Mon. Not. R. astr. Soc. (1982) **199**, 425–433

High-resolution mapping of the giant H I envelope of the Seyfert galaxy Mkn 348

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Received 1981 July 9

Summary. We have mapped the giant H I envelope of Mkn 348 (NGC 262) with a spatial resolution of 1 arcmin and a velocity resolution of $17\,\mathrm{km\,s^{-1}}$ using the Westerbork Synthesis Radio Telescope. The envelope is $\sim 9 \times 6$ arcmin ($\sim 175 \times 115$ kpc) in total size to a column-density limit of 5.5×10^{19} $\mathrm{cm^{-2}}$ (*cf.* the Holmberg diameter of 2 arcmin). A bright central region is elongated north-east/south-west and a fainter outer ring-like feature north/south. The outer 'ring' shows velocities which increase from north to south while the inner region shows velocities which increase from south-west to north-east.

If the H I is virialized with respect to the mass distribution of the Galaxy, then either Mkn 348 has a mass-to-light ratio at least an order of magnitude smaller than normal, or the dynamical axis of the H I is within $10°$–$20°$ of the line of sight (consistent with the ellipticity of the optical disc of Mkn 348 which suggests that it is probably seen within $15°$ of face-on). We consider hypotheses that the H I envelope (i) represents primordial material gradually being accreted by the galaxy, (ii) is produced by ejecta from the active nucleus, or (iii) was produced by a tidal interaction several gigayears ago between Mkn 348 and the nearby bright spiral NGC 266.

1 Introduction

In a survey of H I in Seyfert galaxies Heckman, Balick & Sullivan (1978) discovered that the type 2 Seyfert galaxy Mkn 348 had a very large envelope of H I. They estimated an H I mass of $\sim 2 \times 10^{10} M_\odot$ and a size of at least 100 kpc (adjusted to $H_0 = 75\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$, which will be used throughout this paper). In a more detailed study (Morris & Wannier, 1980) hereafter MW, the H I was found to have a total spatial extent of ~ 200 kpc, or nearly an order of

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magnitude larger than the optical size (Huchra 1980). Apart from its active nucleus, the galaxy appears optically to be a morphologically normal early-type disc galaxy (S0/a or Sa) seen nearly face-on (Huchra 1980; Adams 1977). The kinematics of the H I were found to be peculiar by MW, who suggested that non-circular motions might be present.

We have obtained an H I map of Mkn 348 at high spatial resolution (~ 1 arcmin) using the Westerbork Synthesis Radio Telescope (WSRT). These observations raise very interesting questions concerning the H I envelope's origin, maintenance, and relation to the active nucleus.

2 Observations and data reduction

Mkn 348 was observed with the WSRT for a total of 24 hr in 1978 August. The observational parameters are listed in Table 1. The 5120-channel line receiver has been described by Bos, Raimond & van Someren Gréve (1981).

The WSRT autocorrelation spectrometer was configured to have 63 spectral channels covering a bandwidth of 2.5 MHz. The channel width was hence 39 kHz, although, since Hanning-smoothing was applied during the autocorrelation, the effective spectral resolution was only 78 kHz or 17 km s^{-1}.

The recorded phases and amplitudes were calibrated in the standard way through observations of unresolved continuum sources interspersed with the observations of Mkn 348. These data were then combined and Fourier transformed using the WSRT/Leiden reduction package, LINEMAP. The resulting maps for channels 4 to 20 and 40 to 56 were combined to produce a map of the radio continuum, and this map was subtracted from the channels in which an H I signal was present (channels 23 to 37, corresponding to a range of heliocentric radial velocity (optical definition) of 4474 to 4593 km s^{-1}) to remove the effects of the unresolved nuclear radio source of 0.30 ± 0.01 Jy and of other sources in the field.

The maximum antenna spacing in our observations was 1440 m, so that the original maps had a resolution of 25 × 48 $arcsec^2$ with the major axis of the synthesized beam oriented north/south. These high-resolution maps were relatively noisy and so were smoothed to a 1-arcmin circular beam. No cleaning was necessary.

The data were then analysed using the Groningen Image Processing System (GIPSY). Each individual map was corrected for the primary beam and then integrated over the area

Table 1. Observational parameters for Mkn 348 = NGC 262.

