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NEUTRAL HYDROGEN EMISSION—ABSORPTION IN THE IRR II GALAXY NGC 5363

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ABSTRACT

The neutral hydrogen profile of the peculiar galaxy NGC 5363 reveals broad weak emission characteristic of disk emission from an early-type galaxy, as well as absorption attributed to a cloud located in front of the core continuum source. The peak optical depth of the absorption feature is $\tau \lesssim 0.06 \pm 0.005$. The relatively broad absorption range and its asymmetry likens the feature to those seen in several other systems, in particular that of NGC 253.

Subject headings: galaxies: general — radio sources: 21 cm radiation

I. INTRODUCTION

NGC 5363 is a peculiar galaxy located in a nearby loose group that contains at least six bright members. While its nearest neighbor NGC 5364 is an undisturbed Sc, NGC 5363 is alternatively classified as an Ep or an Irr II. A nuclear continuum radio source less than 5″ in size at 2695 MHz was noted in the survey of Crane (1977); VLBI observations at 2380 MHz found the source size to be 0″.007 (Crane 1979).

A IIIa-J plate reproduction and its tracing containing most of the group are presented by Kormendy and Bahcall (1974). Included are two dissimilar galaxies classified as Irr II's: the low luminosity NGC 5360 and the brightest member, NGC 5363. Because of the spatial proximity of the three galaxies, NGC 5360, NGC 5363, and NGC 5364, the aggregate was included in the search for neutral hydrogen appendages extending outward from the disks of spiral galaxies in groups presented by Haynes (1981). No H I streams as such were found in the group around NGC 5363. However, in the course of that survey, neutral hydrogen absorption in the direction of NGC 5363 was observed. Further integration revealed the H I spectrum reported here. It is characterized both by the broad asymmetric absorption feature and by broad and shallow emission, typical of what is expected for an early-type galaxy.

II. THE H I SPECTRUM

Initial observations of NGC 5363 were made as part of the overall survey of H I streams presented by Haynes (1981). The original spectrum showed hydrogen absorption, but the emission profile was secured only after substantial additional integration. The absorption was also confirmed independently by van der Hulst and Crane (1980). All data were obtained using the Arecibo 305 m telescope. The front end consisted of a single channel of a cooled upconverter parameter amplifier receiver attached to a linear polarization line feed giving a half-power beam width of about 3′.9. A single spectrum was obtained via use of 504 autocorrelator channels over a 10 MHz bandwidth, giving a spectral resolution before smoothing of about 4.2 km s^{-1}. The system temperature was about 60 K. Further details on the use of this system for spectral line observations are included in Hewitt, Haynes, and Giovanelli (1981).

Figure 1*a* shows the unsmoothed, total power difference spectrum. A total of 130 minutes was spent on source. A smoothed version of the same spectrum is presented in Figure 1*b* where Hanning smoothing has been applied after a three-channel rectangular smoothing function. The most prominent feature is the absorption seen to reach a maximum depth at $V_\odot = +1158$ km s^{-1}. Shallower absorption extends toward higher velocities. Broad and weak emission centered at a midpoint velocity of $V_\odot = +1136$ km s^{-1} occurs over a range of 605 km s^{-1} as measured at 20% of the peak.

In order to obtain a measure of the continuum flux from this source, drift scans across the source and 1′ to the north and south were made. The continuum flux obtained at 1407 MHz (the peak of the frequency response of this system) was measured to be $S_{1407} = 160 \pm 6$ mJy. Other measures of the continuum flux of this source include that at 2380 MHz of Dressel and Condon (1978), $S_{2380} = 132 \pm 6$ mJy; and that given by Crane (1977) at 2695 MHz, $S_{2695} = 108$ mJy (for the nuclear component); and Crane (1979) at 2380 MHz, $S_{2380} = 113$ mJy (for the nuclear component).

