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LETTER

Letter to the Editor

The HI Content of the Elliptical Galaxy NGC 4278

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Summary. The elliptical galaxy NGC 4278 has been measured in the 21-cm line of neutral hydrogen with the Nançay radiotelescope. Its neutral hydrogen mass is equal to 1.7 x 10^8 solar masses, which leads to an HI mass to luminosity ratio of 0.04 and an HI mass to total mass ratio equal to 0.14 x 10^{-2}. The 21-cm line has a rather large width of about 510 km s^{-1}, comparable to the velocity dispersion found by Osterbrock from the ionized gas in the nucleus of the galaxy.

Key words : elliptical galaxies-neutral hydrogen-interstellar matter-21-cm line radiation

I. INTRODUCTION

In the sample of elliptical galaxies surveyed by Humason et al. (1956), only 15% of these E0-E7 galaxies showed the emission blend of [OII] at λ3727, always confined to the nuclear region. In their detailed study of a selected set of elliptical galaxies, Minkowski and Osterbrock (1959) concluded that the emission lines were formed in large HII regions located in the nuclei of these systems.

In order to check whether the ionized gas is only a small part of a larger neutral cloud and whether the absence of emission indicates a lack of ionizing material or a lack of ionizing radiation, several 21-cm line studies have been made (Robinson and Koehler, 1965; Gallagher, 1972; Bottinelli et al., 1973; Guibert, 1973; Knapp and Kerr, 1974; Huchtmeier et al., 1975; Shostak et al., 1975). These 21-cm line investigations have set HI upper limits of a few times 10^8 solar masses in each galaxy, with no confirmed detection in the about two dozen observed ellipticals.

Considerations of mass loss from stars during the later stages of their evolution have provided an origin for gas in ellipticals (Tinsley, 1972; van den Bergh, 1972). The mechanisms which would account for the failure to detect HI in any elliptical have been extensively discussed by the above authors. One requires that either the gas is ionized (Rose and Tinsley, 1974), or swept by means of an intergalactic wind, falling into the centre of the galaxy where it is transformed into stars, or that the mass loss by stars is overestimated.

However, it should be emphasized that the upper limits quoted by the various authors were derived under the assumption that the 21-cm lines from elliptical galaxies would have 330 km s^{-1} wide rectangular profiles. Shostak et al. (1975) noted that the line shapes need not be rectangular and that either high galactic masses or turbulent motions in the nuclei could easily broaden the line widths by factors of 2 or 3. Any HI emission from ellipticals with a much greater linewidth might be undectable.

The data obtained by Gallagher (1972) for NGC 4278 with the NRAO 140 ft telescope showed a peak centered near the optical velocity. But he concluded that the reality of the signal must be considered as doubtful owing to the fact that the baseline curvature made the interpretation difficult.

A similar trend was observed later by Huchtmeier et al. (1975) with the 100 m radio telescope in Effelsberg. Using a fourth order polynomial fit to the baseline they suspect a "marginal line" with a maximum antenna temperature of about 0.02-0.03 degree K and a half-power width of about 100 km s^{-1}, corresponding to a neutral hydrogen mass (reduced to our 9.6 Mpc distance) of about 3 X 10^7 solar masses.

It appears thus that further observations of NGC 4278 would be quite necessary. They would also be interesting due to the fact that NGC 4278 is an intermediate luminosity galaxy while most studies have concentrated on giant ellipticals such as NGC 4472; Balkowski (1973), Bottinelli and Gouguenheim (1974a) have shown that the HI mass to luminosity ratio within a morphological type increases when the luminosity decreases. If this result (confirmed by Huchtmeier et al., 1976) holds for very early type galaxies, the search for neutral hydrogen should concentrate on intrinsically less luminous ellipticals.

We present here the HI detection obtained from a 21-cm line study of NGC 4278 performed with the Nançay radiotelescope.

II. RESULTS

The observations were carried out during several periods (Nov. 1974, Feb., Ap., Dec. 1975) with the Nançay radiotelescope, with a beam 4x25 arcmin and two sets of 15 adjacent channels spaced by 63.5 and 190.5 km s^{-1} respectively, with the usual on and off procedure; the total system temperature was ≈ 120°K. The line profile

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obtained after 8 hours of integration is given in Figure 1. Only a first order straight line fit to the baseline was used. The comparison between the line profiles obtained with the two banks of channels shows that a curvature of the baseline cannot account for the observed profile.

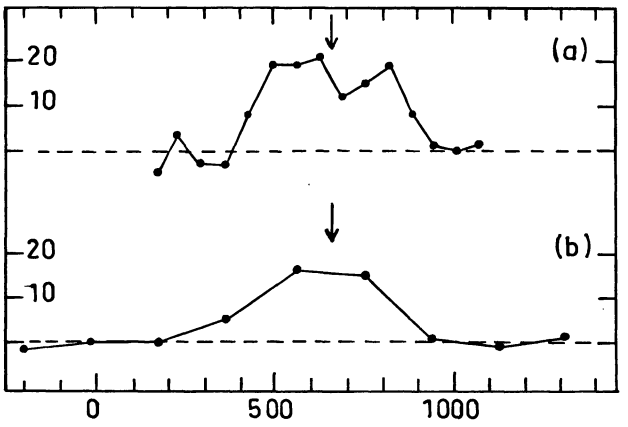

Fig.1. 21-cm line profiles for NGC 4278 obtained at Nançay, in 10-29 W $m^{-2}Hz^{-1}$ versus radial velocity, with respect to the Sun, in km s^{-1} ; (a) with the 63.5 km s^{-1} resolution; (b) with the 190.5 km s^{-1} resolution. The arrow indicates the optical radial velocity.