Date of observations	1978 August
Number of 12-hr measurements	2
Total number of interferometers	40
Shortest and longest spacing	36, 1440 m
Spacing increment	36 m
Half-power width of synthesized beam in α and δ	25 × 48 $arcsec^2$
Total bandwidth	2.5 MHz
Central radial velocity (heliocentric, optical definition)	4540 km s^{-1}
Velocity resolution	17 km s^{-1}
Centre of field (1950.0) = centre of Mkn 348	$\alpha = 0^h 46^m 4^s.86$ $\delta = +31° 41' 5''.61$
Primary beam at half-power	38 arcmin
Maps at 1 × 1 arcmin² resolution	
Equivalent T_b(K) for 1.0 mJy/snyth. beam area	0.18 K
rms noise	0.45 K
Detection limit (5 σ) at field centre in a 17 km s^{-1} wide channel and 1 × 1 $arcmin^2$ area	$n_H = 7 \times 10^{19}\ cm^{-2}$

Table 2. Observed and derived parameters for Mkn 348 (NGC 262) (for $H_0 = 75\ \mathrm{km\ s^{-1}\ Mpc^{-1}}$).

Hubble type	S0/a or Sa
m_{Holm}	~14.3
V_{Hel} (H I)	4540 km s^{-1}
V_0 (relative to Local Group)	4757 km s^{-1}
Distance	63 Mpc
Holmberg diameter	~2 arcmin ≡ 37 kpc
L_B	$2.2 \times 10^{10} L_\odot$
H I flux integral	20.0 ± 2.0 Jy km s^{-1}
$M_{\mathrm{H\,I}}$	$1.8 \times 10^{10} M_\odot$
Outer H I ring:	
PA major axis	~0°
diameter major	9.5 arcmin ≡ 176 kpc
diameter minor	6.1 arcmin ≡ 112 kpc
axial ratio	0.65
'V_{rot}' (observed along line of sight)	42 ± 10 km s^{-1}
Inner H I:	
PA major axis	~45°
diameter major	6 arcmin ≡ 110 kpc
diameter minor	4 arcmin ≡ 73 kpc
axial ratio	0.67
'V_{rot}' (observed along line of sight)	25 ± 10 km s^{-1}

of the H I source to obtain the H I flux as a function of radial velocity (see Fig. 1). To produce a map of the total H I distribution it is not sufficient simply to add all the individual channel maps. Because the location of the H I changes from channel to channel, such a procedure would unnecessarily add noise to the resultant map. A more sophisticated, albeit somewhat subjective, method of combining the channel maps, the so-called 'window' method, was used instead. In this method each channel map was inspected, and features showing a spatial and kinematic continuity from map to map were identified. The H I brightness was also plotted in contour form as a function of velocity and right ascension for a series of east/west strips which covered the region of H I signal and which were separated

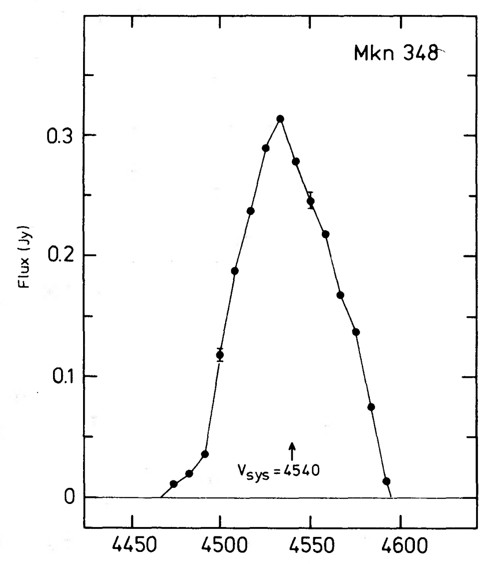

Figure 1. Global H I velocity profile for Mkn 348. The total H I 'line integral' is 20.0 ± 2.0 Jy km s^{-1}. All radial velocities are heliocentric and follow the 'optical definition' ($c\ \Delta\lambda/\lambda_0$).

