VLA OBSERVATIONS AT 6 AND 20 CM OF OPTICAL JET-LIKE FEATURES ASSOCIATED WITH THE PECULIAR GALAXY MCG 5-29-86

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ABSTRACT

The galaxy MCG 5-29-86 is associated with a peculiar pair of symmetric optical jet-like features emerging from the nuclear region perpendicular to the major axis. VLA observations at 6 and 20 cm of this peculiar object show that both the main body of the galaxy and the "jets" are not radio active. We suggest that the jets may be an edge-on view of a thin disk or a ring of old population stars rotating around a prolate central bulge of the galaxy.

I. INTRODUCTION

In the course of optical inspection of deep plates taken with the Palomar 48-in. Schmidt telescope, one of the authors (K.W.) noticed a galaxy associated with a very long pair of jet-like features. The "jets" emerge from the central region of the galaxy perpendicular to the major axis (Fig. 1). If the galaxy is a rotating disk as seen edge-on, our jets could be evidence for an anisotropic explosion of a galactic nucleus. A variety of plasma and hydromagnetic theories predicts that an explosion in the rotating nuclear disk of a galaxy produces an energetic plasma jet perpendicular to the disk plane (Blandford and Rees 1974; Wiita 1978; Morita 1981). Most of the jet phenomena found so far are identified in elliptical galaxies (De Young 1976; Aizu 1978; Spark and Shu 1980). However, there has been no clear evidence for an explosion in a rotating nuclear disk in elliptical galaxies.

In this respect, if our peculiar jets in MCG 5-29-86 are due really to an explosive phenomenon that occurred at the nucleus of an edge-on galaxy, it might be evidence for an anisotropic explosion predicted by the theories. To make clear whether or not the optical jets are really an energetic phenomenon, we conducted a radio continuum observation of this galaxy at 6 and 20 cm using the Very Large Array (VLA) of NRAO.

II. OPTICAL PROPERTIES OF MCG 5-29-86

The galaxy MCG 5-29-86 has been catalogued by Vorontsov-Velyaminov and Arkipova (1964) with a remark that the galaxy has faint jets. Figure 1(a) reproduces a photograph of this galaxy taken with the Palomar 48-in. Schmidt telescope on the IIIa-F emulsion combined with a Wr 23 filter with an exposure time of 60 min. Figure 1(b) shows a photograph taken with the Kitt Peak 4-m telescope on a IIIa-J emulsion with an exposure time of 75 min (courtesy of Dr. H. Arp). The main part of the galaxy consists of a nearly round central bulge with a more flattened disk, which suggests that it is an edge-on disk galaxy of early type.

A pair of jet-like features emerge from the central region of the galaxy at a position angle of 60°, almost perpendicular to the major axis. The angle between the jets and the major axis of the galaxy is approximately 80°. The axes of the northeastern and southwestern jets are converged toward the nuclear region of the galaxy with an open angle of $\sim 195°$. The length and width of each jet are, respectively, 40 and 5 arcsec. The former should be compared to the 30-arcsec diameter of the main part of the galaxy.

The magnitude of the galaxy is about $m_{pg} = 16$ (Vorontsov-Velyaminov and Arkipova 1964). The mean surface brightness of the jets was measured to be one-tenth of the sky brightness by using the KPNO 4-m plate. If we adopt 22.0 ± 0.5 mag/arcsec^2 as the sky brightness at KPNO, we get $m_B = 18.0 \pm 0.5$ as the total magnitude of the jets. Spectra of the central part of the galaxy and jets were taken with the Palomar 5-m telescope (Arp and Wakamatsu 1981, private communication). From the absorption lines, the main body has a recession velocity of 7040 km s^{-1}, which puts the galaxy at a distance of $140h^{-1}$ Mpc, where $h = H/(50$ km s^{-1} Mpc$^{-1})$ and H is the Hubble constant. The galaxy shows no emission lines. The jets show neither emission lines nor absorption lines, suggesting that they are high-energy phenomena. However, we cannot give a

