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The interstellar medium in the Seyfert galaxy NGC 7172

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ABSTRACT

We present aperture and surface photometry of the Seyfert galaxy NGC 7172, which is a member of the compact group HCG 90, and has a prominent equatorial dust lane. We use the observed colour excess in the dust lane, obtained from broad-band B and V images, to estimate the neutral hydrogen content as $M_{\rm H\,I}^{\rm tot} = 2.6 \times 10^8$ $M_\odot$ and $\log(M_{\rm H\,I}/L_B) = -1.8$. We analyse the flux from NGC 7172 at various wavelengths and discuss the properties of the interstellar medium in the galaxy. Based on the results from surface photometry, and the properties of the interstellar medium, we conclude that the morphology of NGC 7172 is of type S0–Sa.

Key words: galaxies: active – galaxies: individual: NGC 7172 – galaxies: ISM – galaxies: photometry – galaxies: Seyfert – galaxies: structure.

1 INTRODUCTION

Studies of the morphology and stellar content of the host galaxies of Seyfert nuclei (Adams 1977; Simkin, Su & Schwarz 1980; Yee 1983; MacKenty 1990) have shown that almost all Seyferts occur in early-type normal or barred spirals. The disc parameters of the host galaxies are similar to those of normal spirals (Yee 1983; MacKenty 1990; Kotilainen & Ward 1994), while the colours are redder than in the normal galaxies, which is explained as being due to dust extinction in the optical and reradiation from this dust in the infrared (Kotilainen & Ward 1994).

Nuclear activity can influence the interstellar medium in the host galaxy, as evidenced by the detection of extended line-emitting regions on kiloparsec scales in many Seyferts (Unger et al. 1987; Baum & Heckman 1989; Wilson 1992), and theoretical studies of the effect of continuum radiation on the interstellar medium (Begelman 1985; Shanbhag & Kembhavi 1988; Storchi-Bergmann, Mulchaey & Wilson 1992). The interstellar medium is an indicator of star formation activity in galaxies, and an important tool in the study of their structure, dynamics and evolution.

In this paper we report observations of the Seyfert NGC 7172, an Sa(pec)-type spiral galaxy (de Vaucouleurs, de Vaucouleurs & Corwin 1976) with a strong equatorial dust lane. Using colour differences between the dust lane and the body of the galaxy, we obtain an estimate of the total neutral hydrogen content in the dust lane. We further use published far-infrared (FIR) and CO fluxes to study the dust properties in the galaxy.

NGC 7172 belongs to a compact group (HCG 90) including NGC 7173 (E2), NGC 7174 (Sb pec) and NGC 7176 (E0) (Hickson 1982). Sharples et al. (1984) discovered the active nucleus based on a search of galaxies in *HEAO-A2* X-ray source error boxes (Piccinotti et al. 1982). They classified the nucleus as Seyfert 2 on the basis of narrow widths of its emission lines. The nucleus is heavily obscured by the dust lane. The Balmer decrement $\rm H\alpha/H\beta > 6.5$ (Sharples et al. 1984) and polarization studies (Brindle et al. 1990) indicate strong reddening. Assuming case B recombination, the Balmer decrement implies $E(B-V) = 0.77$ mag. For standard Milky Way dust and dust-to-gas ratios this is equivalent to a neutral hydrogen column density $\approx 4 \times 10^{21}$ atom cm^{-2}.

Results from surface photometry of this object in the near-infrared (NIR) and optical wavelengths have been presented in a series of papers by Kotilainen et al. (1992a, b) and Kotilainen, Ward & Williger (1993, hereafter KWW). These studies were, however, restricted to the inner 30-arcsec radius, which is too small to define the disc structure. We present results of surface photometry based on broad-band optical CCD images reaching out to radii of 70 arcsec.

2 OBSERVATIONS AND DATA REDUCTION

BVR CCD images of NGC 7172 were obtained at the prime focus of the CTIO 4-m telescope in 1983 August 17, as a part of a programme (KWW) to study Seyfert galaxies in the Piccinotti sample of hard X-ray-flux-limited AGN (Piccinotti et al. 1982). The seeing was ~1.5 arcsec. The images were bias-subtracted and flat-field-corrected, following the standard procedure. The sky background was subtracted by taking the mean sky value from regions clearly unaffected by the galaxy ($r \geq 100$ arcsec) and stars. The R frame was found to be out of focus, and so the image was not used in surface photometry. The aperture photometry is not as seriously affected, since we obtain the average values over apertures of size larger than the defocused point spread function (PSF) value.

Transformation coefficients to the standard BVR system were derived from observations of six standard stars in the E-region standards list (Graham 1982). The transformation equations relating the instrumental magnitudes to the standard system are

$$B-V=1.348(b-v)-0.230,$$

$$V-R=0.677(v-r)+0.046,$$

$$V \quad =v-1.447-0.235(B-V),$$

where b, v and r are the instrumental magnitudes. No atmospheric extinction correction has been applied to the data since the observations were made close to the meridian, at airmass <1.5. All reductions were performed using IRAF and other associated packages.

2.1 Colour map

The V and R frames were aligned to the B frame using stars in the frames and applying a shift + rotation transformation. $B-V$ and $V-R$ colour maps were then obtained. Fig. 1(a) shows the $B-V$ colour map of the galaxy. The $B-V$ and $V-R$ colours of the galaxy are approximately constant outside the dust lane, with mean colours $\langle B-V\rangle=0.90\pm0.03$ and $\langle V-R\rangle=0.88\pm0.05$. The bad focus in the R frame would increase the systematic error in the $V-R$ colour about the estimated mean, but not the constancy of the value. We do not, however, use the $V-R$ colour map in further analysis.

