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HI OBSERVATIONS OF THE PECULIAR GALAXY NGC 660

Stephen T. Gottesman and Mary Elaine Mahon
Department of Astronomy
University of Florida
Gainesville, Florida

We present observations of HI emission from the peculiar galaxy NGC 660. HI was detected in the companion galaxy UGC 01195 as well. Sixteen hours of observations were obtained with the VLA telescope of the National Radio Astronomy Observatory during December 1986 and March 1987.

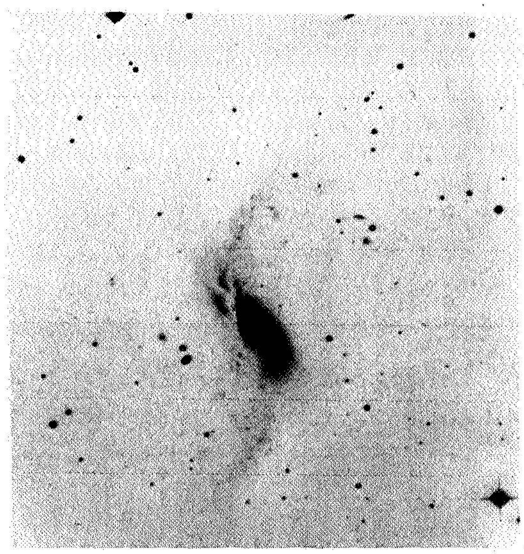

Figure 1

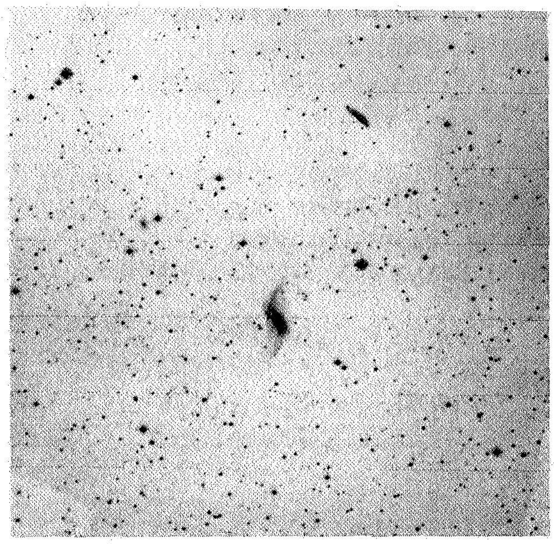

Figure 2

Photographs of NGC 660 show a central bar-like structure crossed by two systems of absorption, as well as an outer ring or disk inclined about 50 degrees with respect to the major axis of the central body (see figure 1). Figure 2 shows UGC 01195, an irregular, distorted galaxy located 22 arcminutes or 72 kpc N.W. of NGC 660. In table 1 we list the systemic parameters of interest.

The Continuum Emission

The high resolution (2") maps of Condon, Condon, and Puschell (1982) at 20-cm show two peaks in the extended central continuum source of more than 5" in extent. The smeared peak (589°K) of these continuum features, seen in our maps with 14" resolution (figure 3), agrees with the IR and optical position of the galaxy to better than 6". At a lower intensity, the emission extends for more than 2 arcminutes along position angle 46 degrees in the general direction of the narrow dust lane.

Table 1

Observational and Related Parameters

	NGC 660	UGC 01195
Right Ascension	$01^h40^m.36$	$01^h39^m.7$
Declination	13°23'.64	13°43'
Type	SBa pec	irregular
[a]Dimensions on PSS plate	10'.0 X 4'.5	3'.5 x 1'.1
[a]Photographic magnitude	12.8	13.9
[b]$\log(L_{TOT}/L_\odot)$	10.9	
Systemic Velocity of HI ($V_\odot$)	842 km/s	[c]772 km/s
Distance (H=75 km/s/Mpc)	11.2 Mpc	
Angular Resolution	14".89 X 13".50	14".89 X 13".50
Linear Resolution (kpc)	0.81 X 0.73	0.81 X 0.73
RMS Sensitivity	0.76 mJy/Beam	0.76 mJy/Beam
....	2.2°K	2.2°K
Total Integrated Flux	164 Jy*km/s	
Detected HI Mass	$4.9 \times 10^9\ M_\odot$	
Velocity Resolution	21 km/s	21 km/s
[d]Keplerian mass of NGC 660	$1.2 \times 10^{11} M_\odot$	

a. UGC Catalogue of Galaxies
b. $L_{TOT} = L_{FIR} + L_B$ from Young, J.S., Kleinman, S.G., Allen, L.E. 1988, Ap. J. 334: L63-67.
c. Calculated as the average velocity over the channels in which it appeared.
d. $M = R^*(V_{RAD}(R)^*\csc I)^2/G$, where R=17 kpc, $V_{RAD}(R)$=150 km/s, and I(HI ring)=60°.