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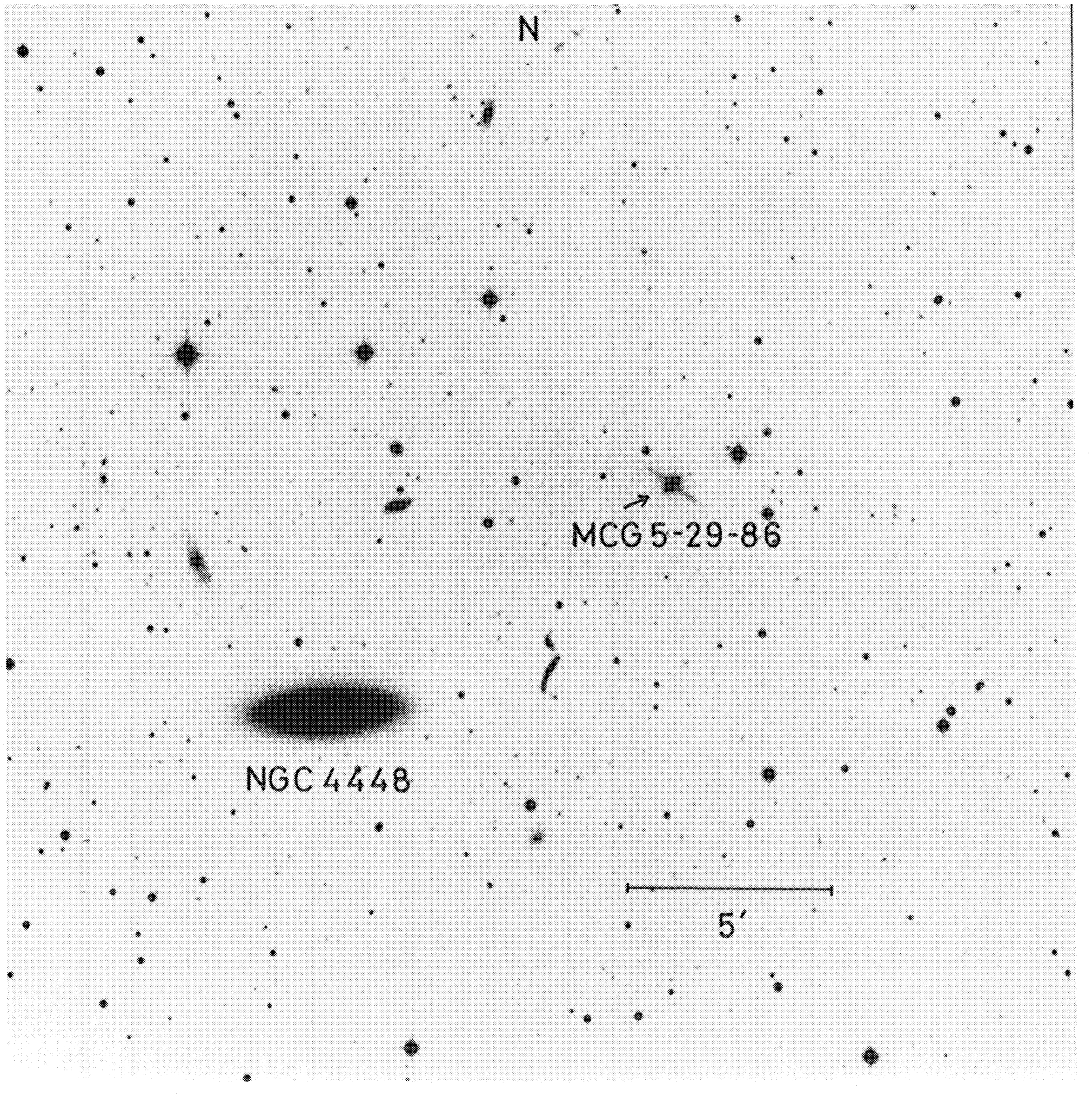

FIG. 1(a). A field around MCG 5-29-86 (arrowed) taken with the Palomar 48-in. Schmidt telescope on a IIIa-F emulsion with a Wr 23 filter at an exposure time of 60 min.