Fig. 1(b) shows a plot of the $B-V$ colour across the dust lane. Along the dust lane, the colours indicate an increase in reddening towards the centre (Fig. 1a). There is an extremely blue region of size ≈ 13 arcsec, about ≈ 45 arcsec east of the nucleus. The colour of this region, corrected for an $E(B-V)=0.77$ (Sharples et al. 1984), is $B-V=-0.25\pm0.05$. This value compares well with the colours of giant extragalactic H II regions with massive stars (Mayya 1993).

2.2 Aperture photometry

BVR magnitudes of the galaxy were obtained using circular apertures of sizes 3, 6, 9, 12, 18 and 24 arcsec diameter on the images, with the origin on the central pixel of the galaxy. The magnitudes, zero-point-calibrated with respect to the estimates of Hamuy & Maza (1987), are listed in Table 1; also tabulated are the magnitudes from these authors and KWW. The magnitudes estimated by us are in agreement with the other estimates, within errors.

2.3 Surface photometry

Elliptical isophotes were fitted to the galaxy using the ellipse-fitting routine in the STSDAS software package, which is based on the method outlined by Jedrzejewski (1987). The foreground stars in the galaxy region were masked and excluded from the isophotal analysis. Ellipses of mean intensity were iteratively fitted to isophotal contours for different lengths of the semimajor axis, starting with trial values of ellipticity, position angle and ellipse centre. The fitting program estimates the first two harmonics of the Fourier series representing the deviations from the trial ellipse, and minimizes these to obtain the best-fitting ellipse. Parameters of this ellipse, such as mean intensity along the isophote, ellipticity and position angle are then estimated. The third and fourth harmonics of the residual intensity from the best-fitting ellipse are then evaluated using the method of least squares.

The fitting was started from the 6-arcsec isophote, which is unaffected by the seeing PSF of 1.5-arcsec FWHM. Ellipses were fitted outwards up to 70-arcsec radius along the major axis, and inwards up to the centre. The semimajor axis length for each successive ellipse was increased (or decreased) by 10 per cent. The ellipse centre was held fixed during the fitting. In Fig. 2, we show the isophotal contours with the fitted ellipses. The latter are seen to fit well to the contours outside the dust lane.

3 ANALYSIS AND RESULTS

3.1 Estimation of neutral hydrogen

H I 21-cm line studies by Bottinelli, Gouguenheim & Paturel (1980) give an upper limit to the total neutral hydrogen content as $M_{\mathrm{H\,I}}<7.4\times10^{8}\,\mathrm{M}_{\odot}$. X-ray observations imply a high absorbing column $N_{\mathrm{H\,I}}=9^{+10}_{-9}\times10^{22}\ \mathrm{cm}^{-2}$, an order of magnitude greater than that implied by the IR and optical extinction, and also 21-cm line measurements (Turner & Pounds 1989; Warwick et al. 1993). The Galactic foreground reddening to NGC 7172 is small, $N_{\mathrm{H}}(21\ \mathrm{cm})=1.65\times10^{20}$ atom cm^{-2} (Elvis, Lockman & Wilkes 1989).

Table 1. Aperture photometry.

Filter	Aperture Size (arcsec)	This Work	K et al[1]	HM[2]
B	3.0	17.82	17.47	
	6.0	16.63	16.38	
	9.0	16.02	15.84	
	12.0	15.60	15.47	
	18.0	15.04		15.10
	24.0	14.67		14.61
V	3.0	16.48	16.33	
	6.0	15.35	15.22	
	9.0	14.80	14.70	
	12.0	14.41	14.34	
	18.0	13.91		13.97
	24.0	13.58		13.51
R	3.0	15.95	15.50	
	6.0	14.73	14.47	
	9.0	14.12	13.96	
	12.0	13.71	13.59	
	18.0	13.18		13.22
	24.0	12.83		12.78

[1]KWW.
[2]Hamuy & Maza (1987).

We estimate here the neutral hydrogen content using the optical extinction due to dust measured from the $B-V$ image. The extinction $E(B-V)$ in the dust lane is estimated as

$$E(B-V)=(B-V)_{\text{dust}}-(B-V)_{\text{gal}}.$$

3.1.1 *Effective optical depth*

If we assume very little or no extinction in the galaxy outside the dust lane, then an estimate of the unobscured galaxy intensity along the dust lane may be obtained from a smooth model of the galaxy generated using parameters of the fitted ellipses. The task BMODEL in STSDAS has been used to construct such a smooth galaxy model, linearly interpolating the intensity values between the ellipses. The observed intensities when divided by the model galaxy give an estimate of the optical depth A_λ across the dust lane.

We have obtained the optical depth in both B and V bands in this manner, and find the values to be close to unity except in the dust obscured regions. Using a 3×9 arcsec^2 aperture along the dust lane, we estimate the ratio A_B/A_V and find it to be nearly constant, with mean value $\langle A_B/A_V\rangle=1.27\pm0.2$. This value is similar to that determined for the interstellar