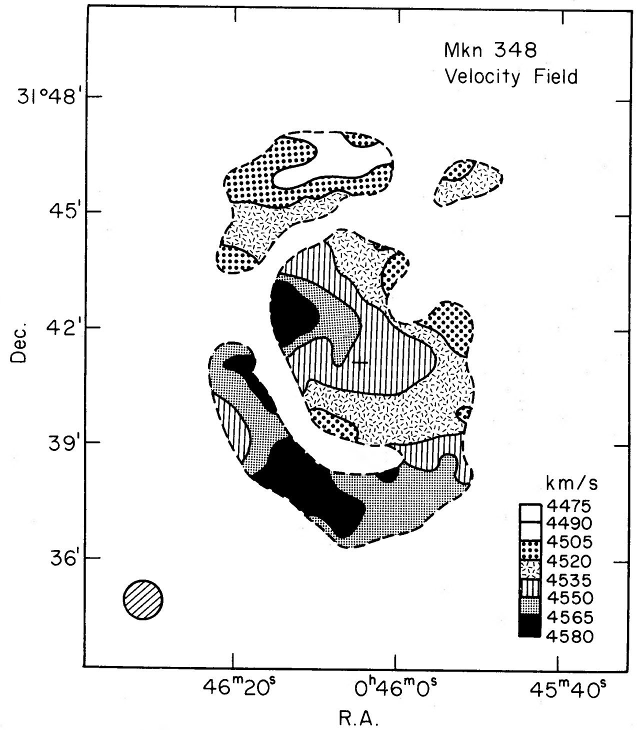

Figure 2. Velocity field of Mkn 348. The intensity-weighted mean radial velocities are displayed with a step of 15 km s^{-1}.

by 0.5 beam widths in declination. These plots were also inspected for features showing kinematic and spatial continuity. 'Windows' were then constructed which included only that part of each velocity/right ascension plot which was deemed to show H I in emission. These windowed data were then combined to produce both a total H I map (shown as a contour map in Plate 1), and an isovelocity plot in which the velocity at each point was determined from the weighted mean of the H I signal. This isovelocity map is shown in a grey-scale form in Fig. 2.

3 Results

3.1 H I SIZE

Plate 1 shows that the H I cloud associated with Mkn 348 has a size of ~ 9.5×6 arcmin^2 (~ 175×115 kpc^2) with our sensitivity of 5.5×10^{19} cm^{-2} in column density. This agrees quite well with the size reported by MW.

Because the shortest antenna spacing in our synthesized aperture is 36 m, we are insensitive to structure in the H I on an angular scale > 10 arcmin. A comparison of the flux in our maps with the single-dish H I profile by Heckman *et al.* (1978) and the map by MW suggests that we have missed no significant flux. But since the Heckman *et al.* data were obtained with a 10 arcmin beam, and MW mapped only an area 10 arcmin square, faint diffuse H I extending over > 10 arcmin cannot be ruled out.

Clearly, it is the enormous size of the H I relative to the optical size of the galaxy that is its most remarkable feature. The optical size of Mkn 348 on the Palomar Sky Survey blue plate is only 1.3 arcmin. From the photometry of Mkn 348 reported by Huchra (1980) we estimate a Holmberg diameter of 2 arcmin for Mkn 348, while a deep IIIa-J Palomar Schmidt photograph of Mkn 348 kindly provided by A. G. de Bruyn (shown in Fig. 2) indicates a *total* optical diameter of 3 arcmin. A deep plate taken by A. R. Petrosyan, who

