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HI OBSERVATIONS OF INTERACTING GROUPS OF GALAXIES

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Nous testons l'idée d'Arp à savoir que des groupes multiples de galaxies en intéraction sont éjectés hors de systèmes brillants proches de nous. Les observations à 21 centimètres indiquent que, si ceci est le cas, les membres du groupe en intéraction ont pour la plupart des masses HI comparables ou inférieures aux galaxies naines, bien que la largeur des raies et la morphologie de ces galaxies suggèrent des masses totales normales. D'autres conséquences de l'hypothèse d'éjection sont brièvement discutées.

I. Introduction

Arp (1972) has suggested that compact, interacting groups of galaxies might be young objects ejected from nearby bright galaxies. In a later discussion (Arp 1973a) he considers six multiple interacting systems which are situated at small angular distances from large galaxies. Despite redshift differences of as much as 7000 km s^{-1}, the conclusion is offered that these systems are physically associated with the large galaxies. The groups would therefore be at the same distances as their larger bretheren, and their redshifts would have a major non-velocity component.

A test of this hypothesis can be made by searching for 21-cm neutral hydrogen emission from the groups. Population I material is clearly present in many group members (see Arp 1973b), and the majority are classified as spirals. HI is therefore expected to be present, and if detected could rule out the cosmological redshift distances if the latter resulted in unreasonable hydrogen masses. This scheme was used to evaluate the distance to both low and high-redshift members of Stephan's Quintet

(Balkowski et al. 1973, Shostak 1974a). These authors assumed that the detected high-redshift emission came from NGC7319. Distances were derived supposing that NGC7319 possessed integral properties similar to those of a typical Sbc galaxy. A recent Westerbork study (Allen and Sullivan 1976) shows that the emission originates outside the optical images of the galaxies, and accordingly the HI content of NGC7319 is still unmeasured.

A different approach was taken by Shostak (1974b) in an attempt to find emission from another high-redshift quintet member, NGC7318B. The galaxy was not detected, but the flux limit obtained was used to set a bound on the HI mass as a function of distance. At 11 Mpc, the distance to the low-redshift group member and to the nearby bright spiral NGC7331, NGC7318B had an HI mass less than that of the dwarf Sextans A (Roberts 1975).

We present here 21-cm observations of three more multiple interacting groups, as well as an observation of high-redshift systems in the vicinity of NGC7331.

II. Observations

Observations were made using the 140-ft (43 m) telescope of the National Radio Astronomy Observatory. This instrument has a half-power beam diameter of 21 arcminutes at 21-cm. Integration periods of $\sim$12 hours were used on group members, with blank sky comparison observations taken every ten minutes. The receiver configuration, processing and calibration were as described in Shostak (1974a).

In Table 1 we list the observations and derived HI masses or limits as a function of distance D (Mpc). The latter are computed assuming the HI is optically thin and, if unobserved, has a profile width of 200 km s^{-1}. Limits therefore refer to an individual galaxy, since this width is typical of that observed (uncorrected for inclination) in normal spirals. Flux limits are five times the rms noise, or greater for spectra having substantial baseline curvature. The spectra are shown in figure 1.

III. Individual Objects

1. Burbidge's Chain and NGC247. HI detection of the chain is reported by Balkowski and Chamaraux (1975), and their analysis of member b results in a cosmological distance for the group. The position observed