Table 1 summarizes the parameters obtained from measurements of the H I spectrum. Parameters for the emission and absorption components have been derived separately by assuming an average emission over the

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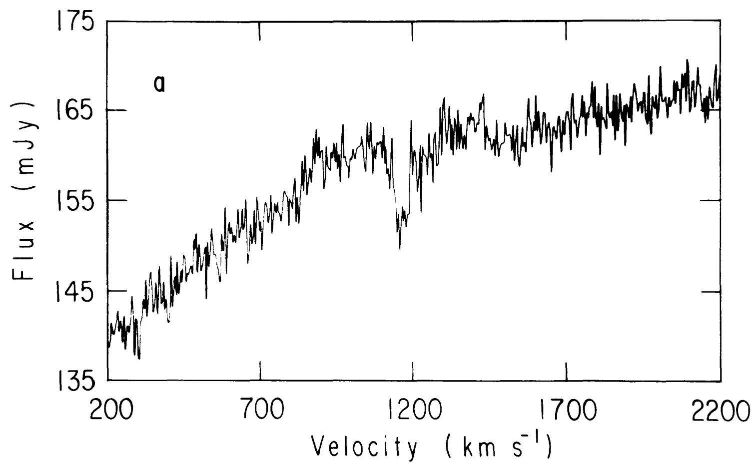

FIG. 1*a*

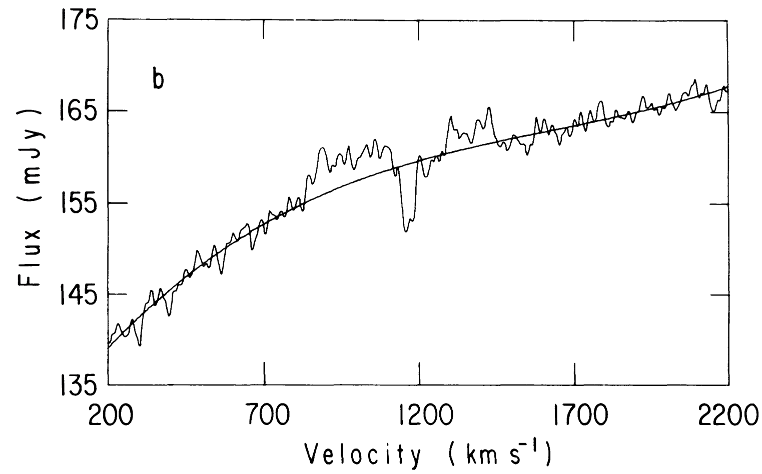

FIG. 1*b*

FIG. 1.—(*a*) Unbaselined and unsmoothed total power difference spectrum of NGC 5363. The 10 MHz signal was sampled by 504 autocorrelator channels spaced at 19.53 kHz. Total on-source integration time was 130 minutes. (*b*) Spectrum shown in (*a*) after three-channel rectangular and Hanning smoothing. The smooth curve superposed is the polynomial baseline that has been subtracted to derive the profile characteristics.

absorption range. The polynomial baseline which has been subtracted from the spectrum before measurement of the H I flux is shown in Figure 1*b*. The hydrogen mass and total mass derived from the emission profile parameters have been calculated, as outlined in Haynes (1981). Because a substantial amount of the emission profile is contaminated by absorption, the assumption of an average emission is approximate at best. The distance hD, with $h=H_0/100$ and H_0 (the Hubble constant), comes from the luminosity-weighted mean velocity corrected for solar motion derived by Haynes for the NGC 5363 group (six velocities) $\langle V_0 \rangle = 1164$ km s^{-1}. The broad and weak emission is characteristic of disk rotation in an early-type galaxy; this early-type classification gains further implication from the large corrected velocity width (Roberts 1978) of 834 km s^{-1}, assuming an inclination of 46°.5 derived from the axial ratio given in Holmberg's (1958) catalog, and from the low hydrogen mass fraction $hM_H/M_T = 1.4 \times 10^{-4}$.