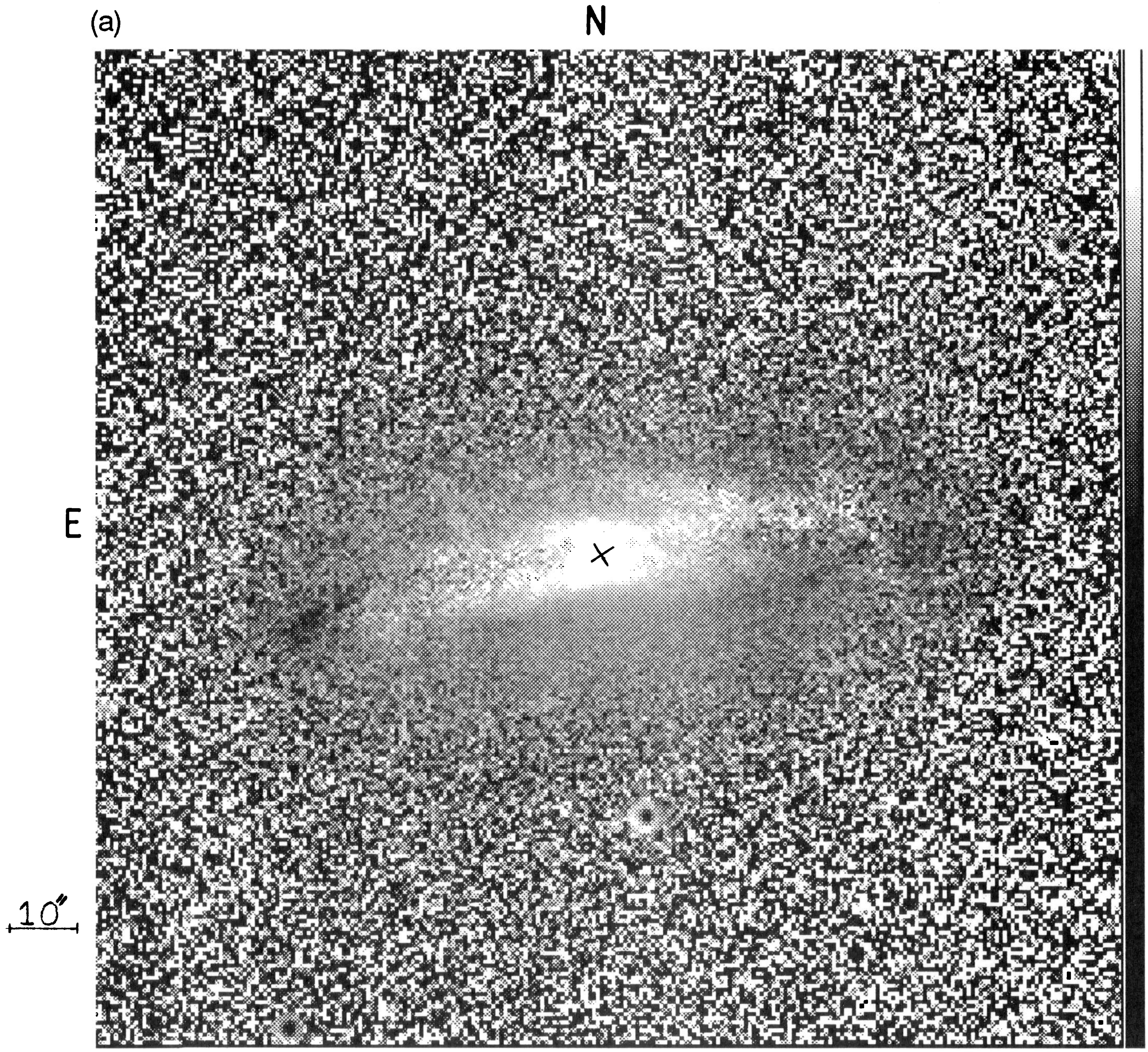

Figure 1. (a) $B-V$ colour map of NGC 7172. Lighter regions correspond to redder colours. Range in $B-V$ is between 2.5 and 0.52 mag. X denotes the centre. (b) $B-V$ across the galaxy, averaged over 10 pixels about the centre, showing the increase in reddening due to the dust lane. Scale: 1 pixel = 0.6 arcsec. Pixel 122 corresponds to the centre of the galaxy.

