The Strange ‘Barred’ Spiral Galaxy ESO 235-58 – A Case of Morphological Deception

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THE STRANGE "BARRED" SPIRAL GALAXY ESO 235−58: A CASE OF MORPHOLOGICAL DECEPTION

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ABSTRACT

On the SRC-J southern sky survey, the galaxy ESO 235−58 ($\alpha=21^\text{h}03^\text{m}$, $\delta=-48^\circ19'$, 1950) looks deceptively like a late-type barred spiral with a weak, broken ring surrounding the bar. However, the bar shows a straight, splitting dust lane, atypical of normal bars but just like what is seen in an edge-on spiral galaxy. In this paper, we use CCD images to show that the apparent bar is indeed likely to be an edge-on galaxy, possibly of Hubble type Sb. The object is part of a group of nine galaxies at a distance of 47 Mpc, and from the photometry we find that the edge-on component has a low luminosity, corresponding to a corrected absolute blue magnitude of $M_B=-18.0$ (for $H_0=100$). The outer spiral part is asymmetric and may be perturbed by one or both of the neighboring large spirals ESO 235−55 and ESO 235−57. Since we can find no evidence for an independent bulge or nucleus of this part, we believe that ESO 235−58 is not simply a case of superposition of two unrelated objects, but instead is an interacting galaxy of the type related to polar rings. This interpretation is supported by preliminary single-dish HI observations and published optical spectroscopy. Here we present mainly $B$ images, a $B−I$ color index map, an unsharp-masked image, integrated parameters, and luminosity profiles of the object to highlight its structural properties.

1. INTRODUCTION

The Catalogue of Southern Ringed Galaxies (Buta 1991, hereafter referred to as CSRG) is the result of a major attempt to classify, measure, and characterize the different ring phenomena in galaxies. The goals of the project are to identify resonances in galaxies and to provide samples for follow-up work needed for probing certain aspects of internal dynamics. The catalogue is being prepared from searches of the very high quality SRC-J southern sky survey, whose advantages have been discussed by Buta (1986) and Buta & Crocker (1991). It was pointed out by Buta & Crocker (1991) that one of the great values of a survey like the CSRG is for the identification of cases of special interest, that is, exceptional examples of rings or other morphological aspects that make some galaxies worthy of a more careful study. In this paper, we bring attention to one of these interesting cases, an object whose peculiar nature was overlooked in three previous extensive catalogues covering the same sky area as the CSRG: the ESO-B Catalogue (Lauberts 1982), the Southern Galaxy Catalogue (Corwin et al. 1985), and the Catalogue of Southern Peculiar Galaxies and Associations (Arp & Madore 1987).

The galaxy in question is known as ESO 235−58. On the SRC−J sky survey, the galaxy at first sight looks like a common late-type barred spiral with a particularly prominent bar encircled by a weak inner pseudoring and two faint outer arms. Figure 1 (Plate 38), based on our $B$-band CCD image, has been printed to emphasize this impression. However, on closer inspection of the Science Research Council image, the apparent bar appears to have a straight dust lane splitting it in two, making it resemble an edge-on galaxy. Figure 2 (upper panel) (Plate 39), which is also based on our $B$-band CCD image, shows this feature very clearly. The dust lanes normally seen in the bars of low inclination galaxies do not bisect the nucleus this way and usually lie on the leading edges of the bar. The presence of the dust lane means that ESO 235−58 is probably not a ringed barred spiral of late Hubble type, but rather is either a case of superposition or is an interacting galaxy of some sort, possibly the kind related to inclined disks and polar rings. If the latter interpretation is correct, ESO 235−58 would be the only example where the inner component has an aligned gaseous disk. We believe the data we present here support this interpretation.

2. OBSERVATIONS

The observations were made on 1992 August 26 with a TEK 1024 CCD array (pixel size 0.43 square) attached to the 1.5 m telescope of Cerro Tololo Inter-American Observatory. The images were obtained in filters which match the Johnson $BV$ and Cousins $I$ systems with total exposures of 1500 s in $B$, 600 s in $V$, and 300 s in $I$. Flat-fielding was accomplished with combined twilight and dome flats, and all reductions were carried out within IRAF.2 The data were calibrated with observations of standard stars from Graham (1982) and Landolt (1992). An independent

1Visiting Astronomer, Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc. (AURA), under cooperative agreement with the National Science Foundation.