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Table 1

Observations

Source	Obs. Pos'n (1950)	Type	Redshift (cz)	M_H ($M_\odot$)	Refs.
NGC 247	$\alpha = 00^h44^m36^s$ $\delta = -21^\circ01'00''$	Sd	165 km s^{-1}	$9.7\times10^7 D^2$	
Burbidge' Chain	00 45 02 -20 42 01	a. - b. Sc c. - d. - e. Sc	- 6164 - - 6308	$\lesssim 1.4\times10^6 D^2$	1
NGC2974	09 40 00 -03 29 00	E4	2013	not observed	2
VV116	09 36 23 -04 38 14	a. E b. E c. S d. S e. S	6577 6797 6852 6451 6600	$\lesssim 8.5\times10^5 D^2$	3,4
NGC3718	11 29 54 53 21 00	SBap	990	$2.1\times10^7 D^2$ [a]	5
VV150	11 30 01 53 13 24	quintuple chain; Easternmost is Seyfert	7900 to 8300 mean is 8080	$\lesssim 8.5\times10^5 D^2$	4,6
NGC6052	16 03 06 20 41 00	Irrp	4600	$\lesssim 1.4\times10^6 D^2$	4
Seyfert's Sextet	15 57 00 20 55 00	N6027 S0/a a. Sa b. S0/a c. Sbc d. Sc e. Irr	4481 4141 4430 4581 19930 -	no spectrum	7
NGC7331	22 34 48 34 10 00	Sbc	817	$6.1\times10^7 D^2$ [a]	
Companion Field	22 35 11 34 09 31	N7335 Sa N7337 SBa N7340 -	6298 6900 6400	$\lesssim 8.5\times10^5 D^2$	2,8

[a] spectrum from 300-ft telescope. References: 1. Burbidge et al. 1963. 2. de Vaucouleurs and de Vaucouleurs 1964. 3. Burbidge and Burbidge 1961. 4. Arp 1973. 5. Peterson and Shostak 1974. 6. Sargent 1972. 7. Burbidge and Sargent 1971. 8. Lynds 1972.

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here is from Burbidge et al. (1963), and is somewhat north of those given by Balkowski and Chamaraux. Taking the more accurate French positions, our data are consistent with emission from member e at 6308 km s^{-1} when allowance is made for beam attenuation. However Balkowski and Chamaraux's detection of member b is in conflict with the present spectrum which shows no signal at cz=6164 km s^{-1} greater than 15 mJy. The beam attenuation at the position of b is only 20%.

Note that the nearby bright spiral NGC247 has a velocity width (corrected for inclination) of only 230 km s^{-1}, and is therefore not a massive galaxy. Using the relation of Tully and Fisher (1976), its absolute magnitude is expected to be $-18^{m}.3$, with a resulting distance of 3.5 Mpc. The HI mass limit on chain members at a similar distance is less than any galaxy in Roberts' (1975) compilation.

2. VV116. Burbidge and Burbidge (1961) concluded that this quintet is probably bound at its cosmological distance. The suggested parent, NGC2974, is classified E4, and accordingly was not observed for HI. Adopting the latter's redshift distance (24 Mpc, for H_o=75 km $s^{-1}Mpc^{-1}$), the HI limit on quintet members would be $M_H \lesssim 5x10^8$ $M_\odot$, or comparable to the Magellanic Clouds. This should be set against the (uncorrected) line width of 330 km s^{-1} measured by the Burbidge's for member d, a value characteristic of massive spirals.

3. VV150 and NGC3718. A previous analysis showed that NGC3718's integral properties are not abnormal despite its peculiar classification (Peterson and Shostak 1974). Using NGC3718's redshift distance (15 Mpc) we derive the very low HI limit $M_H \lesssim 1.6x10^8$ $M_\odot$ for VV150. The easternmost member of VV150 is a Seyfert (Sargent 1972).

4. Seyfert's Sextet and NGC6052. This suggested pairing is distinguished by the fact that both the majority of the interacting group and the nearby spiral have comparable redshifts. A telescope fault invalidated the spectrum of the sextet. However, even the limit on M_H for NGC6052 is not particularly restrictive at cosmological distances. The angular separation between the sextet and NGC6052 is 92'. Adoption of the ejection hypothesis demands that group members, typically separated by <1', should be expelled at velocities differing by, at most, $\sim$1%. The observed differences in