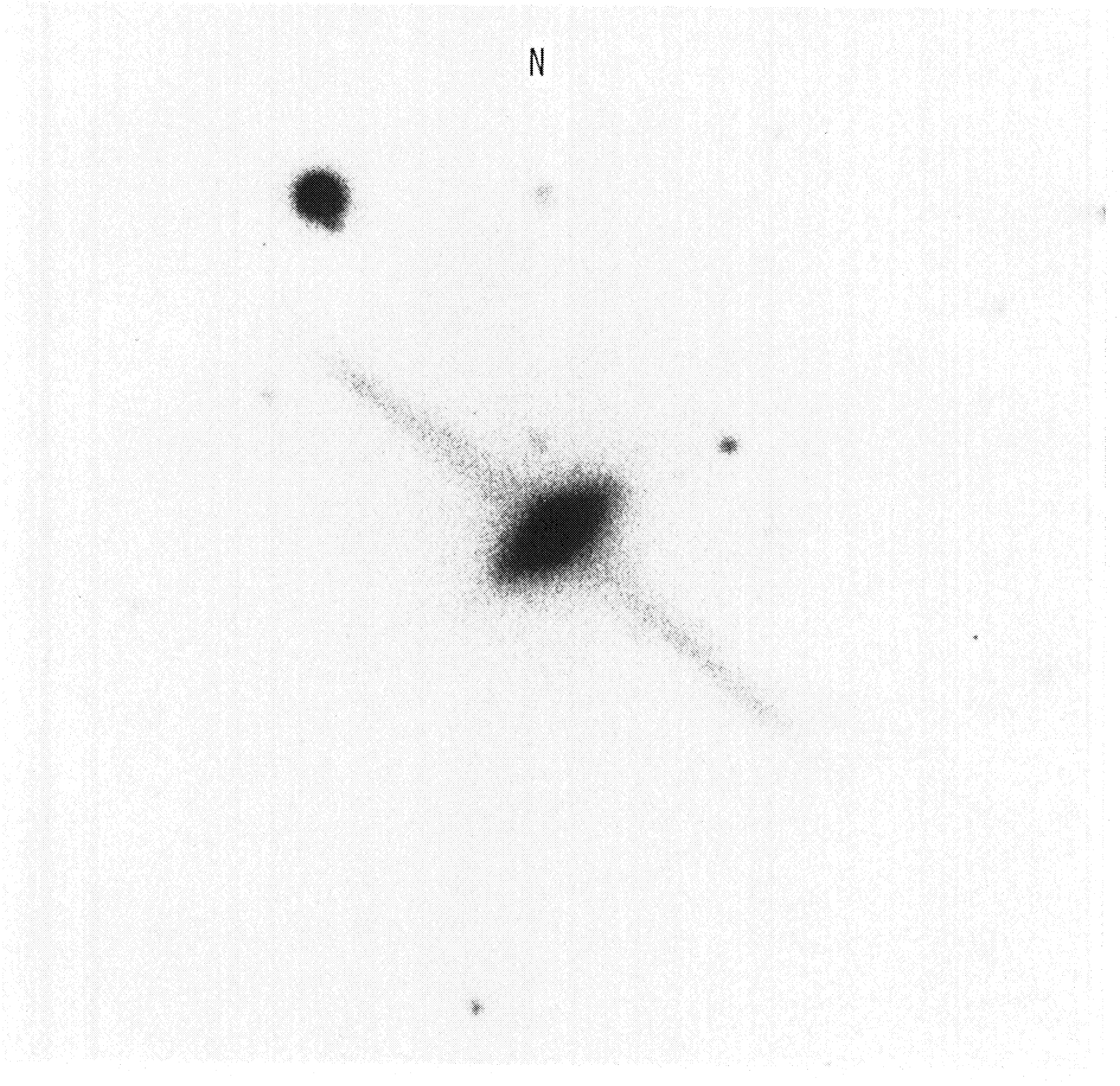

FIG. 1(b). MCG 5-29-86 taken with the Kitt Peak 4-m telescope on a IIIa-J emulsion at an exposure time of 75 min (courtesy of Dr. H. Arp). The scale is shown in Fig. 3.

definite conclusion as yet, because the jets are extremely faint and the quality of the spectra is still poor. According to a preliminary UGR color study using the Kiso 105-cm Schmidt telescope (B. Takase 1981, private communication), the galaxy is not particularly blue. Table I summarizes the optical properties of MCG 5-29-86 and its jets.

III. RADIO OBSERVATIONS

Radio continuum observations at 6 and 20 cm were made with the VLA of NRAO in New Mexico. The allocated observing time was 7 h on 22 March 1981. We used the *A* configuration of the array, which had 26 an-

TABLE I. Optical properties of MCG 5-29-86.

