A HI SEARCH FOR DWARF GALAXIES IN THE FORNAX CLUSTER

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Abstract

The results of a neutral Hydrogen survey of the Fornax cluster of galaxies are presented. Sources already known from pointed observations of galaxies within the cluster are confirmed. No dwarf ellipticals nor isolated HI clouds are seen down to a limit of approximately 3 x $10^7 M_\odot$. The results and implications for cluster and galaxy evolution are briefly discussed.

1 Introduction

The neutral hydrogen content of galaxies within clusters provides detailed clues to the dynamical and evolutionary effects occurring within regions of high galactic density. Studies of the Virgo (6,8,12) and Coma (18) clusters have shown that there is a general HI deficiency within the spirals and that their characteristic HI sizes are smaller than their counterparts in the field. In addition, the later-type galaxies are dynamically distinct from the, virialised, cluster core. This has led to the suggestion that late-type galaxies are substantially modified as they pass through the cluster core (7).

Due to their low mass, and hence binding energy, dwarf galaxies should provide ideal tracers of the dynamical effects within clusters. However, their low mass also puts likely constraints on the amount of cold gas that these galaxies will contain hence searches for HI in dwarf galaxies, together with isolated HI clouds with no optical counterpart, have concentrated on nearby groups and clusters. Bothun (3) detected over half of the dwarf irregular galaxies he observed in the Virgo cluster, but no dwarf ellipticals. Also, although HI clouds with very low-surface brightness optical counterparts are known to exist (10), only one isolated HI cloud has been found (16).

The unavailability of synthesis instruments in the Southern Hemisphere has led to a delay in searches for HI in dwarf galaxies in southern clusters. Hence searches for HI in low surface-brightness galaxies (LSBGs) has, until fairly recently, concentrated on the Local Group and the Virgo cluster. However, these are by no means ideal candidates as their angular scales are large and hence are not easily mapped by synthesis telescopes. Observations have therefore been either pointed towards known dwarfs and LSBGs or blind surveys of large areas of sky (4,6). The southern sky contains two ideal clusters/groups for such a study - the Centaurus group and the Fornax cluster. The Centaurus A group is currently under investigation with the Parkes Multi-beam survey (1,17) whilst the Fornax cluster has already been observed using pointed observations with the Parkes radio-telescope and short observations with the Australia Telescope Compact Array (ATCA, 2). The Fornax cluster is one of the closest rich groups of galaxies, at a redshift of approximately 1400 kms^{-1}. It has a high elliptical-to-spiral galaxy ratio (9) whilst extensive optical studies (9,11) have shown that it contains a large population of dwarf ($M_B > -18$) galaxies. Pointed single-dish observations detected several of the bright spirals within the cluster (5) but have failed to find either any isolated HI clouds or gas in the dwarf galaxies (2). In the following we report the results of a deeper HI survey of a large area of the Fornax cluster using the ATCA.

2 Observations

The observations were carried out over a 3-day period in January 1996 using the ATCA. The 750m configuration was used to map a rectangular area measuring 4°.5 x 2°. The selected region was centred in Declination on the core of the Fornax cluster (taken as NGC1399) whilst in Right Ascension it covered between $-1°.5$ to $+3°$ about the central galaxy. The range in RA was taken to include the extension of the cluster to the East noted by Ferguson (11). The mosaicing mode of the ATCA was used to map the area. Due to observational constraints the total integration times per pointing were not equal over the whole grid but were typically about 18 minutes. The correlator was centred at 1500 kms^{-1} with a velocity range of 3200 $kms^{-1}$and 6 kms^{-1} resolution.

3 Results and Discussion

Two maps were made. Firstly a map of the continuum sources was constructed by summing over all frequencies whilst the 3D spectral map was produced from the continuum removed visibilities. The beam size for both maps was 83″ x 72″ with a pixel size of 15″. Correlation of the positions of the point sources with the Ferguson catalogue (11) showed only two sources coincident with possible cluster members - NGC 1399 and NGC 1365. The latter is a known radio source whilst NGC 1365 is detected primarily due to the strong contamination by HI emission.

Line emission was detected by visual inspection of the constructed velocity cube. Although automatic methods of detecting sources were attempted, these were not as successful at identifying sources as looking by eye. Properties of the 5 detected sources are given in Table 1 whilst Figure 1 shows 4 of their optical and radio images. All these sources have been detected previously in HI using the Parkes radiotelescope (5).

Assuming any unseen source is unresolved and has a velocity width of 100 kms^{-1} then the limiting HI mass detectable in this survey is $\sim 3 \times 10^7 M_\odot$. If a $M(HI)/L_\odot$ ratio of unity is also assumed, then there are 3 irregular galaxies lying within our surveyed area that Ferguson

Name	m_B	cz (kms^{-1})	M_{HI} ($M_\odot$)	$M_{HI}/L_\odot$	R (deg.)
NGC 1365	10.32	1636	$1.0 * 10^{10}$	0.7	1.2
NGC 1427a	13.42	2028	$8.7 * 10^{8}$	1.0	0.4
NGC 1437a	13.89	895	$1.1 * 10^{9}$	2.0	1.2
ESO358-G60	15.8	803	$7.7 * 10^{8}$	6.7	1.4
ESO358-G63	12.6	1932	$1.5 * 10^{9}$	0.8	1.7

Table 1: Properties of detected HI sources. R is the projected angular distance from the cluster centre