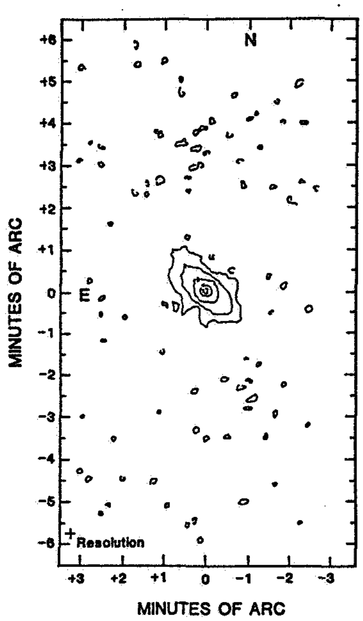

Figure 3: The continuum structure of NGC 660 at 20-cm. The peak brightness temperature in the map is 589°K and the contour levels are 2.95, 11.78, 58.90, 294.50, and 589.00°K.

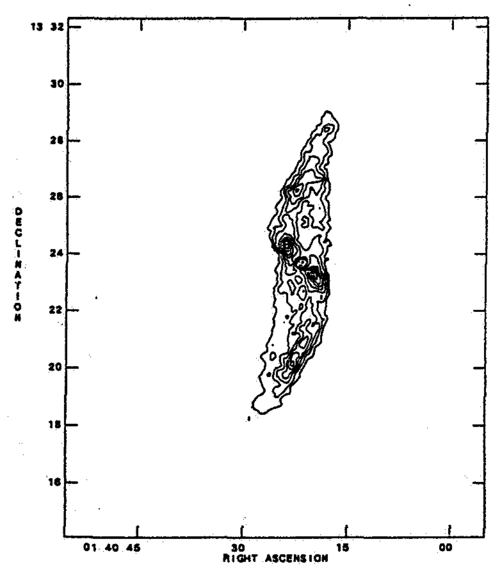

Figure 4: The integrated HI flux of NGC 660. The peak flux observed is 1.6167×10^3 Jy/Beam*m/s and the contour levels are at $1.8615 \times 10^2 \times$ (1, 2, 3, 4, 5, 6, 7, 8) Jy/Beam*m/s. Owing to absorption at the center of the galaxy, there is a hole in the map.

HI Emission

NGC 660 appears to be a disturbed galaxy for which there is strong evidence that two HI kinematical systems exist: one along the principal axis of the ellipsoidal optical system and one inclined to it by about 53°. A kinematic fit to the line of nodes for the extended HI component gives a major axis position angle of -7°, inclination I = 60.5° , and a systemic velocity V = 842 km/s. The position angle for the continuum major axis and narrow dust lane is 46°. A contour map of the integrated flux (figure 4) reveals that the short, intense diagonal feature is associated with the narrow equatorial dust lane, while the extended gas is associated with the tilted asymmetric ring.

Even though rotation dominates the velocity pattern of the gas, gross deviations from circular motion are apparent (see figure 5). A comparison of the corrected H-alpha maps of Young, Kleinman, and Allen (1988), to our HI velocity field shows that there may be a connection between the disturbed velocity contours in HI (see figures 5 and 6) and an arc of HII regions, seen in the H-alpha maps, extending towards the southwest.

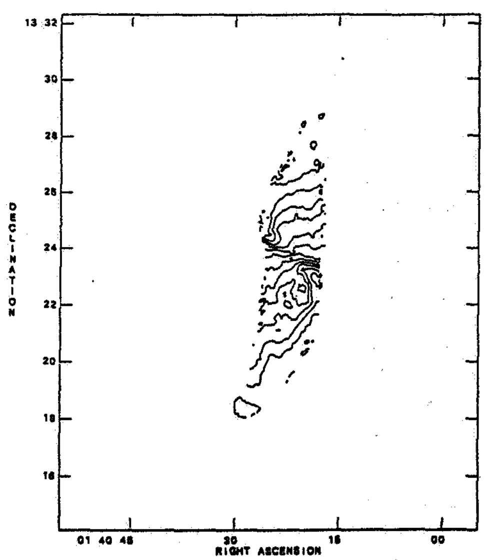

Figure 5: Integrated Mean Velocity field of NGC 660. The contour levels are at 700, 720, 740, 760, 780, 800, 820, 840, 860, 880, 900, 920, 940, 960, and 980 km/s.