Position: R.A.(1950)	$12^h25^m12^s.4$
Dec.(1950)	28°58′28″
Magnitude, m_{pg}	16th mag.
Magnitude, m_B of jets	~18th mag.
Redshift, *cz*	7040 km s^{-1}
Distance	140 Mpc h^{-1} [a]
Length of major axis of main part	30″ (20 kpc)
Length of minor axis	15″ (10 kpc)
Position angle of the major axis	140°
Position angle of jets	60°
Angle between jets and major axis	80°
Length of each jet	40″ (30 kpc)
Width of jet	5″ (3 kpc)

[a] $h = H/(50 \text{ km s}^{-1} \text{ Mpc}^{-1})$.

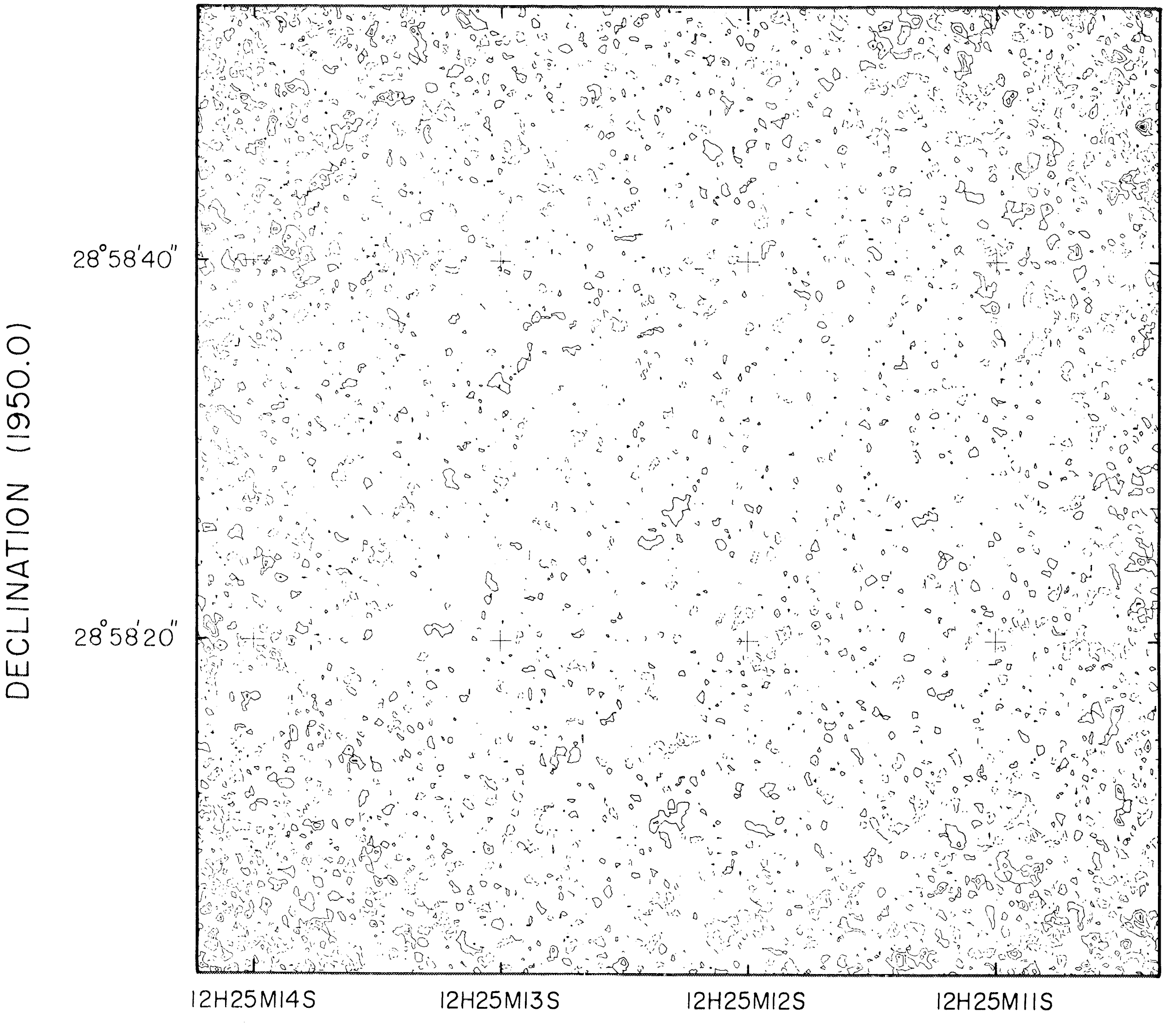

FIG. 2(a). Surface brightness map at 6 cm. Contour units are in 77 μJy/beam.