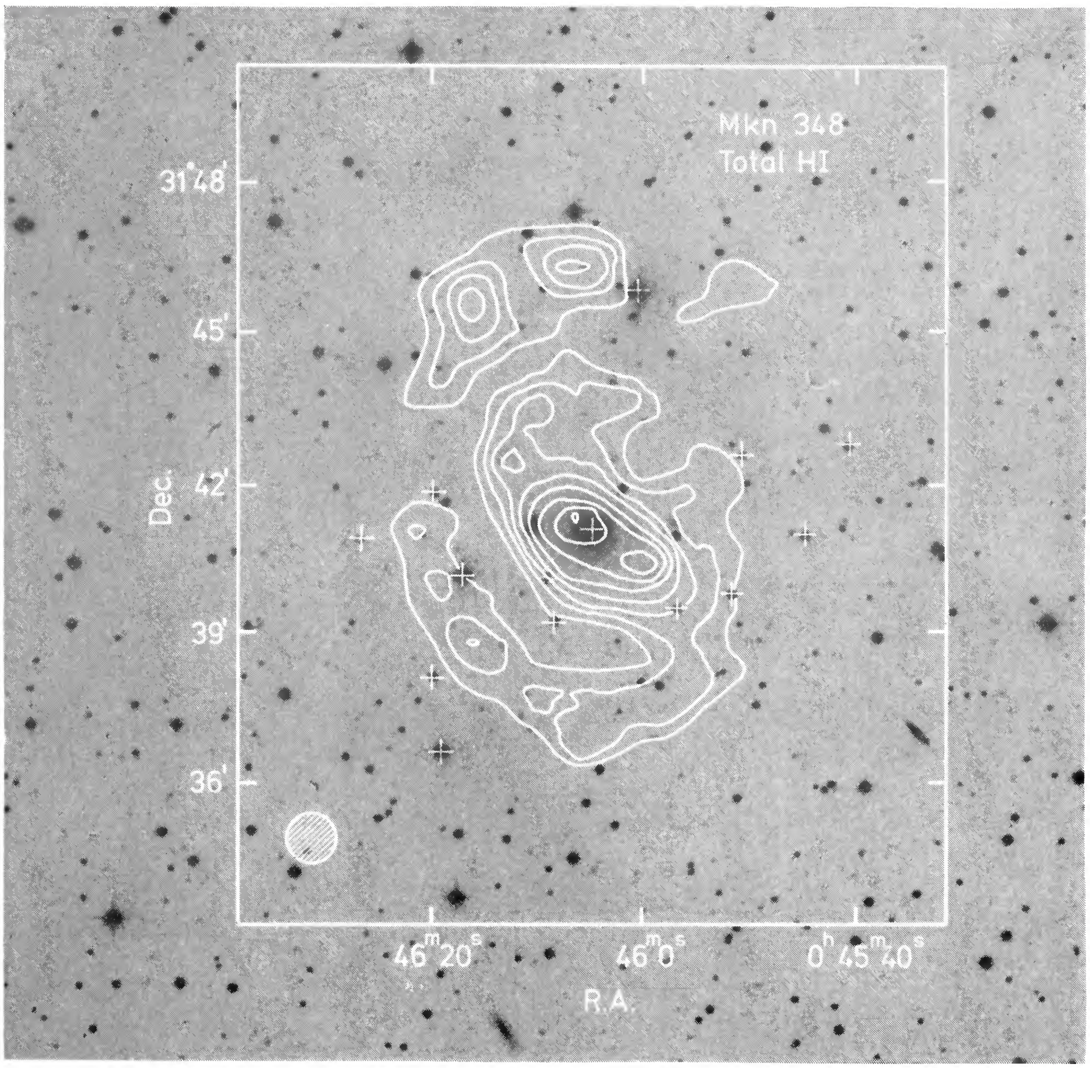

Plate 1. Map of HI column density superposed on a photograph of Mkn 348 (from a IIIa–J plate kindly provided by by A. G. de Bruyn). The value of lowest contour ($\sim 4\sigma$) and the contour step are 5.5×10^{19} cm^{-2}. The beam at half-power is shown by the hatched circle in the lower left corner. The crosses mark the positions of field stars and of the centre of Mkn 348. Coordinates are for 1950.0.

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kindly allowed one of us (WTS) to inspect it, shows some scattered nebulosity extending 3–3.5 arcmin north of the centre of Mkn 348, but nothing so far out in the other directions. We have thus detected H I with a column density $n_{\mathrm{H\,I}} \sim 1 \times 10^{20}\ \mathrm{cm}^{-2}$ out to 5 Holmberg radii, far beyond the detectable optical 'edge' of the galaxy on a deep plate. For comparison, the survey work of Briggs *et al.* (1980) indicates that H I extending to even 2–3 Holmberg radii with $n_{\mathrm{H\,I}} > 3 \times 10^{18}\ \mathrm{cm}^{-2}$ is very rare among normal spiral galaxies.

3.2 HI DISTRIBUTION (PLATE 1)

About half of the total H I is concentrated in the inner parts of the envelope and is centred roughly on the optical image of the galaxy. The region is $\sim 4 \times 6$ arcmin in size and elongated south-west/north-east. In the outer parts the H I shows a broken ring-shaped structure, elongated north/south. The 'ring' has major and minor diameters of 9.5 and 6 arcmin respectively, and its centre is offset 40 arcsec to the north-east with respect to the nucleus of Mkn 348.