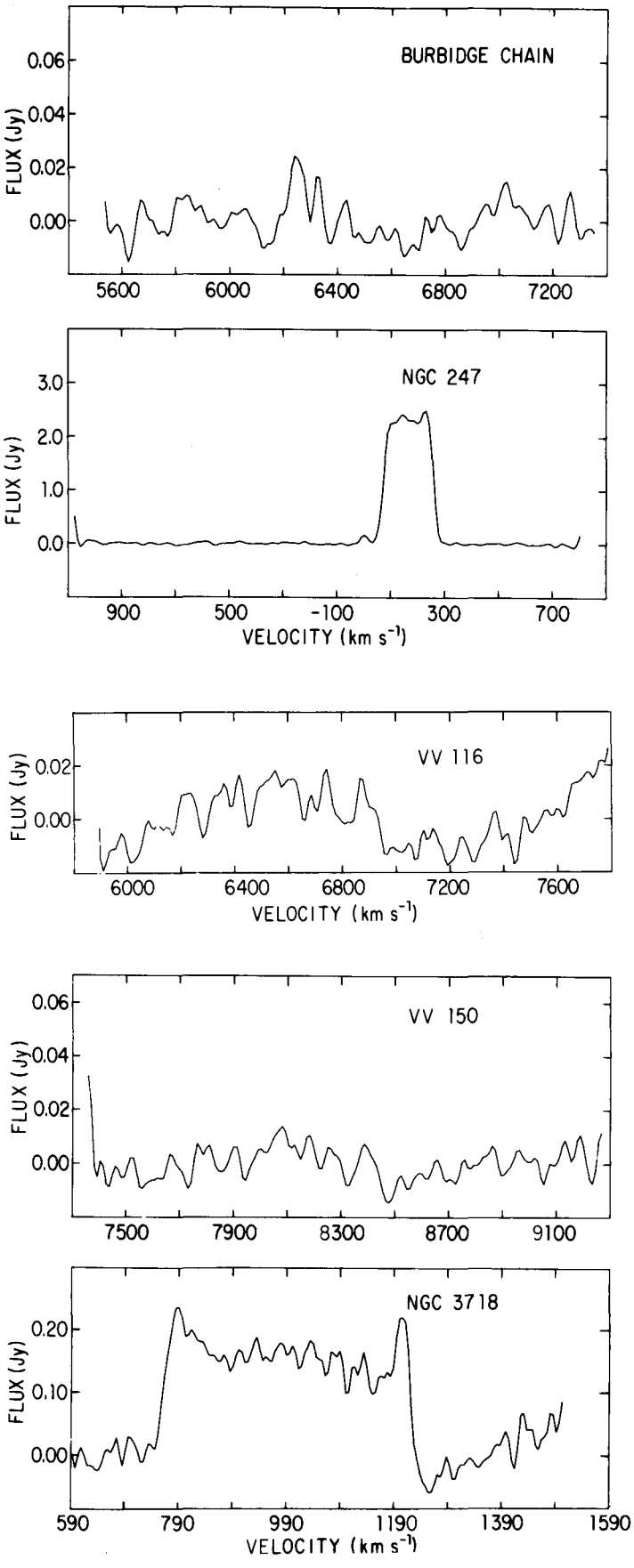

Figure 1.