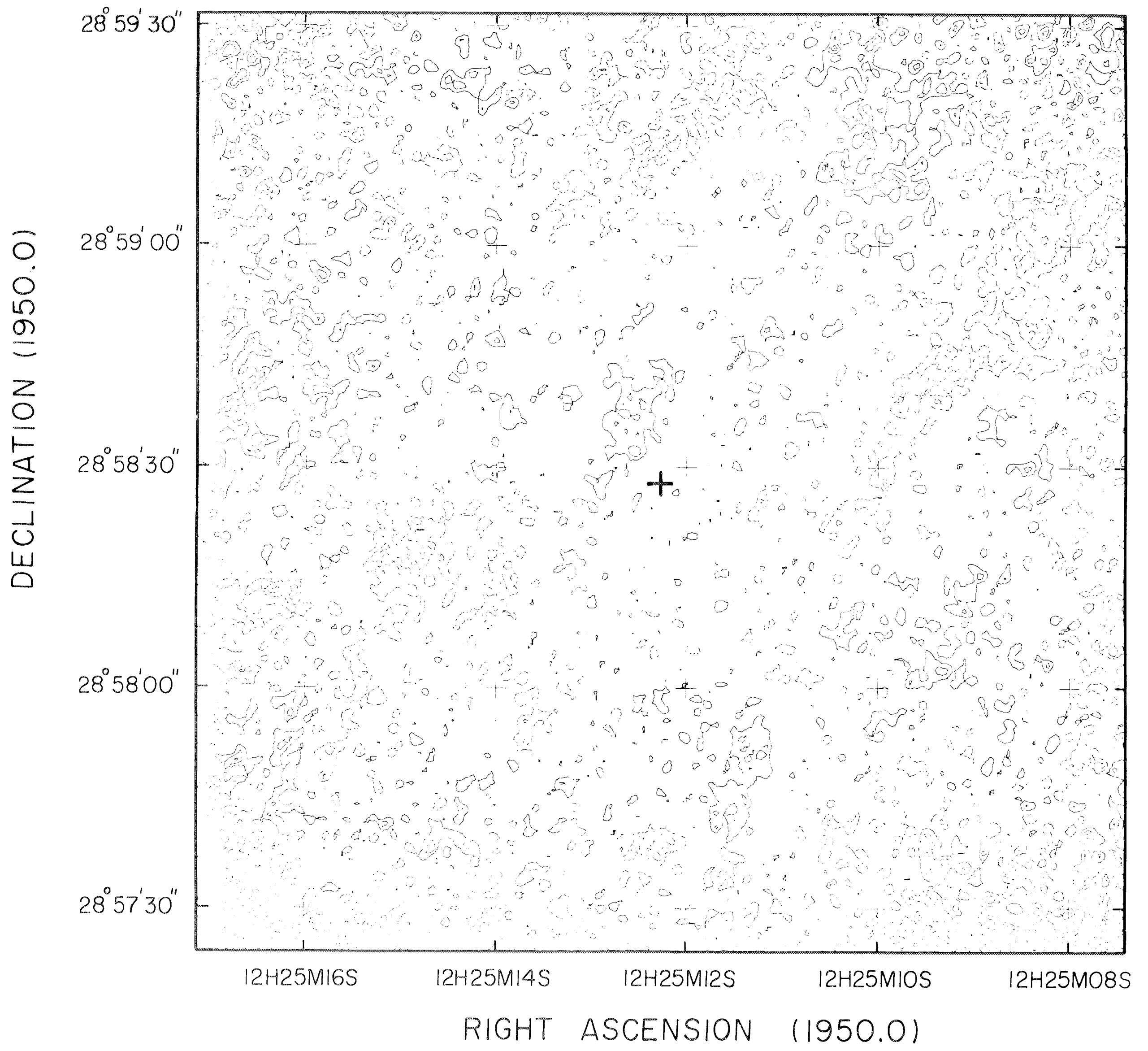

FIG. 2(b). Same as Fig. 2(a) but at 20 cm. Contour units are in 137 μJy/beam.

