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TWO ISOLATED H I CLOUDS IN THE VIRGO CLUSTER?

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Abstract. Seventy years after the start of radio astronomical observations and over 50 years after the first observations of the 21 cm H I line, a seemingly 'routine' H I survey at Jodrell Bank of an already thoroughly studied part of the local Universe – the Virgo Cluster – has yielded a surprising result: the detection of what appear to be two isolated H I clouds in the cluster, without optical counterparts, with H I masses of about 10^8 $M_\odot$ (for an assumed distance of 16 Mpc) and angular sizes of about $4'$ to $6'$, or 20–30 kpc, estimated from follow-up Arecibo H I observations. Their estimated peak H I column density of 4×10^{19} atoms/cm^2 may be too low for star formation. H I synthesis observations and deep CCD imaging are planned of these objects.

Key words: galaxies: clusters: Virgo

1. INTRODUCTION

We have carried out (Davies et al. 2004) a fully sampled 21 cm H I line survey of a $4°\times8°$ area ($\alpha\times\delta$) in the Virgo Cluster using the 4-beam instrument on the Lovell 76 m radio telescope at Jodrell Bank. These data have an rms noise level of about 4 mJy, i.e. about 3 times better than that of the standard HIJASS northern hemisphere blind H I line survey being carried out with the multi-beam instrument. The survey HPBW is $12'$ and the radial velocity range is about – 1000 to 10 000 km/s. Virgo Cluster objects were searched for in the 500 to 2500 km/s range, through inspection of the data cube by eye as well as by an automated search with the POLYFIND galaxy finder (Davies et al. 2001).

Thirty-one objects were detected, 27 of which are previously catalogued members of the Virgo Cluster. The H I detections of galaxies listed in the NGC, UGC and IC catalogues are all of late type spirals. Previous H I observations detected 6 other galaxies that are below the detection limit of our survey and 3 objects that are near the limits of our velocity search range (500 to 2500 km/s) and, therefore, not detected by us. Our observations indicate that the H I mass function of the cluster turns down at the low mass end, making it very different compared to the field galaxy H I mass function. This is quite different to the Virgo Cluster optical

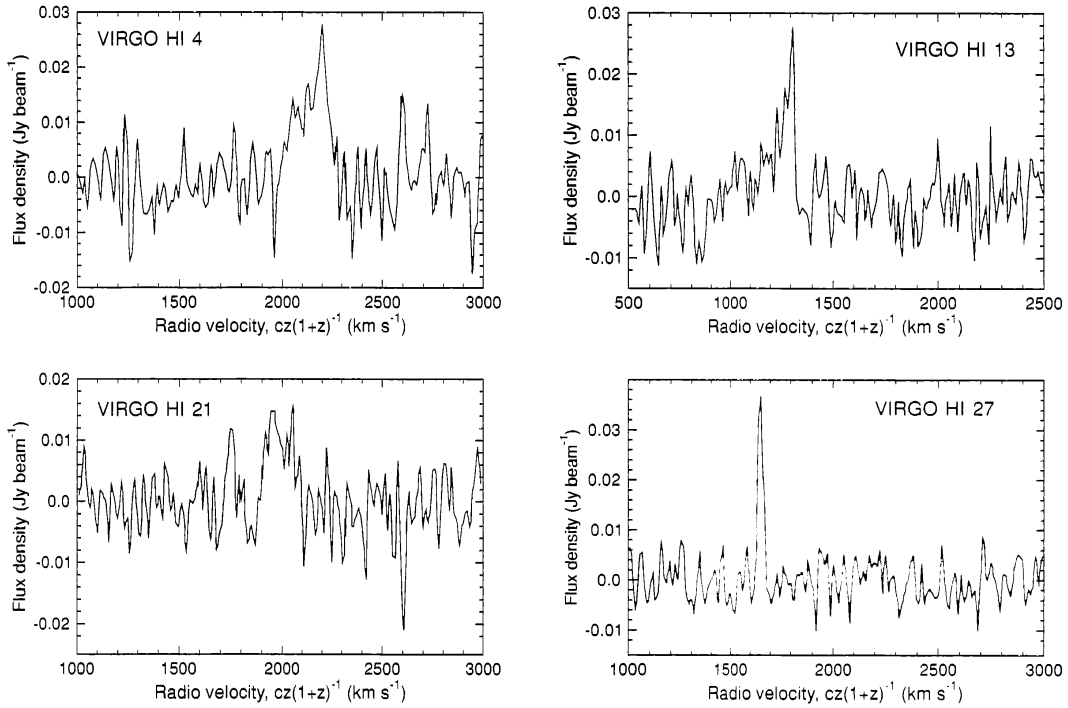

Fig. 1. Jodrell Bank survey H I line spectra of the 4 objects with no optical identification.