2IRAF is distributed by the National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc. (AURA), under cooperative agreement with the National Science Foundation.
dent check on the zero points from these stars is provided by aperture photometry of ESO 235−57, a large edge-on galaxy included within our CCD field. This object was measured in $V$ with three apertures and in $B−V$ with two apertures by Griersmith (1980). For the two apertures having both $V$ and $B−V$, the CCD images give $B$ and $V$ brighter than Griersmith’s measures by $0.050±0.013$ and $0.044±0.025$ mag, respectively. The average difference in $B−V$ (observed minus calculated) is $+0.006±0.013$ mag. The agreement is good, especially for $B−V$, so that our CCD color measurements should be reliable.

3. MORPHOLOGY AND GROUP MEMBERSHIP

The image in Fig. 1 includes most of the area of the TEK 1024 array. It shows that ESO 235−58 does bear a strong resemblance to a late-type ringed, barred spiral, similar to several illustrated in Sandage (1961) and Sandage & Bedke (1988). The dust lane in the apparent bar is remarkably regular in the close-up in the upper panel in Fig. 2, but we have enhanced its visibility in two ways. First, we illustrate in the lower panel of Fig. 2 a $B−I$ color index map, coded such that red features are light and blue features are dark. The lane is very much redder than its surroundings, particularly near the center, and so stands out very clearly. Second, in Fig. 3 we show an unsharp-masked image, constructed by subtracting from the full resolution $B$-band image a median-smoothed image with box size chosen to provide the clearest view of the dust lane. In this image, we see only the apparent bar of ESO 235−58, and it very much resembles such well-known edge-on galaxies as NGC 891 and NGC 4565 (Sandage 1961). There can be little doubt that it really is an edge-on galaxy, possibly of Hubble type Sb based on its apparent bulge-to-disk ratio. The dust lane is very clear near the center and is slightly bowed. It does not split the bulge equally, indicating that the inclination is slightly less than 90°. To get an accurate estimate of the inclination, we fit ellipses to isophotes in the $I$-band to determine the location of the nucleus. The offset of the center of the dust lane from this position is 1.2 arcsec. Given that the dust lane extends to a radius of $\approx 20$ arcsec in the $B−I$ color index map, an inclination between 86° and 87° is implied.

The outer structure of ESO 235−58 appears to consist of a weak ring feature, from which two asymmetric outer arms emerge. This ring is very blue, as shown in the $B−I$ color index map. We used a cursor on a television display to map the feature, and then fitted an ellipse to the $(x,y)$ points. The resulting major and minor axis dimensions were then averaged with two visual estimates from CSRG. The feature is only roughly represented by an ellipse having a major axis diameter of $1.46±0.04$, an axis ratio of $0.39±0.02$, and a major axis position angle of $146°±2°$. The apparent angle between the major axis of the ring and the edge-on part is 40°.

The optical radial velocity of ESO 235−58 has been
measured by da Costa et al. (1984). They derived a velocity of 4342 km s\(^{-1}\) from a cross-correlation analysis of absorption lines and 4267 km s\(^{-1}\) from emission lines. Since the typical errors in the velocity measurements in that paper are quoted to be ±40 km s\(^{-1}\), based on comparison with 21 cm redshifts, the difference between the emission and absorption line radial velocities of ESO 235–58 is not significant.\(^3\)

Two prominent galaxies lie near ESO 235–58: the large edge-on Sbc galaxy ESO 235–57 (see bottom of Fig. 1) and the large face-on Sbc galaxy ESO 235–55. According to Maia et al. (1989), all three galaxies are likely to be part of a group including six other objects (Group 29), whose mean radial velocity, corrected for a dipole Virgocentric flow with infall velocity of 300 km s\(^{-1}\), is 4662 km s\(^{-1}\). Table 1 lists information from RC3 (de Vaucouleurs et al. 1991) for these nine objects. Using a Hubble constant of 100 km s\(^{-1}\) Mpc\(^{-1}\), we will adopt a distance of 46.6 Mpc, which was used to compute the absolute magnitudes in Table 1. It appears that ESO 235–58 is among the lowest luminosity members of the group. On the SRC-J sky survey, none of the other members appears obviously distorted.