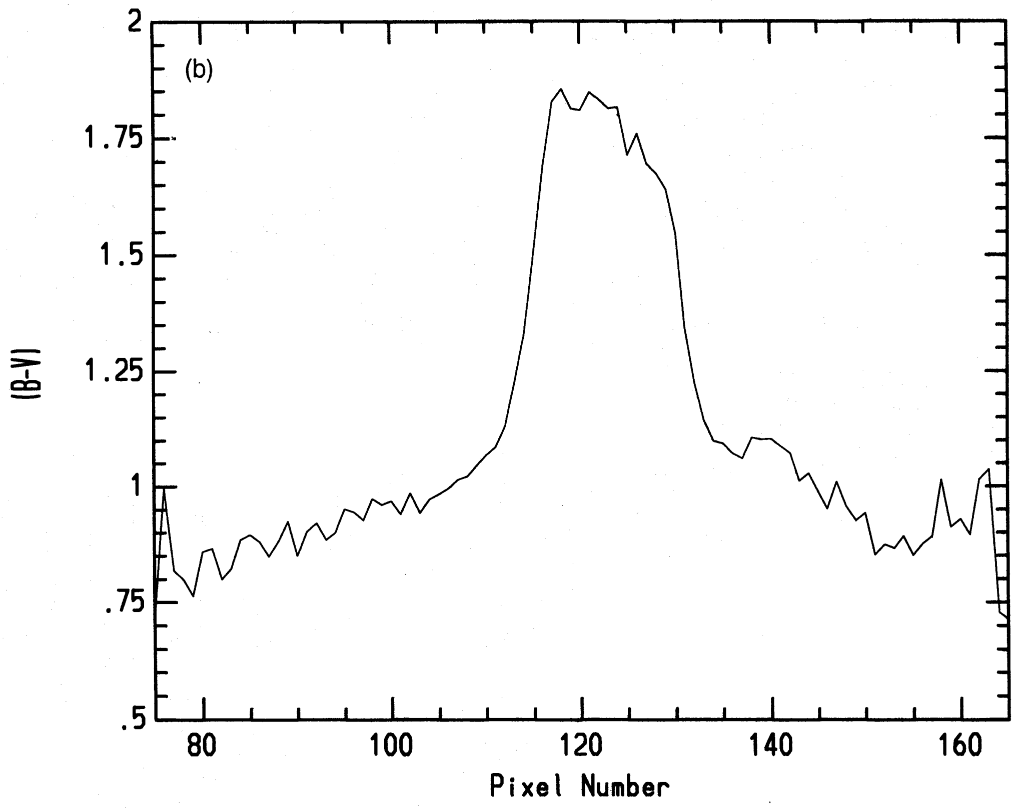

Figure 1 – *continued*

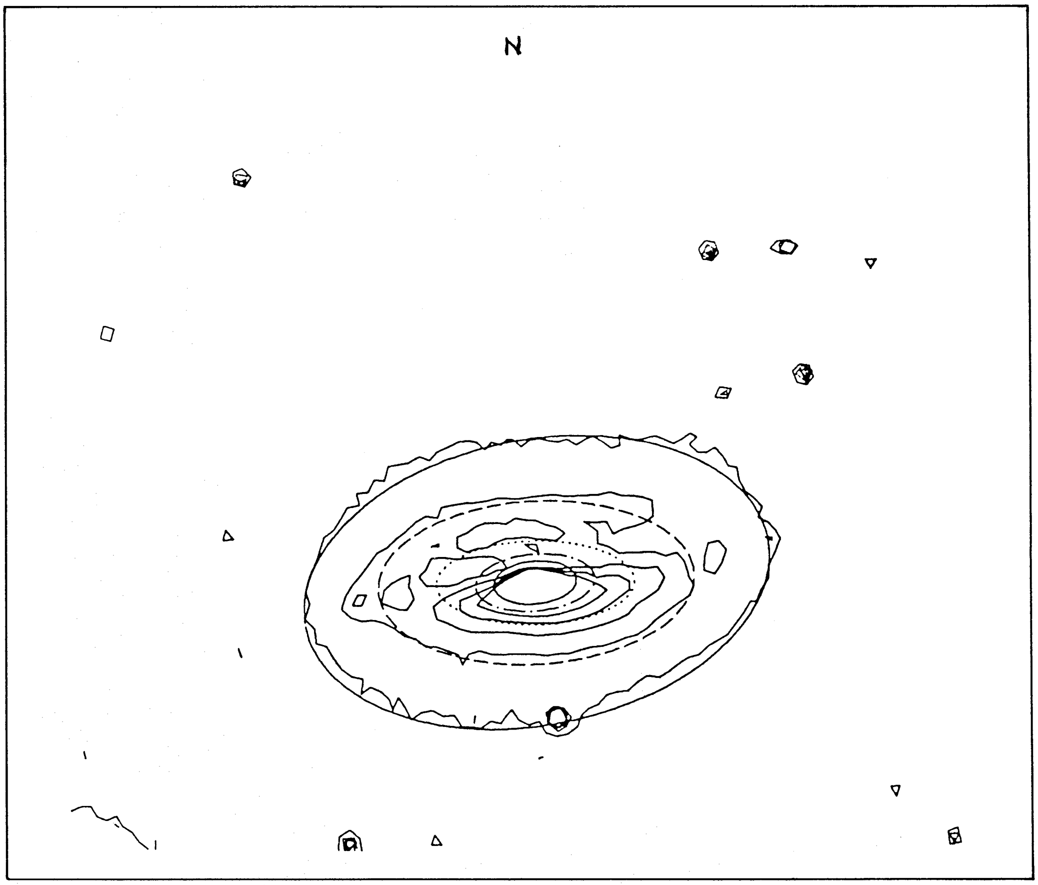

Figure 2. Isophotal contours (full lines) with fitted ellipses (dashed lines).