3.3 VELOCITY FIELD (Fig. 2)

The velocity field is complex, but seems to have some large-scale regularity. In the outer ring the radial velocities increase systematically from the northern ($V = 4490\ \mathrm{km\,s^{-1}}$) to the southern edge ($V = 4575\ \mathrm{km\,s^{-1}}$), whereas in the inner parts the velocities increase from south-west to north-east. This general behaviour is clearly visible also in Fig. 4, where the observed brightness temperature is displayed as a function of radial velocity and position along a north–south axis. A case that bears some similarity to Mkn 348 in this regard is the

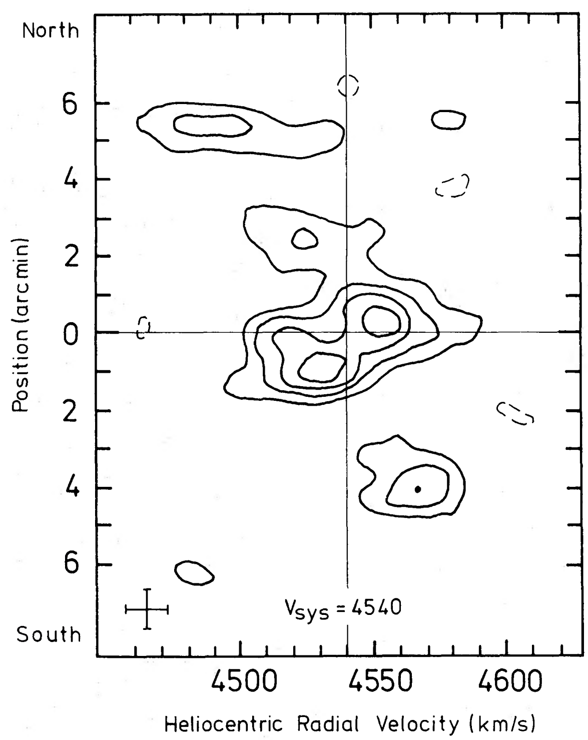

Figure 3. Distribution of observed brightness temperature as a function of radial velocity and of position relative to the nucleus of Mkn 348 in the north–south direction (PA = 0°). The contour values are -0.9 (dashed), 0.9 ($\sim 2\sigma$), 1.8, 2.7 and 3.6 K. Angular and velocity resolutions are indicated by the cross in the lower left corner.

irregular galaxy NGC 4449 in which van Woerden, Bosma & Mebold (1975) found a very large H I extent, and opposite velocity gradients in the inner and outer parts. Such velocity gradients have also been reported for IC 10 by Cohen (1979).

The definition of systemic velocity for MKN 348 is not straightforward, because of asymmetries in the optical and velocity structure. From the global profile (Fig. 1) the mid-point between the 20 per cent peak intensity points is at 4540 ± 5 km s^{-1}. This value is close to that of the central velocity of the gas in the inner part (see Fig. 3) and will be adopted here as the heliocentric systemic velocity. We note that the mean of the extreme velocities observed in the outer region (4530 km s^{-1}) is only 10 km s^{-1} different.

4 Discussion

4.1 KINEMATICS AND MORPHOLOGY

In order to interpret the morphology and kinematics of the H I, some insight into its three-dimensional configuration is required.

First, the elongation of the outer ring-like H I structure, coupled with the location of the highest and lowest radial velocities at the ends of the elongated shape strongly suggest that this may be a rotating *circular* ring ~9.5 arcmin (175 kpc) in diameter inclined at about 50° to the plane of the sky with a line of nodes at approximately PA = 0°. On this assumption one can derive a de-projected rotational velocity of 55 km s^{-1} with respect to the centre of Mkn 348 for a ring of radius 4.8 arcmin. The orbital period is then so long ($\sim 1 \times 10^{10}$ yr) that the gas in the ring has made little more than one revolution in the Hubble time. If it is assumed for simplicity that the mass is spherically distributed within the radius R of the ring, then the total mass, given by $RV_{\rm rot}^2/G$, is $\sim 6 \times 10^{10} M_\odot$.