### Table 1. MCL group 29 data.\(^a\)

<table>
<thead>
<tr>
<th>Name</th>
<th>(\alpha) (1950)</th>
<th>Type</th>
<th>(B_T)</th>
<th>(M_{B}^n)</th>
<th>(V_{opt})</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESO 235–49</td>
<td>2101.2–4823.3</td>
<td>E:</td>
<td>1.08</td>
<td>13.45</td>
<td>-19.9</td>
</tr>
<tr>
<td>ESO 235–53</td>
<td>2101.8–4759.3</td>
<td>Sb sp</td>
<td>1.40</td>
<td>13.35</td>
<td>-20.0</td>
</tr>
<tr>
<td>ESO 235–55</td>
<td>2102.5–4824.4</td>
<td>SAB(rs)bc</td>
<td>1.56</td>
<td>12.65</td>
<td>-20.7</td>
</tr>
<tr>
<td>ESO 235–57</td>
<td>2102.9–4822.2</td>
<td>Sbc: sp</td>
<td>1.43</td>
<td>13.25</td>
<td>-20.1</td>
</tr>
<tr>
<td>ESO 235–58</td>
<td>2103.0–4819.3</td>
<td>SB(rs)d</td>
<td>1.38</td>
<td>14.82</td>
<td>-18.5</td>
</tr>
<tr>
<td>ESO 286–49</td>
<td>2103.4–4723.3</td>
<td>E+:</td>
<td>1.04</td>
<td>13.90</td>
<td>-19.4</td>
</tr>
<tr>
<td>ESO 286–71</td>
<td>2107.9–4701.0</td>
<td>SB(s)dm:</td>
<td>1.09</td>
<td>13.02</td>
<td>-20.3</td>
</tr>
<tr>
<td>NGC 7014</td>
<td>2104.5–4722.8</td>
<td>E+:</td>
<td>1.26</td>
<td>13.02</td>
<td>-20.3</td>
</tr>
<tr>
<td>NGC 7038</td>
<td>2111.8–4725.7</td>
<td>SAB(s)c:</td>
<td>1.51</td>
<td>12.01</td>
<td>-21.3</td>
</tr>
</tbody>
</table>

Notes to Table 1

\(^a\) Group as defined by Maia, da Costa, and Latham (1989); data are from RC3 (machine version RC3.9a)

In flux terms, Component B will be defined as the difference (A+B)–A.

### Table 2. Definitions of ESO 235–58 components.\(^a\)

<table>
<thead>
<tr>
<th>Component A</th>
<th>Coordinates of center:</th>
<th>0&quot;(^a), 0&quot;(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semimajor axis radius:</td>
<td>24&quot;(^c)</td>
<td></td>
</tr>
<tr>
<td>Axis ratio:</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Position angle:</td>
<td>106(^a)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Components A+B</th>
<th>Coordinates of center:</th>
<th>7&quot;4 west, 2&quot;1 north</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semimajor axis radius:</td>
<td>74&quot;(^c)</td>
<td></td>
</tr>
<tr>
<td>Axis ratio:</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>Position angle:</td>
<td>106(^a)</td>
<td></td>
</tr>
</tbody>
</table>