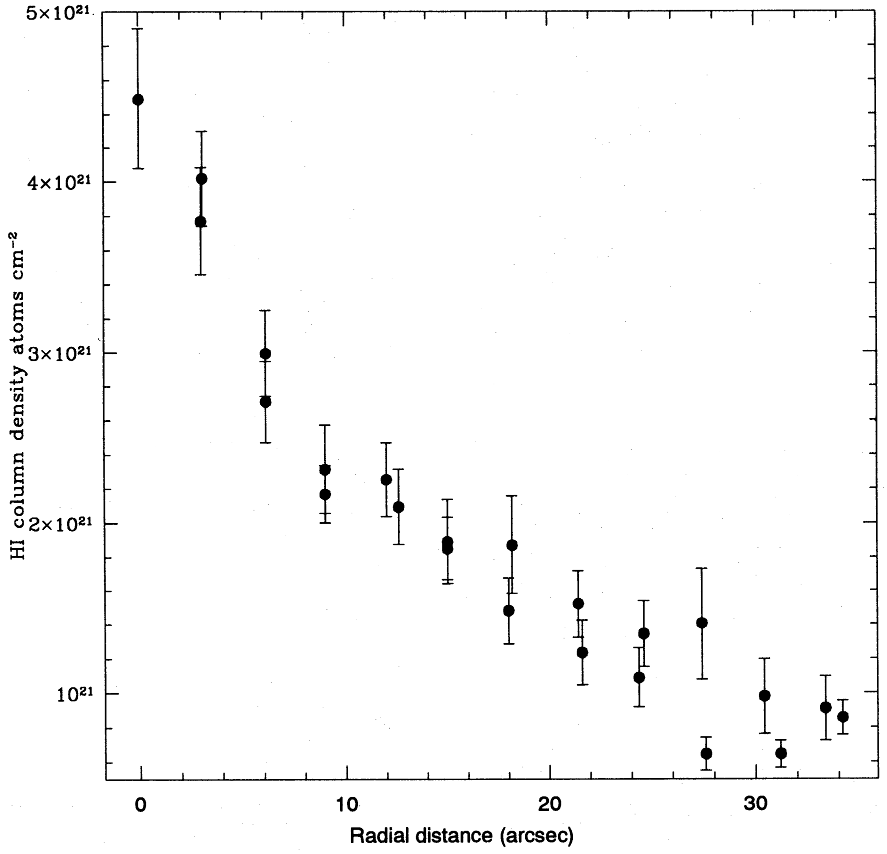

Figure 3. Distribution of N(H I) along the equatorial dust lane plotted as a function of distance from centre.

Table 2. Neutral hydrogen column density.

$N_{HI}/10^{21}$ atoms cm^{-2}	Method	Source
4	Balmer decrement	Sharples et al 1984
< 10	21 cm line at z=z(NGC 7172)	Bottinelli et al 1980
90^{+100}_{-90}	X-ray low energy cut-off	Warwick et al 1993, Turner & Pounds 1989
4.5±0.5	Optical extinction, $(B-V)$ colour	This work

dust extinction in our Galaxy (Savage & Mathis 1979). IR spectra of the nucleus (Roche et al. 1991) indicate that the extinction in NGC 7172 is predominantly due to silicate absorption. The dust properties in NGC 7172 may therefore be considered similar to those in our Galaxy.

3.1.2 *Neutral hydrogen*

The atomic hydrogen column density N(H I) and the total hydrogen column density $N(\mathrm{H\,I}+\mathrm{H_2})$ are correlated with the colour excess $E(B-V)$ in our Galaxy (Savage & Mathis 1979). Assuming homogeneous distribution of gas and a dust-to-gas ratio in NGC 7172 similar to that in our Galaxy, we have (Burstein & Heiles 1978)

$$N(\mathrm{H\,I})/E(B-V)=5.0\times10^{21}\ \mathrm{atom\ cm^{-2}\ mag^{-1}}.$$

We have obtained the distribution of the colour excess $E(B-V)$ along the dust lane using the same 3×9 arcsec^2 aperture as above, and converted this to a distribution of H I column density using the above equation; this is shown in Fig. 3. The column density around the nucleus is estimated to be 4.5×10^{21} atom cm^{-2}. In Table 2 we list the estimate of $N_{\mathrm{H\,I}}$ along with the estimates based on 21-cm line, spectroscopy and X-ray observations. The $N_{\mathrm{H\,I}}$ estimate from the Balmer decrement and the optical extinction are similar and also consistent with the upper limit estimated from 21-cm line measurements. X-ray observations give a much higher value.

The total H I content in the dust lane (34×9 arcsec^2) is

$$N_{\mathrm{H\,I}}^{\mathrm{tot}}=D^2\int_{\mathrm{dust}}N_{\mathrm{H\,I}}\,\mathrm{d}\Omega,$$

where D is the distance to the galaxy used to convert the angular sizes in arcsec to the physical sizes in kpc, and the integration is performed over the dust lane with a beam size $\mathrm{d}\Omega$, which in this case is the size of the aperture used. Using $D=33.9$ Mpc (Tully 1988) and the estimate of $N_{\mathrm{H\,I}}$ obtained from the map, we get for the total number of H I atoms and mass,

$$N_{\mathrm{H\,I}}^{\mathrm{tot}}=3\times10^{65}\ \mathrm{atom},\qquad M_{\mathrm{H\,I}}^{\mathrm{tot}}=2.6\times10^{8}\ \mathrm{M_{\odot}}.$$

Using the Galactic dust-to-gas ratio of ~100 (Burstein & Heiles 1978), the dust mass is $M_{\mathrm{d}}=2.6\times10^{6}\ \mathrm{M_{\odot}}$. Table 3 lists the hydrogen and dust mass estimates. The mass of H I estimated here is a lower limit, since we are unable to estimate the H I in regions beyond the dust lane. The

Table 3. Hydrogen and dust masses (in $M_\odot$).

M_{HI}	M_{dust}	M_{H_2}	Method
$<7\times10^8$			21 cm line emission
2.6×10^8			dust lane $(B-V)$ colour
	2.6×10^6		M_{HI}, and Galactic dust-to-gas ratio
	2.1×10^6		100μm flux
		2.6×10^9	L_{CO} and Galactic L_{CO} to M_{H_2} ratio
		1.6×10^9	M_{dust} and dust to M_{H_2} ratio for spirals

estimated mass is consistent with the upper limit $M_{H_I}^{tot}<7\times10^8\,M_\odot$ obtained from 21-cm observations (Bottinelli et al. 1980; Sharples et al. 1984). Using $\log L_B=10.23$ (Tully 1988), and our estimate of M_{H_I}, we get a neutral hydrogen content of $\log(M_{H_I}/L_B)=-1.8$, which is much lower than the value -0.55 ± 0.41 expected for an Sa-type galaxy (Haynes & Giovanelli 1984).