The absorption profile is more complex. It appears to be composed of two components: one broad extending toward the higher velocities, and the other narrower but deeper, centered at $V_{\odot} = +1158$ km s^{-1}. The identification of the shallow feature is uncertain because of the H I emission from the entire disk contained within our beam. If we assume that the absorbing H I completely covers the central continuum source, the peak optical depth given by

$$\tau = -\ln\left[1 + \frac{T_A(\text{line})}{T_A(\text{source})}\right]$$

is $\tau = 0.06 \pm 0.005$. A mean value of the optical depth over the entire absorption range of $\langle \tau \rangle = 0.024$ gives a

TABLE I

EMISSION AND ABSORPTION IN NGC 5363

Parameter	Emission[a]	Absorption[a]
$\int S\,dV$ (Jy km s^{-1}) ...	1.53	-0.73
$V_{\odot}$ (km s^{-1})[b]	$+1136$	$+1200$
ΔV (km s^{-1})[c]	605	170
$h^2 M_{\mathrm{H}}$ ($10^7\ M_{\odot}$)	5.6	...
hM_T ($10^{11}\ M_{\odot}$)	4.0	...
τ_{peak}	...	0.06 ± 0.005

[a] Derived assuming an averaged emission over the absorption region. The absorption parameters are for both absorption features collectively.

[b] Midpoint velocity.

[c] Full width at 20% of peak.

mean column density of $N_{\mathrm{H}} = 8.4 \times 10^{20}$ cm^{-2} where a value of 100 K has been used for the spin temperature.

Since the central continuum source contributes nearly all the flux, at least at 2380 MHz, the assumption that the absorbing cloud (or clouds) covers the nuclear source completely seems warranted. If, however, the cloud(s) covers only part of the central source, the optical depth might be much greater.

III. DISCUSSION

The neutral hydrogen profile of NGC 5363 can contribute to an understanding of its nature as a peculiar object. The Irr II class is an inhomogeneous set of objects. Certainly NGC 5363 bears little resemblance to its neighbor NGC 5360 which is similarly classified. NGC 5360 belongs to a class of lower luminosity peculiar objects fairly common in nearby loose groups. Krienke and Hodge (1974) describe NGC 5363 as an S0 galaxy with an anomalously large amount of dust. Several similar galaxies, e.g., NGC 3077 (van der Hulst 1979) and NGC 2777 (Haynes 1981), show signs of interaction with more massive companions. Cottrell (1978) has proposed that at least some Irr II's arise from gravitational encounters. In fact, the configuration of the two Irr II galaxies near NGC 5364 closely resembles that of the M81/M82/NGC 3077. There is no obvious evidence, however, for tidal disruption among the galaxies in the NGC 5363 group (Haynes 1981).

The optical systemic velocity of $V_{\odot} = +1125$ km s^{-1} as given by de Vaucouleurs, de Vaucouleurs, and Corwin (1976) agrees well with the H I emission midpoint velocity. The H I absorption lies predominantly off-center, toward higher velocities, and is most readily explained in terms of material moving toward the nuclear region as seen in our own and other galaxies. In contrast to the narrow H I absorption lines seen in the spectra of QS0s, the wideness of the line here matches those seen in several nearby galaxies, most notably NGC 253 (Whiteoak and Gardner 1973), M82 (Guélin and Weliachew 1970), and 3C 178 (Roberts and Steigerwald 1977; Haschick, Baan, and Burke 1978). Furthermore OH has been detected in absorption in NGC 5363 (Rickard 1980), as it has been in NGC 253.

The structural detail of the continuum source must be better known before the nature of the absorbing gas can be understood. Interferometric observations would permit better separation of the H I absorption from emission from the entire galactic disk which contaminates our spectrum. It is likely that the absorbing cloud lies within the galaxy itself and in front of the nuclear source. As in the cases of M82 (Weliachew 1974) and NGC 253 (Gottesman *et al.* 1976), the velocity gradient across the absorption feature may reflect the rotation of the galaxy, which is clearly implied by the emission profile.

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