Notes to Table 2

\(^a\) Component A refers to the edge-on central part. Component B refers to the ring and spiral part outside the area of component A. In flux terms, Component B will be defined as the difference (A+B)–A.
TABLE 3. Integrated magnitudes, colors, and mean surface brightnesses.\(^a\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>A+B</th>
<th>A</th>
<th>B</th>
<th>Total(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(B)</td>
<td>15.31</td>
<td>15.91</td>
<td>15.27</td>
<td></td>
</tr>
<tr>
<td>(B - V)</td>
<td>0.75</td>
<td>0.63</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>(V - I)</td>
<td>1.14</td>
<td>1.29</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>(\mu'(B)) (mag arcsec(^{-2}))</td>
<td>-22.97</td>
<td>25.96</td>
<td>-22.97</td>
<td>-22.97</td>
</tr>
<tr>
<td>(\mu'(I)) (mag arcsec(^{-2}))</td>
<td>-20.58</td>
<td>24.67</td>
<td>-20.58</td>
<td>-20.58</td>
</tr>
<tr>
<td>(B_0)</td>
<td>15.32</td>
<td>15.55</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>((B - V)_0)</td>
<td>0.77</td>
<td>0.49</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>((V - I)_0)</td>
<td>1.15</td>
<td>0.73</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>(M^B_V)</td>
<td>-18.7</td>
<td>-18.0</td>
<td>-17.8</td>
<td>-18.7</td>
</tr>
<tr>
<td>(M^I_J)</td>
<td>-20.3</td>
<td>-19.9</td>
<td>-19.0</td>
<td>-20.3</td>
</tr>
</tbody>
</table>

Notes to TABLE 3

\(^a\) See Table 2 for definitions of components A and B, which refer to limited areas on the images

\(^b\) Integrals of extrapolated elliptically-averaged profiles

galaxies. For this purpose, we have treated the two parts as separate galaxies of different types and inclinations. For Component A, we adopted a Hubble type \(T=3\) (Sb) and a logarithmic axis ratio of \(\log R=0.57\). For Component B we adopted a Hubble type of \(T=7\) (Sd) and a logarithmic axis ratio of \(\log R=0.19\). With these parameters and the galactic extinction, radial velocity, and inclination corrections from RC3, we obtained the corrected magnitudes \(B_0\) and the corrected colors \((B - V)_0\) and \((V - I)_0\) given in Table 3. In Fig. 4, we plot a color–color diagram using the integrated photoelectric colors of 36 early-to-intermediate Hubble-type ringed galaxies to help define the normal galaxy sequence (Buta & Crocker 1992). The ESO 235–58 component colors are indicated by the open circles in this diagram. In spite of the uncertainties in the inclination corrections, the colors of both components lie within the scatter of the normal galaxies, suggesting normal populations of stars.

The mean surface brightnesses, \(\mu^\prime\), in Table 3 are simply defined as magnitude plus 2.5 log(area) of the relevant parts. In the \(I\) band, the two parts have enormously different average surface brightnesses, that for Component B being less than 1% of the night sky brightness and that for Component A being 36% of the night sky brightness. The corrected magnitudes and colors and the adopted distance of 46.6 Mpc were used to derive the absolute magnitudes \(M^B_V\) and \(M^I_J\) given in the last two lines of Table 3. If they are indeed at the same distance, both components are of comparable but relatively low luminosity in blue light, but Component A is more than twice as luminous as Component B in the \(I\) band. This suggests that Component A has the greater amount of mass.

The structure of the system is further illustrated by the profiles in Fig. 5. Here we display a mean profile (filled circles) along the major axis of Component A, extended to as far out into Component B as possible. The profile was constructed using smoothing ranging from full pixel resolution near the center to 8×8 pixel binning in the very outer parts. The major axis color profiles are shown only to \(r=30^\prime\) since they have very low signal-to-noise outside this region. To better determine the luminosity and color distribution beyond the edge-on part, we computed an elliptically-averaged profile with the following ellipse parameters: axis ratio 0.64, position angle 106°, and centered on Component A. The luminosity and color profiles are indicated by the dashed and solid curves in Fig. 5 (see also Table 4). The dashed part of the profile covers Component A and is not meaningful since the adopted ellipse does not have the shape of Component A. However, the profile is
TABLE 4. Azimuthally-averaged profiles.