3.2 Radial luminosity profiles

The light distribution of normal spiral galaxies can be divided into two distinct components, a bulge and a disc. The radial luminosity profile across the bulge can usually be represented by a de Vaucouleurs model with the intensity distribution $I_{bulge}\propto10^{-(r/r_b)^{1/4}}$, where r_b is the effective radius. The radial profile across the disc is taken to be exponential with scalelength r_d, so that $I_{disc}\propto e^{-r/r_d}$ (Mihalas & Binney 1981). Spiral arms in the galaxy induce fluctuations about the mean value in the profile, which average out when one goes far out in radial distance. In the case of Seyferts, the active nucleus at the centre contributes an unresolved source to the profile.

We have modelled the observed radial profile of NGC 7172 with bulge, disc and point-source components by constructing model galaxies with the three components, and convolving these with a PSF estimated from foreground stars in the frame of the galaxy. The intensity profile of such a model galaxy is defined by seven parameters: the effective radius of the bulge r_b, the disc scalelength r_d, the central bulge luminosity per square arcsec $\mu_B(0)$, the ratio of the disc luminosity to bulge luminosity D/B, the ratio of the point source luminosity to the bulge luminosity P/B, and the ellipticity e_b and e_d of the bulge and disc respectively. The best-fitting values for the seven parameters were obtained from the observed intensities along the major axis, using the method of least squares.

The observed profile and the best fits in B filter are shown in Fig. 4, and the values of the fitted parameters are tabulated in Table 4. The χ^2 values are 1.8 for the B profile and 2.0 for

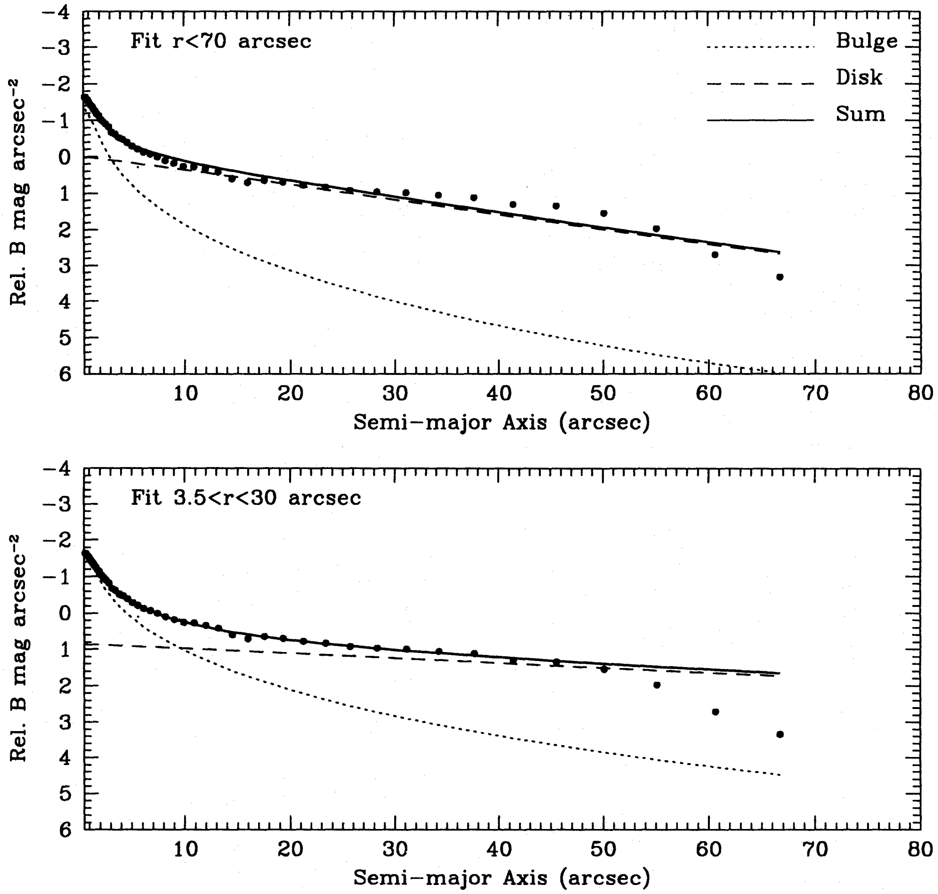

Figure 4. Radial luminosity profiles in B filter, with the best fits to the bulge and disc components. Top panel: fit range $r<70$ arcsec. Bottom panel: fit range $3.5<r<30$ arcsec.

Table 4. Best-fitting parameters for radial luminosity profile.

Filter	r''_b	r''_d	$\mu_b(0)$†	D/B	P/B*	e_b	e_d	Source
B	22.6	26.5	17.3	9.2		0.04	0.45	This Work[1]
V	18.9	23.7	15.9	7.2		0.04	0.45	
B	29.0	9.1		4.4	33.5			KWW
V	23.5	10.3		5.9	35.8			
B	29.0	53.6	17.6	11.1		0.04	0.47	This Work[2]

†mag arcsec^{-2}.
* < 3 arcsec.
[1]Fit range $r < 70$ arcsec.
[2]Fit range $3.5 < r < 30$ arcsec.

the V profile. The nuclear point source is not detected by the fitting routine. This is probably due to obscuration of the nucleus by the dust lane, and also poor seeing conditions. The fit was repeated with only five parameters, keeping e_b and e_d fixed. This does not change either the χ^2 or the values of the fitted parameters significantly, and the nuclear source still remains undetected. We also give in Table 4 the best-fitting values obtained by KWW.