A similar argument can be made for the H I in the inner region in which both the velocity gradient and the direction of elongation of the H I are south-west/north-east, suggesting a rotating circular disc ~100 kpc in diameter inclined at about 50° to the plane of the sky with a line of nodes at PA = 45°. These assumptions lead to a de-projected rotational velocity of 33 km s^{-1}, a rotation period 1×10^{10} yr, and a total mass interior to a radius of 3 arcmin of $1.5 \times 10^{10} M_\odot$.

Huchra (1980) determined a blue Holmberg luminosity of $L_{\rm B} = 2.2 \times 10^{10} L_\odot$ for Mkn 348. Coupled with the assumption of a normal mass-to-light ratio (Faber & Gallagher 1979) for Mkn 348 (supported by the normal *UBV* colours reported by Huchra 1980), this leads to a mass of $\sim 10^{11} M_\odot$ *within a radius of ~1 arcmin* of the centre of the galaxy. Since the relative H I velocities increase out to a radius of ~3 arcmin in the south-west/north-east direction, simple virial arguments would require that the total mass within a radius of 3 arcmin be *at least* 3 times larger than the mass within 1 arcmin. This leads to a mass $> 3 \times 10^{11} M_\odot$ within 3 arcmin, or more than an order of magnitude larger than the mass estimated above, on the assumption of a circular, rotating H I disk.

This dilemma can be resolved if either the mass-to-light ratio of Mkn 348 is at least an order of magnitude lower than normal, or if the dynamical axis (axes) of the H I is (are) more nearly along the line-of-sight than the H I morphology would suggest. This latter possibility would imply that neither the outer 'ring' nor inner 'disc' are intrinsically circular in shape.

For consistency with a normal mass-to-light ratio, the dynamical axis of the H I out to a radius of 3 arcmin must be within 10° of the line-of-sight, while the corresponding value for the axis of the outer H I 'ring' is 20°. While such a face-on orientation is unlikely *a priori*, it does agree with the values of 12° and 14° derived for the inclination of the *optical* disc of Mkn 348 (Huchra 1980; Keel 1980). However, a more thorough investigation of the optical morphology of the very faint outer regions is required to confirm these values. The assumption of such a nearly face-on orientation for the axes increase the rotational velocities of the inner 'disc' and outer 'ring' to 145 and 125 km s^{-1} respectively, and decreases the corresponding rotational periods to 2.2 and 4.3×10^9 yr. These periods are still significant fractions of the Hubble time.

The kinematic and geometrical picture for Mkn 348 seemingly required for consistency between the data and a normal mass-to-light ratio is then of an optical disc with a Holmberg radius of 1 arcmin (~17 kpc), a rotating disc with a semi-major axis of 3 arcmin (50 kpc) oriented north-east/south-west, and a rotating broken ring (which is probably not co-planar with the inner H I disc) having a semi-major axis of ~ 5 arcmin (~ 90 kpc) oriented roughly north–south. The planes of these three flattened systems are all viewed at an angle of $< 20°$ with the plane of the sky. Such a 'warped disc' configuration seen nearly face-on has been suggested for the kinematically similar case of IC 10 (Cohen 1979). The gap in the H I surface brightness between the inner and outer H I systems does not allow us to see whether the position angle of the apparent dynamical axis varies smoothly with radius, as one might expect in a warped-disc configuration.

Note that other geometrical and kinematic interpretations are certainly allowed by the data (e.g., rotating oblate spheroids, or radial rather than rotational motion). Alternatively, MKN 348 may in fact be characterized by an anomalously low mass-to-light ratio. Higher quality H I maps and a determination of the dynamics of the *optical* galaxy are required to evaluate these possibilities further.

4.2 THE ORIGIN OF THE GIANT H I ENVELOPE

We consider three hypotheses for the origin of the H I envelope: that it is (1) a primordial remnant of the gas from which Mkn 348 formed, (2) gas which has been ejected from Mkn 348, (3) 'tidal debris' from a past encounter between Mkn 348 and another galaxy.

In the first case, since Mkn 348 has optical colours and a morphology that are normal for its Hubble type (Huchra 1980), it would seem unlikely that the visible object is itself a 'young galaxy'. The H I envelope may still be primordial, but it has then remained uncollapsed into stars for considerably longer than the gas which formed the optically visible part of the galaxy.