<table>
<thead>
<tr>
<th>$r$</th>
<th>$\mu_B$</th>
<th>$\mu_B - \mu_V$</th>
<th>$\mu_V - \mu_I$</th>
<th>$r$</th>
<th>$\mu_B$</th>
<th>$\mu_B - \mu_V$</th>
<th>$\mu_V - \mu_I$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>21.27</td>
<td>1.23</td>
<td>1.76</td>
<td>31.00</td>
<td>25.30</td>
<td>0.56</td>
<td>0.72</td>
</tr>
<tr>
<td>0.35</td>
<td>21.27</td>
<td>1.41</td>
<td>2.01</td>
<td>31.40</td>
<td>25.35</td>
<td>0.57</td>
<td>0.73</td>
</tr>
<tr>
<td>0.70</td>
<td>21.27</td>
<td>1.61</td>
<td>2.25</td>
<td>31.75</td>
<td>25.40</td>
<td>0.59</td>
<td>0.74</td>
</tr>
<tr>
<td>1.05</td>
<td>21.27</td>
<td>1.81</td>
<td>2.48</td>
<td>32.10</td>
<td>25.45</td>
<td>0.61</td>
<td>0.75</td>
</tr>
<tr>
<td>1.40</td>
<td>21.27</td>
<td>2.01</td>
<td>2.67</td>
<td>32.45</td>
<td>25.50</td>
<td>0.63</td>
<td>0.76</td>
</tr>
<tr>
<td>1.75</td>
<td>21.27</td>
<td>2.20</td>
<td>2.82</td>
<td>32.80</td>
<td>25.55</td>
<td>0.65</td>
<td>0.77</td>
</tr>
<tr>
<td>2.10</td>
<td>21.27</td>
<td>2.38</td>
<td>2.95</td>
<td>33.15</td>
<td>25.60</td>
<td>0.67</td>
<td>0.78</td>
</tr>
<tr>
<td>2.45</td>
<td>21.27</td>
<td>2.55</td>
<td>3.07</td>
<td>33.50</td>
<td>25.65</td>
<td>0.69</td>
<td>0.79</td>
</tr>
<tr>
<td>2.80</td>
<td>21.27</td>
<td>2.72</td>
<td>3.18</td>
<td>33.85</td>
<td>25.70</td>
<td>0.71</td>
<td>0.80</td>
</tr>
<tr>
<td>3.15</td>
<td>21.27</td>
<td>2.89</td>
<td>3.28</td>
<td>34.20</td>
<td>25.75</td>
<td>0.73</td>
<td>0.81</td>
</tr>
<tr>
<td>3.50</td>
<td>21.27</td>
<td>3.06</td>
<td>3.37</td>
<td>34.55</td>
<td>25.80</td>
<td>0.75</td>
<td>0.82</td>
</tr>
<tr>
<td>3.85</td>
<td>21.27</td>
<td>3.22</td>
<td>3.45</td>
<td>34.90</td>
<td>25.85</td>
<td>0.77</td>
<td>0.83</td>
</tr>
<tr>
<td>4.20</td>
<td>21.27</td>
<td>3.38</td>
<td>3.53</td>
<td>35.25</td>
<td>25.90</td>
<td>0.79</td>
<td>0.84</td>
</tr>
<tr>
<td>4.55</td>
<td>21.27</td>
<td>3.54</td>
<td>3.61</td>
<td>35.60</td>
<td>25.95</td>
<td>0.81</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Notes to Table 4

These profiles are based on averages within elliptical annuli having axis ratio 0.64, position angle 106°, and centered on the edge-on part. Units are mag arcsec$^{-2}$.

fairly meaningful beyond $r=24''$; here we find an approximately constant $B-V$ color index with radius.

In Fig. 6, we focus on the major and minor axis luminosity profiles of Component A in the $I$ band, to minimize the effects of dust (see also Table 5 for these profiles in $B$ and $V$ as well). The dust lane is still significant enough in $I$ to make the minor axis profile asymmetric. The major axis profile is different from those of the normal edge-on Sa, Sb, and Sc galaxies that were studied by van der Kruit & Searle (1981a,b). These showed an exponential decline over the bright part of the disk and a sharp cutoff in the outer parts. The major axis profile of Component A instead shows a significant change in slope at $r \approx 18''$, but not necessarily a cutoff, and the region between the bulge and this radius is not clearly exponential. The hump in the profile may be due in part to the dust lane, but this lane does not extend beyond $r=20''$. The change in slope beyond this radius resembles what is seen in galaxies with lens components (Kormendy 1979) or Type II exponential disks (Freeman 1970), but could also signify some kind of disk truncation as has been seen in A0136-0801 (Schweizer et al. 1983) and in UGC 9796 (Whitmore et al. 1990).