The disc scalelength estimated by us is a factor 2–3 larger than the estimate of KWW, while the bulge scalelength is comparable. Also, the D/B obtained by us is higher than their value due to the fact that we estimate a larger disc. We note that the disc length obtained by us is dominated by the outer radii beyond 30 arcsec, and this region is not used in the profile fit made by KWW. To see whether we can reproduce the bulge and disc parameters obtained by them, we have obtained a fit using the observed radial profile for $3.5 < r < 30$ arcsec, which omits the central region influenced by a possible point source, and at the large-r end extends only to the limit covered by KWW. We omit the central region since the point source is undetected, and also because the bulge scalelength is dominated by points at $r > 3.5$ arcsec. The fit, which has a χ^2 value 0.07, is shown in Fig. 4. While it is excellent over the range of points used, the observed points at larger radii lie substantially below the fit. This produces a bulge scalelength similar to the previous estimate as well as KWW, while the disc scalelength is different. The reason for this discrepancy is not clear to us, and it could indicate that the model used by us (and KWW) is not applicable.

4 DISCUSSION

NGC 7172 appears as a far-infrared (FIR) source in the *IRAS* catalogue (Knapp et al. 1989). Also, CO emission has been detected by Heckman et al. (1989). We discuss in this section the properties of the dust based on the published FIR and CO fluxes. We also discuss the morphology of the galaxy based on the estimates of neutral and molecular hydrogen content, and the bulge and disc scalelengths obtained from surface photometry.

4.1 Far-infrared emission and dust content

The FIR fluxes at 12-, 25-, 60- and 100-μm bands are 0.4374 ± 0.03, $0.7612 + 0.05$, 5.712 ± 0.3 and 12.29 ± 0.61 Jy respectively (Knapp et al. 1989). The *FIR* ratio F_{60}/F_{100} implies a dust temperature $T_d \sim 36$ K. The total FIR flux, estimated from the fluxes in 60 and 100 μm using

$$F_{\rm FIR} = 1.26(2.58F_{60} + F_{100}) \times 10^{-14}\ {\rm W\ m^{-2}}$$

(Heckman et al. 1989), is $F_{\rm FIR} = 3.4 \times 10^{-13}$ W m^{-2}, and the total FIR luminosity is $L_{\rm FIR} = 1.2 \times 10^{10}\ {\rm L_\odot}$.

The dust temperature in NGC 7172 is similar to that of the general population of dust lane E/S0 galaxies (Brosch 1987). Furthermore, the FIR ratios $\log(F_{12}/F_{25}) = -0.24$ and $\log(F_{60}/F_{100}) = -0.33$ place the galaxy at an intermediate position between galaxies in which the cool component is important and those where OB star formation is responsible for heating the dust. This implies that a minor fraction of the FIR emission is due to Galactic cirrus, while a major fraction of the emission is due to heating of dust by young stars, indicating ongoing star formation, and also due to heating of dust by the central active nucleus.

The total dust mass estimated from the 100-μm flux and using the relation by Bothun, Lonsdale & Rice (1989),

$$M_d = 5D^2_{\rm Mpc}F_{100}[\exp(144/T_d) - 1]{\rm M_\odot},$$

is $M_d = 3.8 \times 10^6\ {\rm M_\odot}$. Using the relation by Thronson et al. (1988),

$$M_d = 11D^2_{\rm Mpc}F_{100}[\exp(96/T_d) - 1]{\rm M_\odot},$$

we estimate $M_d = 2.1 \times 10^6\ {\rm M_\odot}$. These estimates are similar to the dust mass estimated using our optical data, in Section 3.1.1, and are listed in Table 3.

Young et al. (1986) find the molecular hydrogen to dust mass ratio to be ~ 500 for spiral galaxies. Using this, we have

$$M_{\rm H_2} = 1.6 \times 10^9\ {\rm M_\odot}.$$

The molecular hydrogen mass may be obtained independently from CO luminosity (Young et al. 1986):

$$M_{\rm H_2} = 6 \times 10^6 L_{\rm CO}\ {\rm M_\odot},$$

where $L_{\rm CO}$ is in K km s^{-1} kpc^2. With this relation and $L_{\rm CO} = 0.44 \times 10^3$ K km s^{-1} kpc^2 (Heckman et al. 1989), we have

$$M_{\rm H_2} = 2.6 \times 10^9\ {\rm M_\odot}.$$

This is in good agreement with the *IRAS*-derived $M_{\rm H_2}$. The total gas content in NGC 7172, $M_{\rm H\,I} + M_{\rm H_2}$ is therefore $M_{\rm gas} \sim 2.3 \times 10^9\ {\rm M_\odot}$, with $M_{\rm H\,I}$ from Section 3.1.2 and $M_{\rm H_2}$ taken to be the mean of the values obtained from *IRAS* and CO measurements.

4.2 Morphology

NGC 7172 is classified as Sa(pec) (de Vaucouleurs et al. 1976). The neutral hydrogen mass estimated from 21-cm line observations and the optical extinction give a neutral hydrogen content $-1.8 \le \log(M_{\rm H\,I}/L_B) \le -1.4$. The neutral hydrogen content in Sa galaxies is $\log(M_{\rm H\,I}/L_B) = -0.55 \pm 0.41$, while in E and S0 galaxies it is $\log(M_{\rm H\,I}/L_B) = -0.74 \pm 0.37$ (Haynes & Giovanelli 1984). The estimated value of $\log(M_{\rm H\,I}/L_B)$ in NGC 7172 is much less than the observed values for S0 galaxies, which implies that the galaxy could be an elliptical. However, radial luminosity profile fits give a bulge scalelength $r_b = 3.0 \pm 0.3$ kpc, and a disc scalelength $r_d = 4.0 \pm 0.3$ kpc. These values fall well within the range of scalelengths of

S0/Sa galaxies (Mihalas & Binney 1981). It thus appears that NGC 7172 is H I-depleted.