As we have noted above, the velocity structure in the outer H I ring could have a radial component, so that it is possible that primoridal H I is gradually flowing into the inner region of the galaxy. It would then be possible to identify this inflow with the 'fuel' for the active nucleus of Mkn 348. However, five other Seyfert galaxies which have been mapped in H I do *not* show such a giant envelope (Heckman *et al.* 1978 and in preparation; Bosma, Ekers & Lequeux 1977; de Bruyn, private communication), so this mechanism could not be relevant to active galaxies in general.

In the context of the 'primordial' picture for the H I, it is intriguing that recent work (Bania, Thompson & Thuan, private communication) on the H I properties of galaxies in the Pisces I Cluster (part of the Perseus–Pisces supercluster) – of which Mkn 348 is evidently an outlying member – suggests that, like Mkn 348, these galaxies are generally over-abundant in H I. Further study of these cluster galaxies may shed light on the nature of the Mkn 348 H I envelope.

As an alternative to a primordial H I envelope, it is tempting to suppose that the H I is composed of ejecta from the active nucleus of Mkn 348, since this would tie together the two most unusual aspects of the galaxy. In this case, conservation of angular momentum would require the large-scale velocity structure to be due to radial rather than rotational motions. Heckman *et al.* (1981) estimate that $\sim 1 M_\odot$ yr^{-1} is being ejected from the kpc-sized narrow-line region in active galaxies. If Mkn 348 has been continuously active for the Hubble time, the total ejected mass would be similar to the $\sim 2.0 \times 10^{10} M_{\odot}$ of H I in the cloud, although it is very difficult to understand how such a mass flow could be sustained and how the enormous amount of mass lost could have been cycled through the nucleus. And, as we have already pointed out, the anomalous H I properties of Mkn 348 are by no means general among Seyfert galaxies.

Finally we consider the possibility that the H I represents tidal debris. The relatively ordered morphology and kinematics of the H I, together with the absence of a large companion galaxy, suggest that the encounter must have taken place $\gg 10^9$ yr ago. The 12.6-mag SBab galaxy NGC 266 lies 23 arcmin (400 kpc in projection or 5 H I radii) to the NNE of Mkn 348 and has recently been detected at Arecibo in H I by G. D. Bothun & R. A. Schommer (private communication) at a heliocentric velocity of 4670 km s^{-1}. The similarity in redshift of Mkn 348 and NGC 266 suggests that the two galaxies are indeed associated.

A separation of 400 kpc and a relative velocity of 130 km s^{-1} corresponds to a travel time of $\sim 3 \times 10^9$ yr (ignoring projection effects). This time-scale is certainly of the correct order (i.e. $\gg 10^9$ yr, but less than a Hubble time), and the orientation of the major axis of the outer H I structure lies roughly along the line joining Mkn 348 and NGC 266. Furthermore, while NGC 266 is almost an order of magnitude more luminous optically than Mkn 348, the data of Bothun *et al.* show it to have significantly *less* H I. It is then conceivable that much of the H I now associated with Mkn 348 was 'stolen' from NGC 266 several gigayears ago. The misalignment between the dynamical axes of the inner and outer H I in Mkn 348 may then reflect the fact that only the inner H I has had sufficient time since the encounter to come close to dynamical equilibrium with the inner portions of Mkn 348. Shane (1980) has sketched a similar picture for the misaligned inner and outer H I dynamical axes in the 'Spindle Galaxy' NGC 2685, in which the outlying gas is the tidal debris of a late-type galaxy being cannibalized by NGC 2685. Moreoever, since the theft of H I would have occurred many galaxy rotational periods ago, the H I remaining in NGC 266 at present might be expected to show little evidence of the theft, and the shape of its global H I profile is indeed quite normal.

Although this last is the least radical hypothesis for the origin of the giant H I envelope associated with Mkn 348, existing data are insufficient to discriminate clearly between the three general possibilities we have outlined. This extraordinary object is well worth further scrutiny. H I maps with higher spatial resolution and better signal-to-noise ratios, deep multicolour optical plates, determination of the stellar dynamics of the optical galaxy, and further investigation of the H I (and other) properties of the Pisces I Cluster galaxies (particularly NGC 266) are obviously the next steps to take.