5. IRAS PROPERTIES

We have investigated the infrared properties of ESO 235—58. The galaxy is not listed in the IRAS Point Source Catalogue, but appears in 60 and 100 $\mu m$ FRESCOS from IPAC. The galaxy did not get into the PSC because its image is blended with the images of ESO's 235-55 and 235-57. As a consequence, we cannot determine accurate estimates of the individual fluxes. From the trio as a whole, we obtain fluxes of 1.6 and 7.6 $Jy$ at 60 and 100 $\mu m$, respectively, and only limits of 0.4 and 0.6 $Jy$ at 12 and 25 $\mu m$, respectively. The 60 $\mu m$ FRESCO suggests that each galaxy contributes about a third of the net flux.

6. H I PROPERTIES

In 1993 February, Mathewson (1993) very kindly observed ESO 235—58 at our request for 40 min in the 21 cm
The galaxy is clearly detected in \( \text{H} \text{I} \) and displays a normal double-horned profile characteristic of a rotating disk. The observation has a fairly low signal-to-noise ratio, and in particular there is almost no central emission, but there is sufficient flux in the horns to allow measurement of a fairly accurate systemic velocity and line width. The systemic line of neutral hydrogen with the Parkes 64 m telescope.

The \( \text{H} \text{I} \) data may be used with the Tully–Fisher (TF) relation to gauge the absolute magnitude independent of the redshift, and also to get the hydrogen mass to blue luminosity ratio via the hydrogen index. These quantities offer a point of comparison with more "normal" galaxies.

There are three possible interpretations of the structure of ESO 235—58. The first is that the object really is a barred spiral of late-type with a weak inner pseudoring. This is unlikely because bars normally do not display nucleus-splitting dust lanes, but instead the lanes are offset towards the leading edges of the bar, as in NGC 1300. If normal bar dust lanes cross the center at all, it is usually at an angle to the bar axis, as in NGC 1365 and NGC 5383. These and other examples are illustrated in Sandage (1961) and Sandage & Bedke (1988). However, it may not be impossible for bar dust lanes to be more centered than is typically observed. This is illustrated by the theoretical study of Athanassoula (1992), who investigated the basic parameters which can affect the shapes of normal bar dust lanes. She points out that the dust lanes in the bars resemble her centered shock models, and to these we
would add NGC 5334 from the same atlas. However, the dust lane in ESO 235—58 still clearly differs from these in the way it nearly divides the nucleus along the bar axis. We could find no other examples of bar dust lanes in published atlases that do this, so it seems unlikely that the apparent bar in ESO 235—58 is simply an extreme example of "centered shocks." An additional point is that, if the distance is 46.6 Mpc, the diameter of the inner pseudoring would be 20 kpc, much larger even than the inner rings of high luminosity, early-type SB spirals (Buta & de Vaucouleurs 1982). This fact alone would cast suspicion on the nature of the ring as an ordinary bar-driven feature.

The second possible interpretation is that ESO 235—58 represents the chance superposition of an edge-on Sb spiral and a more face-on Sd spiral at different distances. This is not likely for the following reasons. First, the H I and optical radial velocities are in excellent agreement. The optical velocity definitely refers to the edge-on part, and the
hydrogen index suggests that the H I comes from the more face-on part. Thus, the two parts appear to be at the same distance. Second, we can see no evidence for the interstellar dust medium of the foreground galaxy on the color and luminosity distribution of the background one, nor do we see any evidence for the central area of the foreground galaxy blended with the image of the background one. Third, the edge-on part looks like an Sb galaxy from its bulge-to-disk ratio, yet it has a luminosity which is unusually low for such a Hubble type. Also, its luminosity profile differs from those of typical edge-on Sb galaxies like NGC 891 and 4565.