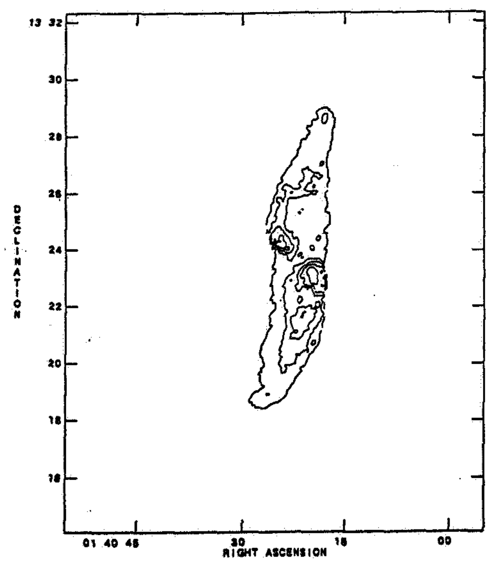

Figure 6: Integrated Mean Velocity Dispersion. The peak contour level observed is 61.5 km/sec. Contour levels are drawn at 10, 20, 30, 40 50, and 60 km/s.

The axis velocity diagram, drawn along P.A. 46° (figure 7) shows clearly the multi-peaked HI spectra in emission and complex, broad, deep absorption at the galactic center. Where the two systems intersect along the line of sight the observed HI brightness temperature is 60°K. The axis velocity diagram for P.A. -7° is given in figure 8.

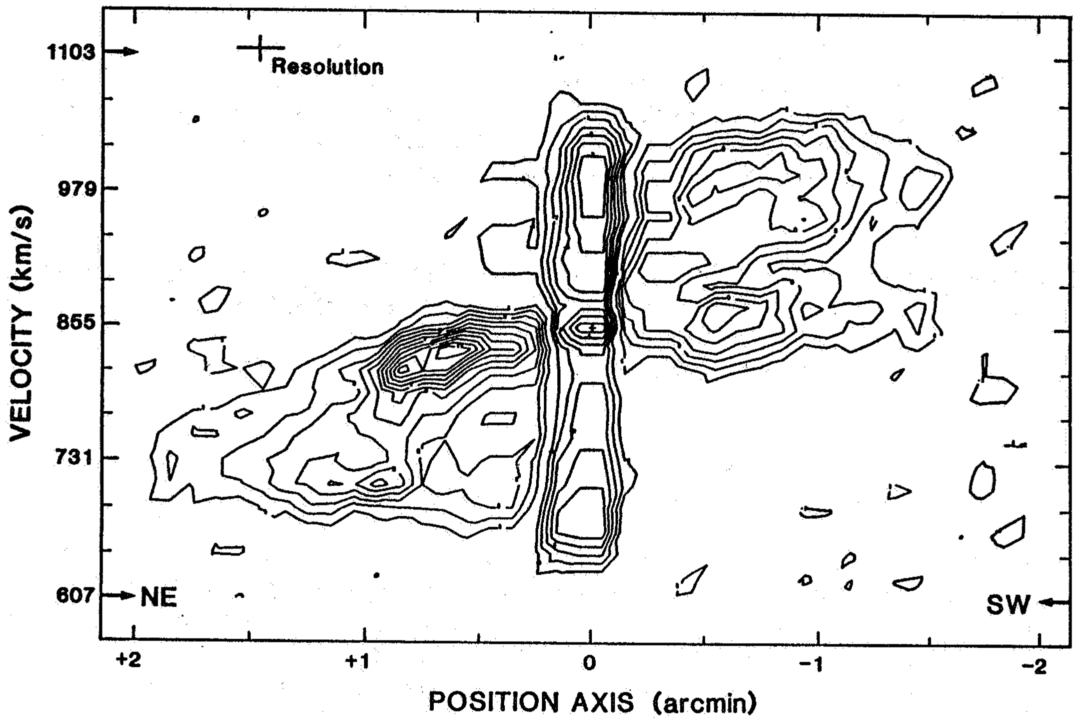

Figure 7: Axis Velocity Profile through the center at P.A. 46°. Contours are plotted at intervals of 4.5°K. The dark contours are negative and represent absorption. The deepest feature is less than -31°K and the brightest feature is greater than 49°K. Note the multiple peaks in the spectra.

