x-axis. The right tick marks an R.A. of $02^h34^m15^s$, the middle tick marks an R.A. of $02^h34^m30^s$, and the left tick marks an R.A. of $02^h34^m45^s$. 

Brandt function. From the resulting solution we fixed the center coordinates at 00h20m50s, 12° 51' 39" (epoch 2000). We then fitted the inner 40° radius of the velocity field with solid-body rotation and from that fixed the systemic velocity at 1800.5 ± 2.0 km s⁻¹. This agreed to 0.3 km s⁻¹ with the systemic velocity determined from the fit with the Brandt function as well. We then fitted tilted-ring models to annuli 20° wide. Here the position angle was fixed at -82° from Figure 5 and the inclination at 42°, as discussed above. The resulting rotation curve is shown in Figure 6. We see UGC 199 attains a rotation speed of about 80 km s⁻¹, for an inclination of 42°.

3.2. DDO 26

To examine continuum objects in the field of view of the radio map of DDO 26, we constructed and deconvolved maps from the D configuration uv data before the continuum was subtracted. The 21 cm continuum emission is illustrated in Figure 7. An outer H i contour of DDO 26 is shown superposed to outline the galaxy. We have not detected any continuum emission from DDO 26 itself. Other sources in the field of view of the primary beam are listed in Table 4, along with their fluxes.

Channel maps of the H i line emission in DDO 26 are shown in Figure 8. We detected H i from 974 to 1078 km s⁻¹. There is clear division into two emission peaks from 977 to 1039 km s⁻¹. The channel maps also show an arm to the northwest of the galaxy center from 1031 to 1068 km s⁻¹. We also display the integrated H i map in Figure 9 so as to bring out the arm.

The integrated H i map is shown superposed on our V-band image in Figure 10 and on the Hα image in Figure 11. The inner H i distribution is elongated along a position angle of 46°. This is rotated about 8° farther to the east than the apparent position angle of the optical distribution that has a major axis position angle of 38° in the V band (see also Swaters 1999). The outer H i contour is close to round even though the center of the H i distribution and the optical are clearly elongated. The second-lowest contour, on the other hand, is more boxy than round. These changes in minor-to-major axis ratio with radius could indicate changes in inclination of the gas disk and be the result of a warp. Warps in gas disks are a common phenomenon, but usually in normal systems they are not as extreme as what we see here.

The integrated H i shows the two peaks with centers about 41″ apart. The H ii regions are clustered around these two peaks. The arm seen in the channel maps is apparent as a bulging of the contours to the northwest of the center of the galaxy. The inner H i distribution and the optical are divorced from the morphology of the H i and optical.

How common is such a large difference in the position angle of the kinematic and morphological major axes in Im galaxies? To address this we examined the sample of Im and Sm galaxies observed by Swaters (1999). We selected from his sample those galaxies with organized velocity fields and with ellipticities greater than 0.1 so that the optical major axis would not be ambiguous. These criteria left 47 galaxies from his larger sample. We determined the difference between the position angles of his H i kinematical axis and his R-band optical morphological axis. We checked most galaxies and adjusted three position angles: one obvious typographical error (UGC 6446) and two that disagreed by large amounts with de Vaucouleurs et al. 1991 (hereafter, RC3) values and with our own V-band image (UGC 10310...
and UGC 11861). The resulting number distribution is shown in Figure 14. The position of DDO 26 is marked. One can clearly see that most Im and Sm galaxies have morphologies and velocity fields that agree within 10°, although there is a tail in the distribution up to 40° difference. Only three galaxies, including DDO 26, have differences larger than this, and all three have differences of 60°–70°. Thus, we see that while DDO 26 is not alone in exhibiting such a large difference, it is unusual compared with most Im and Sm galaxies.

We show a position-velocity diagram in Figure 15 for slices one beam width wide along the optical major axis and the H I kinematic axis. The slice along the optical major axis reflects the two H I peaks and the intensity minimum between them. Otherwise the two slices show a very broad range in velocity at a given location. Figure 16 shows profile cuts at the locations of the two H I peaks, integrated over a square approximating the beam size. One can again see the wide velocity width (44 and 51 km s\(^{-1}\) FWHM). The higher intensity peak (labeled “1” in the figure) has a shallow fall-off to higher velocities, and the lower intensity peak (labeled “2” in the figure) appears to be the blending of two Gaussians.

Clearly, DDO 26 is not kinematically relaxed. The dramatic change in the position angle of the H I distribution, the large offset between the kinematical and morphological major axes, the messy kinematics in the outer parts of the velocity field, the broad profiles of the H I peaks, and the H I arm to the northwest suggest that this galaxy was perturbed sometime in the recent past. There is no obvious perturbing galaxy nearby; the nearest large galaxy (NGC 1012) is 330 kpc distant on the plane of the sky and 42 km s\(^{-1}\) different in radial velocity. However, the double-peaked nature of the H I and optical morphologies suggest another possibility: that DDO 26 consists of two systems in the process of merging. In this scenario, the arm to the northwest would be the result of tidal forces. It is not always easy to tell galaxies that are irregular because of internal processes from galaxies that are irregular because of external processes. Certainly, normal Im galaxies are lumpy in the H I and optical. However, given the unusual characteristics of this system, a merging system is a possibility. If DDO 26 consists of two

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**Fig. 10.** Integrated H I map of DDO 26, shown as contours superposed on our V-band image of the galaxy. The H I contour levels are 3.1, 12.5, 25.0, 37.5, 50.0, 62.5, 75.0, 87.5, 100.0, 112.5, 125.0, and 137.5 times 10\(^{19}\) cm\(^{-2}\). The beam size FWHM (51°50’ × 45°5’) is shown as the elliptical contour at lower left.
systems in the process of becoming one, both the original systems must have consisted of small irregular galaxies to begin with because the mass and luminosity of the combined systems are low.