The molecular hydrogen in atomic hydrogen mass ratio is $M_{H_2}/M_{H_I} \sim 3$–8. This value is similar to that seen in S0/Sa galaxies, for which $M_{H_2}/M_{H_I} = 4.0 \pm 1.9$ (Young & Scoville 1991).

5 CONCLUSIONS

We draw the following conclusions.

(1) The neutral hydrogen mass in NGC 7172 estimated based on the optical extinction in the dust lane is $M_{H_I} = 2.6 \times 10^8$ M$_\odot$. This value is consistent with the upper limits obtained from 21-cm line estimates.

(2) The FIR fluxes imply a dust temperature $T_d \sim 36$ K, and a dust mass $M_d = 3.0 \times 10^6$ M$_\odot$. The mass of molecular hyrogen estimated based on the dust mass, and also using the CO luminosity, is $M_{H_2} = 2.1 \times 10^9$ M$_\odot$.

(3) The total gas content in NGC 7172, $M_{H_I} + M_{H_2}$, is $\sim 2.3 \times 10^9$ M$_\odot$.

(4) The neutral hydrogen content $-1.8 \leq \log(M_{H_I}/L_B) \leq -1.4$, molecular hydrogen to atomic hyrogen mass ratio $M_{H_2}/M_{H_I} \sim 3$–8 and the bulge and disc scalelengths $r_b = 3.0 \pm 0.3$ kpc, $r_d = 4.0 \pm 0.3$ kpc, together indicate a morphological type S0–Sa for the galaxy.

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REFERENCES

Adams T. F., 1977, ApJS, 33, 19
Baum S., Heckman T. M., 1989, ApJ, 336, 681
Begelman M. C., 1985, ApJ, 297, 492
Bothun G. D., Lonsdale C. J., Rice W., 1989, ApJ, 341, 129
Bottinelli L., Gouguenheim L., Paturel G., 1980, A&A, 88, 32
Brindle C., Hough J. H., Baily J. A., Axon D. J., Ward M. J., Sparks W. B., Mclean I. S., 1990, MNRAS, 244, 604
Brosch N., 1987, MNRAS, 225, 40
Burstein D., Heiles C., 1978, ApJ, 251
de Vaucouleurs G., de Vaucouleurs A., Corwin H. G., 1976, Second Reference Catalogue of Bright Galaxies. Univ. Texas, Austin
Elvis M., Lockman F. J., Wilkes B. J., 1989, AJ, 97, 777
Graham J. A., 1982, PASP, 92, 244
Hamuy M., Maza J., 1987, A&AS, 68, 283
Haynes M. P., Giovanelli R., 1984, AJ, 89, 758
Heckman T. M., Blitz L., Wilson A. S., Armus L., Miley G. K., 1989, ApJ, 342, 735
Hickson P., 1982, ApJ, 255, 382
Jedrzejewski R. I., 1987, MNRAS, 226, 747
Knapp G. R., Guhathakurta P., Kim D.-W., Jura M., 1989, ApJS, 70, 329
Kotilainen J. K., Ward M. J., 1994, MNRAS, 266, 953
Kotilainen J. K., Boisson C., Depoy D. L., Bryant L. R., Smith M. G., 1992a, MNRAS, 256, 125
Kotilainen J. K., Ward M. J., Boisson C., Depoy D. L., Smith M. G., 1992b, MNRAS, 256, 149
Kotilainen J. K., Ward M. J., Williger G. M., 1993, MNRAS, 263, 655 (KWW)
MacKenty J. W., 1990, ApJS, 72, 231
Mayya Y. D., 1993, PhD thesis, Indian Institute of Science, Bangalore
Mihalas D., Binney J., 1981, Galactic Astronomy, 2nd edn. W. H. Freeman & Co., San Francisco
Piccinotti G., Mushotzky R. F., Boldt E. A., Holt S. S., Marshall E. E., Serlemitsos R. J., Shafer R. A., 1982, ApJ, 253, 485
Roche P. F., Aitken D. K., Smith C. H., Ward M. J., 1991, MNRAS, 248, 606
Savage B. D. & Mathis J. S., 1979, ARA&A, 17, 73
Shanbhag S., Kembhavi A. K., 1988, ApJ, 334, 34
Sharples R. M., Longmore A. J., Hawarden T. G., Carter D., 1984, MNRAS, 208, 15
Simkin S. M., Su H. J., Schwarz M. P., 1980, ApJ, 237, 404
Storchi-Bergmann T., Mulchaey J. S., Wilson A. S., 1992, ApJ, 395, L73
Thronson H., Hunter D. A., Telesco C., Greenhouse M., Harper D., 1988, ApJ, 334, 605
Tully B., 1988, Nearby Galaxies Catalog. Cambridge Univ. Press, Cambridge
Turner T. J., Pounds K. A., 1989, MNRAS, 240, 833
Unger S. W., Pedlar A., Axon D. J., Whittle M., Meurs E. J. A., Ward M. J., 1987, MNRAS, 228, 671
Warwick R. S., Sembay S., Yaqoob T., Makishima K., Ohashi T., Tashiro M., Kohmura Y., 1993, MNRAS, 265, 412
Wilson A. S., 1992, in Duschl W. J., Wagner S. J., eds, Physics of Active Galactic Nuclei. Springer-Verlag, Berlin, p. 307
Yee H. K. C., 1983, ApJ, 272, 473
Young J. S., Scoville N. Z., 1991, ARA&A, 29, 581
Young J. S., Schloerb F. P., Kenney J. D., Lord S. D., 1986, ApJ, 304, 445