tennas and the longest baseline of 35 km, and the angular resolutions of the synthesized beam were 0.5 and 1.7 arcsec at 6- and 20-cm wavelengths, respectively. The bandwidths were 50 MHz at both frequencies and the system noise temperatures were about 60 K. We used 3C 286 for calibrating flux density and position, and the radio source 1219+289 for calibrating the phases of the array. The effective integration time on the source (MCG 5-29-86) was approximately 2 h at both frequencies. The rms sensitivity was approximately 50 μJy per synthesized beam at both frequencies after removing bad data.

Figure 2 shows the 6- and 20-cm radio maps of the surface brightness, and Fig. 3 shows the 20-cm map superimposed on the photograph of MCG 5-29-86 taken with the Kitt Peak 4-m telescope. No jet-like features in the radio wave range are found associated with the optical jets. Upper limits to the surface brightness at 6 and 20 cm are about 50 and 100 μJy per synthesized beam, respectively. The upper limit to total flux density of the whole galaxy (main part plus the jets; approximately 0.24 arcmin^2) is 5 mJy at 6 cm and 3 mJy at 20 cm. These upper limits yield a spectral power of the object less than $8\times10^{21}\ h^{-2}$ W Hz^{-1} at 6 cm and less than

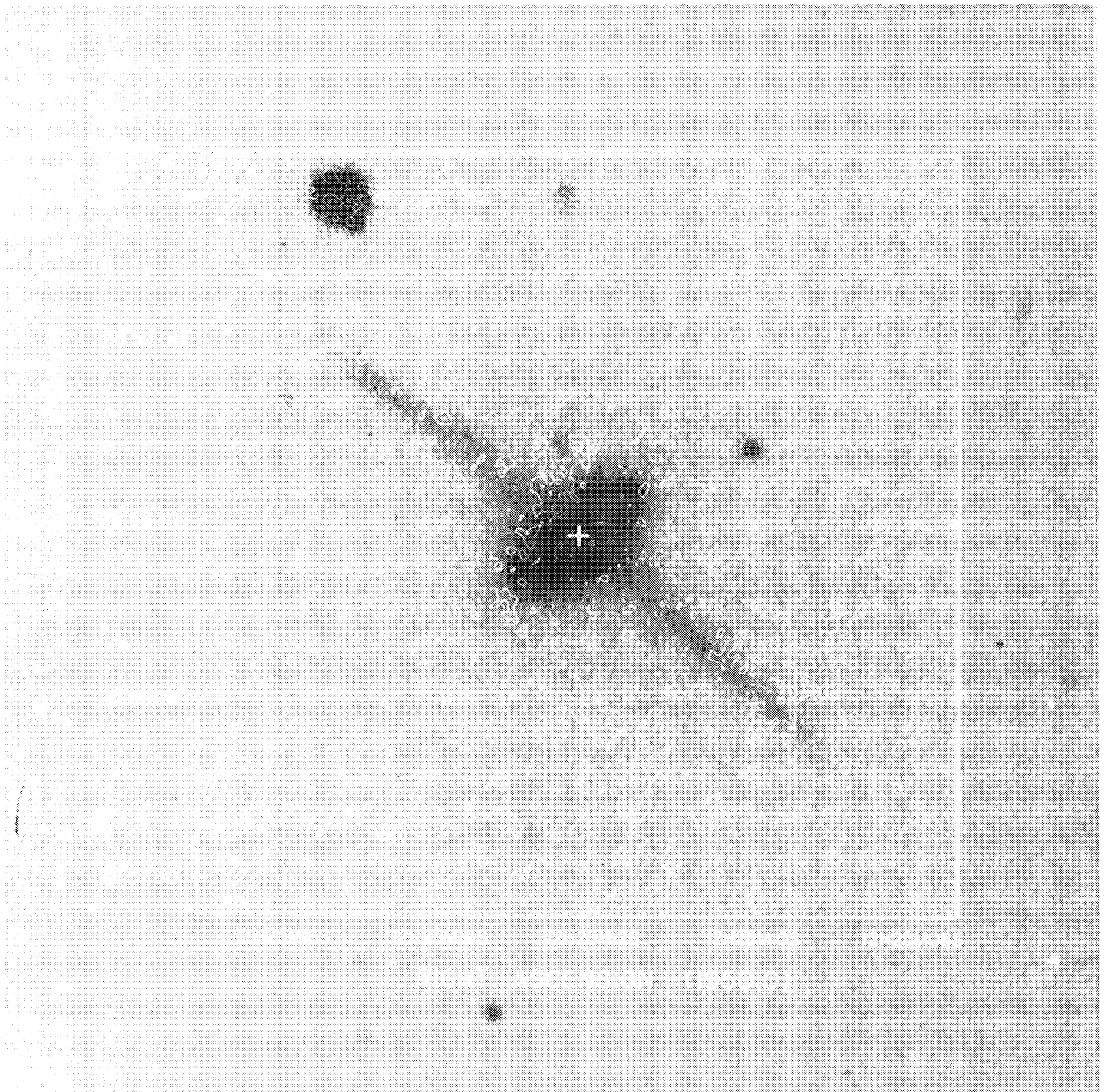

FIG. 3. Same as Fig. 2(b) but superimposed on the photograph of MCG 5-29-86.

TABLE II. Radio observations of MCG 5-29-86.

Wavelengths	6 cm	20 cm	
Resolution (synthesized beam)	0.5″	1.7″	
Surface brightness	< 50 μJy/beam	< 100 μJy/beam	
Total flux density			
Main body of galaxy (30″ × 15″)	< 2 mJy	< 1.3 mJy	
Each jet (40″ × 5″)	< 1.4 mJy	< 0.8 mJy	
Total (galaxy plus two jets; 0.24 arcmin²)	< 5 mJy	< 3 mJy	
Spectral power[a]			
Main part	$< 4.7 \times 10^{21}\ h^{-2}$	$< 3 \times 10^{21}\ h^{-2}$	W Hz⁻¹
Jet	$< 3.3 \times 10^{21}$	$< 2 \times 10^{21}$	W Hz⁻¹
Total	$< 8 \times 10^{21}$	$< 5 \times 10^{21}$	W Hz⁻¹

[a] Spectral power = $4\pi \times$ total flux density $\times$ (distance²).

$5\times10^{21}\,h^{-2}$ W Hz^{-1} at 20 cm (Table II). The values are also given separately for the main part of the galaxy and each of the jets in Table II.

IV. DISCUSSION