4. H I extents

4.1. UGC 199

For UGC 199 we measure a maximum H I radius of 1/6 at the outer contour of $2.2 \times 10^{19}$ cm$^{-2}$ in Figure 3. Thus, the H I extent relative to the optical $R_{HI}/R_{25}$ is only 3.6. Estimating $R_{HI}$ as 40% larger than $R_{25}$, we have $R_{HI}/R_{HI} \sim 2.5$. From data compiled from the literature for Im galaxies, Hunter (1997) shows a peak in the distribution of $R_{HI}/R_{HI}$ of 1.5–2. Note, however, that Hunter’s $R_{HI}$ is the extent measured to $1 \times 10^{19}$ cm$^{-2}$. The H I around DDO 26, therefore, is only marginally more extended than that of typical irregular galaxies. There would have to be highly extended H I around UGC 199 at column densities $(1–2) \times 10^{19}$ cm$^{-2}$ for the extent of the H I around UGC 199 to be much larger. Since our smoothed data that reach this sensitivity limit do not pick up any more flux, this possibility seems unlikely.
4.2. DDO 26

For DDO 26 we measure a maximum H\textsc{i} radius of 2.4 at
the outer contour of 3.1 \times 10^{19} \text{ cm}^{-2} in Figure 10. Thus,
R_{\text{H\textsc{i}}}/R_{25} is 2.4. From Swaters' (1999) R-band d_{25}/d_{26.5} ratio
for DDO 26, we estimate R_{\text{H\textsc{i}}}/R_{\text{H}} \sim 1.7, a value that is typical
for Im galaxies. Thus, there would have to be considerable
gas (1–3) \times 10^{19} \text{ cm}^{-2} at large radii for DDO 26 to
have unusually extended H\textsc{i}.

On the other hand, the comparison with Hunter & Gal-
lagher's (1985) single-dish observations indicates that we
have detected only 56\% of the gas emission. Furthermore,
Hunter & Gallagher would predict an H\textsc{i} diameter greater
than 10', a factor of 2 larger than what we detect. There are
three possible explanations. First, the extended emission is
there, but it is larger than the largest structure the VLA D
configuration is sensitive to and is absolutely smooth
beyond our detection radius. This would require that the
missing H\textsc{i} be extended to more than the 15' radius. Since
the two beam sizes in Hunter & Gallagher's flux comparison
were 10' and 21', this is possible.

Fig. 13.—Contours of the velocity field of DDO 26, shown superposed on our V-band image. The contours are 1010 to 1050 km s\(^{-1}\) in steps of 5 km s\(^{-1}\). The first and last two contours are labeled. The beam size FWHM (51'' \times 45'') is shown as the elliptical contour at lower left.

Fig. 14.—Differences between optical and H\textsc{i} kinematical position angles for a sample of 47 Im and Sm galaxies taken from Swaters (1999). We have marked the value for DDO 26.
Second, the missing emission is at a column density below our detection limit of less than $3 \times 10^{19}$. In the worst-case scenario, the missing emission—$9 \times 10^{8} M_{\odot}$—would be spread evenly over an annulus of radius from 2 to 4, the extent that we detect, to 10, the half-beam size of the Hunter & Gallagher (1985) observation. That would be a column density of $1 \times 10^{19} \text{ cm}^{-2}$. Although Figure 10 goes only to $3 \times 10^{19} \text{ cm}^{-2}$, we would easily have detected a column density of $1 \times 10^{19} \text{ cm}^{-2}$ in our smoothed map, and we do not see this emission.

The third explanation is that Hunter & Gallagher (1985) were mistaken and, in fact, the H\textsc{i} emission associated with DDO 26 is not highly extended. That this might be the case is suggested by Figure 12, in which the Hunter & Gallagher integrated profile matches our VLA profile closely in shape but the Hunter & Gallagher profile is offset to higher flux values. If the Hunter & Gallagher profile has a 0.03 Jy pedestal, with a 9% error in the peak, the two profiles could be brought into agreement. If we were simply missing extended H\textsc{i} that Hunter & Gallagher had detected, we might not expect that missing flux to be so evenly distributed in velocity as Figure 12 suggests. Thus, this explanation seems the most likely.

5. SUMMARY

We have presented VLA D configuration observations of two irregular galaxies that were candidates for unusually extended H\textsc{i} emission. The galaxies UGC 199 and DDO 26 otherwise appeared to be normal low-luminosity systems with modest star formation rates. Our VLA data suggest that the H\textsc{i} around these two galaxies is not unusually extended.

The H\textsc{i} around UGC 199 appears as a regular symmetric distribution with regular rotation and a maximum rotation speed of about 80 km s$^{-1}$. We detect H\textsc{i} to 1 at 2.2 $\times$ $10^{19}$ cm$^{-2}$. The ratio $R_{H_{1}}/R_{25}$ is 3.4, which is similar to values for other irregular galaxies.

By contrast, the H\textsc{i} around DDO 26 shows a concentration into two blobs with an arm to the northwest and some additional emission to the northwest of that. The major axis of rotation is 75° from the morphological major axis, and this is unusual for Im and Sm galaxies. We suggest that DDO 26 has been perturbed in some way and that it could consist of two dwarfs in the process of merging. We detect H\textsc{i} to a radius of 2 at $3 \times 10^{19}$ cm$^{-2}$. The ratio $R_{H_{1}}/R_{25}$ is 2.4, which is typical of Im galaxies. However, we find that we are missing 56% of the flux detected in a single-dish observation and conclude that most likely the single-dish observation is in error.

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