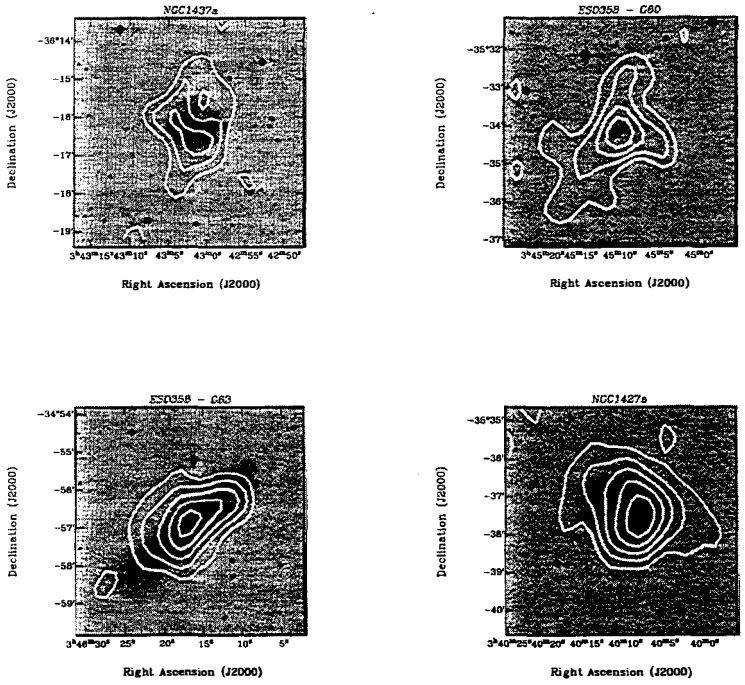

Figure 1: HI contour maps of NGC1437a (top left), ESO358-G60 (top right), ESO358-G63 (bottom left) and NGC1427a (bottom right) overlaid on their respective optical images taken from the STScI Digitized Sky Survey. Contour levels 75,85 and 95% of a maximum value of 2.2 Jy/beam, 60,70,80 and 90% of a maximum of 2.7 Jy/beam, 60,70,80 and 90% of a maximum value of 6.1 Jy/beam and 52,62,72,82 and 92% of a maximum of 4.4 Jy/beam respectively

suggests are cluster members that should have been detected within that limit. These are not seen, although they would be close to the limiting flux.

Sadler (15) provides a review of the current status of HI observations of dwarf elliptical galaxies, indicating that many such galaxies contain significant amounts of cold gas. Assuming a distance modulus of Fornax of 31.0 then the upper limit on $M_{HI}/L_{\odot}$ is 0.02 for a 13th magnitude galaxy in the cluster and 0.1 for a 14th magnitude galaxy. These are comparable to the ratios detected by Lake and Schommer (13) in some ellipticals. Although several elliptical and S0s exist within both the surveyed area and this magnitude range, their lack of detection in HI indicates that bright gas-rich dwarf ellipticals are at best rare in this cluster.

Table 1 gives the angular distance of the detected galaxies from the cluster centre. The scale length of the cluster is $0^{\circ}.48$ (14) indicating that the irregular galaxies with high HI masses preferentially lie outside the cluster core. This is given further support from the velocity information given in Table 1, where it is seen that only NGC 1365 has a velocity close to the cluster systemic value. In addition, the disturbed nature of the HI emission in ESO358-G60 indicates that gas within the faint irregular galaxies can be severely affected by tidal effects. The results are therefore in tentative agreement with those from the Virgo and Coma clusters, where gas is removed from galaxies as they pass through the cluster. However, many more detections are necessary before any firm conclusions regarding the evolution of dwarf galaxies in clusters can be drawn from Fornax.

References

[1] Banks G.D., 1998, *in preparation*

[2] Barnes D.G., Staveley-Smith L., Webster R.L. and Walsh W., 1997, *MNRAS*, **288**, 307

[3] Bothun G.D., Mould J.R., Wirth A. and Caldwell N., 1985, *Astr. J.*, **90**, 697

[4] Briggs F.H., Sorar E., Kraan-Korteweg R.C. and van Driel W., 1997, *Pub. Astr. Soc. Pacif.*, **14**, 37

[5] Bureau M., Mould J.R. and Staveley-Smith L., 1996, *Astrophys. J.*, **463**, 60

[6] Cayatte V., Balkowski C., van Gorkom J.H. and Kotanyi C., 1990, *Astr. J.*, **100**, 604

[7] Cayatte V., Kotanyi C., Balkowski C. and van Gorkom J.H., 1994, *Astr. Astrophys. Suppl.*, **103**, 5

[8] Chamaraux P., Balkowski C. and Gerard E., 1980, *Astr. Astrophys*, **83**, 38

[9] Davies, J.I., 1988, *Ph.D. thesis, Univ. of Wales College of Cardiff*

[10] Djorgovski S., 1990, *Astr. J.*, **99**, 31

[11] Ferguson H.C., 1989, *Astr. J.*, **98**, 367

[12] Lake G. and Schommer R.A., 1984, *Astrophys. J.*, **280**, 107

[13] Helou G., Hoffman G.L. and Salpeter E.E., 1984, *Astrophys. J. Suppl.*, **55**, 433

[14] Morshidi, Z.B., 1998, *Ph.D. thesis, University of Wales Cardiff*

[15] Sadler E.M., 1997, *Proc. Astr. Soc. Aust.*, **14**, 45

[16] Schneider S.E., Helou G., Salpeter, E.E. and Terzian Y., 1983, *Astrophys. J. Lett.*, **273**, L1

[17] Staveley-Smith L., 1997, *Proc. Astr. Soc. Aust.*, **14**, 11

[18] Sullivan W.T. III, Bates B., Bothun G.D. and Schommer R.A., 1981, *Astr. J.*, **86**, 919