In spite of the peculiar feature of the optical jets associated with MCG 5-29-86, which suggests an explosive phenomenon, we could not detect any stronger radio emission than a few mJy at 6 and 20 cm. If the feature is not really due to nuclear activity of the galaxy, we may consider an alternative interpretation of the feature: The jet-like feature is not a jet but a faint disk seen edge-on and the "main part" is just a central bulge of prolate shape.

In fact, a galaxy of very similar appearance is known in the southern hemisphere: Lausten and West (1980) have found a galaxy, NGC 4650A, with a prolate central bulge around which a thin disk of stars rotates. They gave kinematical properties of the galaxy and conclude that the edge-on disk of stars is a warped rotating ring rich in Population I objects like young stars and H II regions. They argue further that the prolate shape of the central bulge as well as the ring structure may be a result of a tidal interaction with a nearby companion galaxy which is located along the direction of the major axis of the bulge and may have passed through the galaxy center on collision. However, we note that there is no candidate for an interacting nearby companion around MCG 5-29-86 (Fig. 1). From a dynamical point of view, it is possible to construct such a prolate elliptical bulge composed of a collisionless star system, elongated in the direction of the rotation axis (Lake 1981). Bertola and Galetta (1978) have given some evidence for prolate elliptical galaxies assocated with bands of dark lanes perpendicular to their major axes.

Insofar as Fig. 1(a) and 1(b) are concerned, the jet-like components of MCG 5-29-86 involve neither young population objects like H II regions and OB associations nor dark lanes indicating the existence of gaseous matter. This fact suggests that, if the jet-like feature is an edge-on view of a Lausten and West-type star ring, the ring must be composed of very old population stars where most of the Population I objects have already evolved. The upper limit to the total radio power of a few 10^{21} W Hz^{-1} at 20 cm as given in Sec. III is not inconsistent with total powers observed for normal disk galaxies (e.g., Hummel 1980).

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