The final and most promising interpretation is that ESO 235—58 is a low luminosity spiral that is currently suffering an accretion event at a large angle to its plane. This would place the galaxy into the domain of inclined ring galaxies, the most extreme examples of which are the polar ring galaxies. Whitmore et al. (1990) have provided an atlas and discussion of polar ring and related galaxies that can shed some light on the nature of ESO 235—58. The origin of polar rings is uncertain, but it appears that accretion of a gas-rich companion or tidal capture of material from a neighbor galaxy are the most likely interpretations. The presence of an inclined disk of material orbiting a galaxy at a large angle to its plane has made these objects useful for probing the shape of dark matter halos (see, e.g., Whitmore et al. 1987; Sackett & Sparke 1990). Among the best cases which have been kinematically confirmed, the main body is an SO galaxy. Whitmore et al. point out that when viewed from certain projection angles, a polar ring+S0 system can look almost normal, sometimes as an edge-on spiral with an unusually large bulge or as a bar enveloped by a ring. If the main SO part is viewed edge-on, then a true polar ring will always appear with its major axis perpendicular to the edge-on part. Since the observed angle is only 40° for ESO 235—58, then the ring in this case either may not be a true polar ring, or is a true polar ring where the gas orbits are highly noncircular. The latter is possible because the ring does not look very elliptical in projection.

The presence of a dust lane in the central component of ESO 235—58 implies that this component has a gaseous disk. As pointed out by the referee, this would make the galaxy the only known example of a polar ring system where such a disk is aligned with the inner component. The implication is that the interaction involved is very recent, because if the gaseous disk in the central component has enough mass, it could destroy the polar ring eventually, or vice versa. Thus, ESO 235—58 may be providing a rare glimpse of a polar ring in formation. Because of the likelihood of noncircular gas orbits, the object unfortunately may not be useful for saying anything about the shape of the potential. The outer material does not appear to be in a sufficiently relaxed, equilibrium condition.

The appearance of the inclined disk material in ESO 235—58 not just as a ring but as a pseudoring with weak outer arms is a complication that would have to be addressed in any model of the system. Since ESO 235—58 has two massive companions close by, their influence may be significant. However, ESO 235—58 would not be the only polar-ring-related object where spiral arms are part of the inclined disk. In the polar ring atlas of Whitmore et al. (1990), the galaxies NGC 660, NGC 3718, and ESO 79—5 resemble ESO 235—58 in this regard.

A confusing aspect of the system is that we cannot determine which side of the inclined ring part is the near side, since we see no evidence for dust absorption of component A by any part of Component B, unlike what is seen in some classical polar ring galaxies (see, for example, Fig. 3 of Whitmore et al. 1990). This could mean that no part of Component B is in the foreground of Component A, or that Component B is low in dust content. We note, however, that the low luminosity of the components of ESO 235—58 is not unusual for polar ring galaxies. For example, the excellent polar ring system A0136—0801 has a comparable luminosity to ESO 235—58, and others equally faint are listed in Table 6 of Schweizer et al. (1983).

8. CONCLUSIONS

In this paper we have discussed some of the basic properties of ESO 235—58, an obscure southern galaxy that at first sight resembles a late-type barred spiral with a weak inner pseudoring. The presence of a straight, splitting dust lane along the apparent bar is almost a sure sign that this feature is really an edge-on galaxy. In this circumstance, ESO 235—58 is either a case of superposition or is an interacting system related to polar ring galaxies. We believe that the H I and optical data tentatively favor the latter interpretation. Although ESO 235—58 resembles a few of the galaxies in the Whitmore et al. (1990) polar ring galaxy atlas, the symmetry of Component A with its regular splitting dust lane makes it a unique and interesting possible example of an inclined ring galaxy. What remains now is to follow up our present observations with higher resolution spectroscopic (both H I and optical) observations to more definitively establish the nature and dynamics of the system.

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FIG. 1. $B$-band image covering a $5'3 \times 5'1$ area centered between ESO 235—58 (top, middle) and ESO 235—57 (bottom, middle). The image is in units of mag arcsec$^{-2}$ and the greyscale encompasses the range $\mu_B = 18.0$ to $28.0$ mag arcsec$^{-2}$. North is at the top and east to the left. The two stars labeled 1 and 2 are $141'$ apart, and can be used for the scale of the picture.

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Fig. 2. Top frame: $B$-band image of ESO 235$-$58 in units of mag arcsec$^{-2}$. Note the splitting dust lane along the apparent bar. Bottom frame: $B-I$ color index map. The greyscale is such that red features are light and blue features are dark. The $B-I$ range displayed is 1.0 to 3.0. The two labeled stars in Fig. 1 can also be used to estimate the scale of both of these images.

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