A possible confusion with neighbouring galaxies can also be eliminated; the two nearest galaxies ,NGC 4283 and NGC 4274 are located to (3.0'E, 1.6'N) and (3.5'W, 19.7'N) from NGC 4278 (Gallouët et al. 1973) respectively and lie outside our telescope beam. Moreover, we can rule out any confusion from NGC 4283, on the basis of its E0 type and of its radial velocity (1133 km s^{-1}) which falls outside the velocity range corresponding to the observed line; NGC 4274 is an Sab with a radial velocity (722 km s^{-1}) very near that we detected, but the observations we made in the direction of NGC 4274 have ensured us against confusion.

The optical and neutral hydrogen parameters are given in Table 1. The HI parameters are obtained through the procedure described by Gouguenheim (1969). The apparent photographic magnitude and the photometric diameter were taken from Holmberg's catalogue (1958). The magnitude was then corrected for absorption in our Galaxy and reduced to the galactic pole, according to the method given by de Vaucouleurs and Malik(1969). The distance was obtained from the Coma I Cloud membership (de Vaucouleurs, 1975). The total mass was evaluated using a total mass to luminosity ratio $M_t / L_o = 30$ (King and Minkowski, 1966).

III. DISCUSSION

NGC 4278 appears as nearly spherical; it is classified as type E1 in Hubble's classification (Humason et al. 1956) and by de Vaucouleurs et al. (1976). It is characterized by a strong λ3727 emission line (Osterbrock, 1960).

Its neutral hydrogen mass to luminosity ratio is much smaller than the mean value of 0.16 obtained for lenticular galaxies by Balkowski et al. (1972) or the value of 0.22 coming from Balick et al. (1976) data. However, it is comparable to the smallest values obtained for the less hydrogen-rich detected lenticulars.

TABLE 1. PARAMETERS FOR NGC 4278

Right ascension (1950.0)	12 h 17 m 35.7 s
Declination (1950.0)	+29° 33' 30"
Distance	9.6 Mpc
Photometric diameter	6.3 arcmin
Apparent photographic magnitude	11.20
Neutral hydrogen flux	$(1.82 \pm 0.6) \times 10^6$ $M_\odot Mpc^{-2}$
21-cm line width	510 ± 100 km s^{-1}
Neutral hydrogen mass	$M_H = 0.168 \times 10^9$
Total mass	$M_t = 120 \times 10^9$ $M_\odot$
Luminosity	$L_o = 4.08 \times 10^9$ $L_\odot$
M_H / L_o	0.041 $M_\odot / L_\odot$
M_H / M_t	0.14×10^{-2}
21-cm line systemic velocity	(680 ± 40)km s^{-1}
Optical radial velocity	659 km s^{-1} (de Vaucouleurs et al. 1976)

From his detailed study, Osterbrock (1960) estimated the mass of ionized material in NGC 4278 to be in the range 10^4 to 10^6 solar masses; his observations showed that the mass of interstellar gas in the nucleus is similar to an exceptionally large gas cloud in our Galaxy, the emission-line spectrum being comparable to the spectrum of an HII region. However the gas has a very large random velocity dispersion and the ionization is not due to the ultraviolet radiation from normal O stars. From our study we find that the ratio of the mass of ionized gas to that of neutral hydrogen is in the range 10^{-2} - 10^{-4}. However we have no indication of the localization of the neutral gas in the galaxy, owing to our lack of spatial resolution.

On the other hand, the width of the 21-cm line is comparable to the spread in velocity of 600-900 km s^{-1} given by Osterbrock (1960) in the nucleus of NGC 4278 or by King (1970) in 11 ellipticals. Here again, the lack of spatial resolution prevents us from concluding whether the line width that we observed results from large random velocity dispersion of the neutral gas or from systematic rotation in the galaxy or a combination of these two effects. Further observations with higher resolution are needed. Moreover we emphasize that the rather large value of the linewidth found for NGC 4278 corroborates our remark concerning the possible underestimation of the upper limits previously assigned to the HI content of ellipticals.

Previous studies (Bottinelli and Gouguenheim, 1974a, 1974b; Balick et al., 1976) have shown a correlation between the HI content and the colour within a type, the bluest galaxies being the most gas rich. For example, most of the bluer lenticulars observed by Balick et al. were detected and all but one that were not detected by them are red. No similar trend seems to be present among ellipticals : 14 galaxies previously studied in the HI line have upper limits of

M_H / L_o comparable to (or lower than) the M_H/L_o value found here for NGC 4278; nevertheless, they do not appear, in the mean, to be redder than NGC 4278. This conclusion is not affected when eliminating the Virgo cluster galaxies; indeed, if they were hydrogen deficient they should introduce a bias in the comparison.

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