Acknowledgments

We thank the staff of the Westerbork Radio Observatory, and in particular Arnold Rots, for their assistance in obtaining the data on which this paper is based. E. Brinks, W. Shane, C. Norman, G. Illingworth, H. Van der Laan, J. Oort, J. Gallagher, A. G. de Bruyn and A. R. Petrosyan, are thanked for their advice and criticism. We thank G. Bothun for early communication of the H I results for NGC 266. TMH thanks the staff of Sterrewacht Leiden for their hospitality during the time when much of this work was done, and WTS similarly thanks the Institute of Astronomy, Cambridge for its hospitality. Access to the facilities of the Groningen Computing Center greatly facilitated the reduction and analysis of the data on which this paper is based. The WSRT is operated by the Netherlands Foundation for Radio Astronomy, with the financial support of the Netherlands Organization for the Advancement of Pure Research (ZWO).

References

Adams, T. F., 1977. *Astrophys. J. Suppl.*, **33**, 19.
Bos, A., Raimond, E. & van Someren Gréve, H. W., 1981. *Astr. Astrophys.*, in press.
Bosma, A., Ekers, R. D. & Lequeux, J., 1977. *Astr. Astrophys.*, **57**, 97.
Briggs, F. H., Wolfe, A. M., Krumm, N. & Salpeter, E. E., 1980. *Astrophys. J.*, **238**, 510.
Cohen, R. J., 1979. *Mon. Not. R. astr. Soc.*, **187**, 839.
Faber, S. M. & Gallagher, J. S., 1979. *Ann. Rev. Astr. Astrophys.*, **17**, 135.
Heckman, T. M., Balick, B. & Sullivan, W. T., 1978. *Astrophys. J.*, **224**, 745.
Heckman, T. M., Miley, G. K., van Breugel, W. J. M. & Butcher, H. R., 1981. *Astrophys. J.*, **247**, 403.
Huchra, J., 1980. *Astrophys. J.*, **238**, L11.
Keel, W. C., 1980. *Astr. J.*, **85**, 198.
Morris, M. & Wannier, P. G., 1980. *Astrophys. J.*, **238**, L7.
Shane, W., 1980. *Astr. Astrophys.*, **82**, 314.
van Woerden, H., Bosma, A. & Mebold, U., 1975. In *La Dynamique des Galaxies Spirales*, Colloque Internationaux de CNRS, No. **241**, 483.

Note added in proof

Several papers of relevance to Mkn 348 have recently been brought to our attention. Hawarden *et al.* (1981) have noted six cases of H I-rich ($M_{HI}/L_B \geqslant 0.5$) early-type galaxies with faint discs, and they suggest that these form a distinct morphological group. Mkn 348 would fall quite naturally into this class. For at least two members of this class – NGC 1512 (Hawarden *et al.* 1979) and NGC 5921 (Longmore *et al.* 1979) – the H I is extended over many galaxy optical diameters, again suggesting kinship with the Mkn 348. It is interesting that in these two cases the galaxies are in interacting systems, which may be relevant to our suggestion that the large-scale H I envelope in Mkn 348 has a tidal origin. Some other members of the H I-rich/faint disc class (which are not known to have large-scale H I envelopes) do not have suitable companion galaxies, (Hawarden, private communication). Finally, Hawarden (private communication) has obtained optical spectra of H II regions lying out in the H I envelopes of NGC 5291 and 1512 and finds abundances that are 1/3-solar to solar. Thus, the giant H I envelopes cannot represent primordial, unprocessed material. This would seem to be most consistent with a tidal origin for the H I. We thank Tim Hawarden for drawing our attention to these intriguing 'cousins' of Mkn 348.

Bergeron *et al.* (preprint) have detected an enormous envelope of ionized gas around the low-redshift quasar MR2251-178. In terms of size and kinematics this gas complex resembles the H I envelope of Mkn 348, and Bergeron *et al.* suggest that the only difference is the much stronger ionizing continuum produced by the quasar. This would then be the second case of a giant gaseous envelope around an active nucleus.

References

Hawarden, T. G. *et al.*, 1979. *Astr. Astrophys.*, **76**, 230.
Hawarden, T. G., Longmore, A. J., Goss, W. M., Mebold, U. & Tritton, S. B., 1981. *Mon. Not. R. astr. Soc.*, **196**, 175.
Longmore, A. J., Hawarden, T. G., Cannon, R. D., Allen, D. A., Mebold, U., Goss. W. M. & Reif, K., 1979. *Mon. Not. R. astr. Soc.*, **188**, 285.