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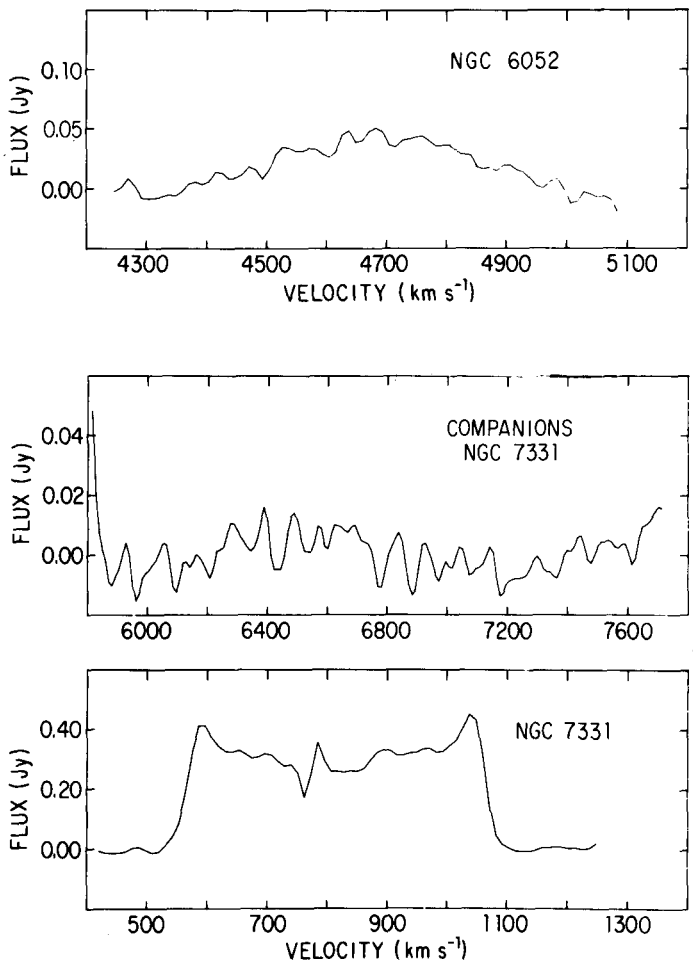

Figure 1 (continued). 21-cm spectra of observed objects. Velocities are heliocentric. Flux densities are in Janskys.

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group redshifts (excluding the high velocity member) are as high as 10%. Consequently, this hypothesis requires that even the low-velocity galaxies -- those at the same redshift as the progenitor galaxy -- have a non-velocity component in their redshifts. Further, the compactness of the sextet decrees that all members were expelled at the same time.

5. Companions to NGC7331 and NGC7331. These companions are on the side of NGC7331 opposite that of Stephan's Quintet. At the distance of NGC7331 (11 Mpc, Shostak 1974a), the companions have HI masses $<10^8$ $M_\odot$. Note that the total mass of NGC7331, computed using the formalism of Roberts (1968), is an order of magnitude greater than that of NGC247.

IV. Conclusions

The proximity of multiple interacting galaxies and bright spirals

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has led to the suggestion that the former are ejected by the latter, the large redshift discrepancies being explained by a non-velocity component. If we embrace this hypothesis, we are led to the following:

a) The progenitor galaxies range from elliptical to irregular, and cover at least one order of magnitude in total mass.

b) Seyfert's Sextet, which has a member with a highly discordant redshift, implies that whatever mechanism produces non-velocity components cannot be a function of age alone. Furthermore, even those members having redshifts comparable to the parent galaxy must have non-velocity components $\gtrsim$10% of their redshift.

c) The detection of HI in Burbidge's Chain having a profile width typical of galaxies (Balkowski and Chamaraux 1975), as well as a comparable width found optically for a member of VV116 (Burbidge and Burbidge 1961), suggests that the non-velocity mechanism is not sensitive to the varying physical parameters which obtain across a galaxy.

d) At the distances of their progenitors, group members generally have HI masses no greater than the dwarf systems of the Local Group. Yet their morphologies and line widths (insofar as measured) are quite dissimilar to the latter. If these groups really are near, they indeed represent a new kind of object.

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DISCUSSION

H. ARP: Which conclusion would you find the more difficult to believe:
1) That these companion chains had intrinsic redshifts or
2) that they had low hydrogen masses?

S. SHOSTAK: If I accept the former, I must perforce accept the latter. Galaxies with low HI masses are well established, of course, whereas the intrinsic redshifts are still hypothetical.

L. GOUGUENHEIM: I think that the histogram of the HI masses that you have shown suffers from a strong bias towards the luminous galaxies.

S. SHOSTAK: The histogram was not intended to show the HI mass spectrum of galaxies; of course it is biased toward the larger systems. The graph is simply meant to indicate the HI mass range of studied galaxies.

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