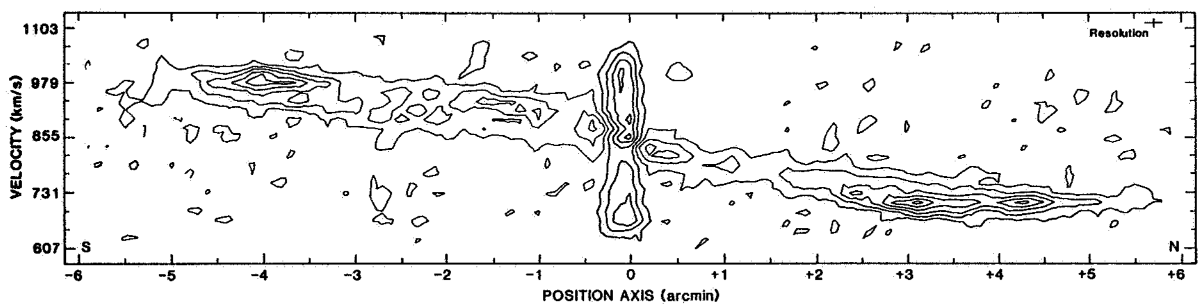

Figure 8: Axis Velocity Profile through the center at P.A. -7°. Contour intervals are at -31.36, -22.40, -13.44, -4.48, 4.48, 13.44, 22.40, 31.36, 40.32, and 49.28°K.

Absorption of the strong central continuum source by HI can be seen in both axis velocity profiles. The mean velocity of the absorbing gas appears to vary systematically across the weakly resolved source, with the width of both components exceeding the half power width of the beam by about 30 percent. The absorbing gas could be associated with a rotating nuclear ring or disk, or it may be distributed along the line of sight and associated with the two inclined kinematical systems. Higher resolution observations of the absorption are required in order to distinguish between these two possibilities. In addition, we note a velocity difference of 20-40 km/s between the absorption and emission peaks at the low velocity end of the profile taken along P.A. 46°. This velocity difference may be indicative of outflow.

The apparently disturbed nature of this galaxy, its nuclear structure, and its starburst characteristics provide strong support for the hypothesis that this is a merged or merging system in which interaction between the systems triggered an intense burst of star formation.

The Companion Galaxy, UGC 01195

The companion galaxy to NGC 660, UGC 01195 is described in the UGC Catalogue of Galaxies as an irregular, distorted, slightly arc-shaped galaxy that exhibits no spiral structure. The rotation of the hydrogen in UGC 01195 is shown schematically in figure 9, by superposition of every other channel in which it was detected. Our channel maps give a total velocity width of 124 km/s and a mean systemic velocity of 772 km/s, corresponding to an observed radial velocity difference between NGC 660 and UGC 01195 of 70 km/s. Ignoring unknown projection effects, the mass required to bind UGC 01195 is 4.1 X $10^{10} M_{\odot}$. This is significantly less than the Keplerian estimate of the mass of NGC 660; thus, it is not improbable that UGC 01195 is a bound satellite.

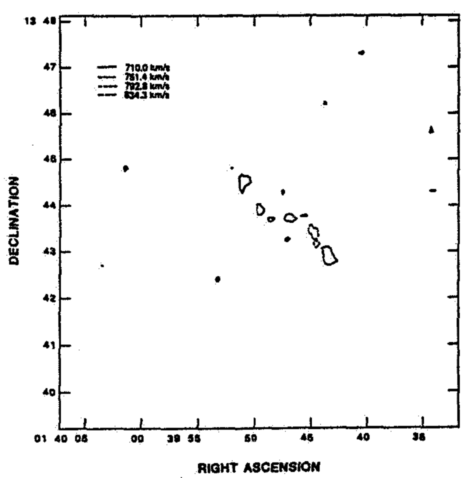

Figure 9: The rotation of UGC 01195 is shown by superposition of every other channel in which HI was detected.

References

Condon, J.J., Condon, M.A., Gisler, G., and Puschell, J.J. 1982, Ap. J., 252, 102.
Young, J.S., Kleinman, S.G., and Allen, L.E. 1988, Ap. J. 334, L63.