luminosity function, which is much steeper than that in the general field. Many of the sample galaxies are relatively gas-poor compared to H I selected samples of field galaxies, confirming the 'anaemic spirals' view of Virgo Cluster late-type galaxies. The velocity distribution of the H I detected galaxies is also very different to that of the cluster as a whole; there are relatively more high velocity galaxies in the H I sample, suggesting that they form part of a currently infalling population. The H I sample with optical identifications has a minimum H I column density cut-off more than an order of magnitude above that expected from the sensitivity of the survey. This observed column density is above the normally expected level for star formation to occur.

In the survey we also detected 4 sources without obvious optical counterparts. Their H I spectra are shown in Figure 1. Longer follow-up observations at Jodrell Bank have confirmed these detections, most of which were found in the Parkes 64 m HIPASS survey data as well. These sources were reobserved with the 305 m Arecibo telescope, resulting in data with a 3 times better spatial resolution (3.6′) and 4 times better sensitivity (1 mJy rms at 15 km/s resolution). Spectra were first taken at the nominal center positions of the HIJASS detections and then H I was searched for at positions around it.

To our Jodrell Bank H I mass limit of $5 \times 10^7 \frac{\Delta v}{50\mathrm{km/s}}\ M_\odot$ and column density limit of $3 \times 10^{18} \frac{\Delta v}{50\mathrm{km/s}}$ atoms cm^{-2} these new detections represent only about 2% of the cluster atomic hydrogen mass. The estimated H I peak column density in VIRGOHI21 and VIRGOHI27 is 10^{19} atoms/cm^2, about an order of magnitude lower than that of the optically identified sources in the survey. It is possible that these two clouds have not reached the column density threshold necessary for star formation. The two objects are resolved by the Arecibo beam, giving them a size

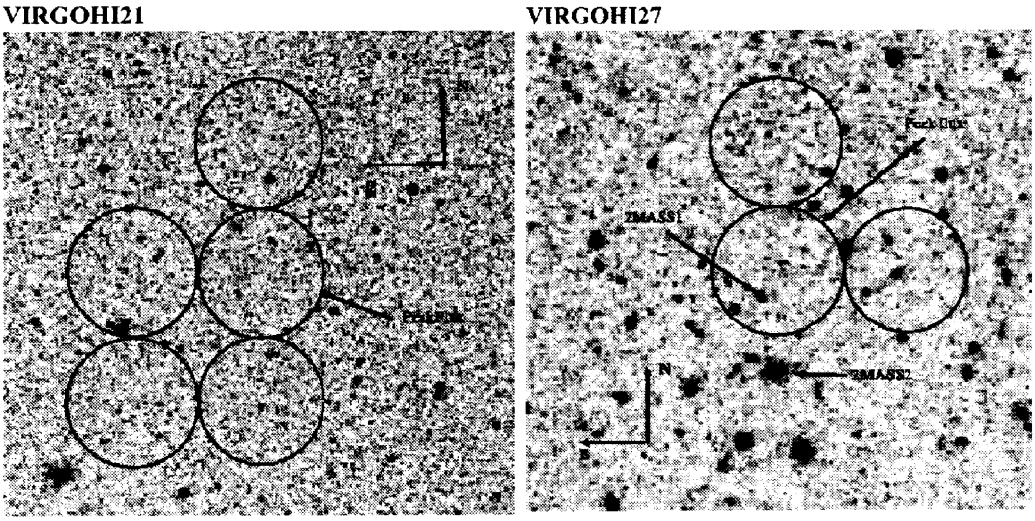

Fig. 2. Digital Sky Survey images ($12'' \times 12''$) of VIRGOHI21 and VIRGOHI27, centered on the Arecibo peak flux positions. The circles indicate the Arecibo beams in which line emission was found. The two 2MASS galaxies discussed in the text are indicated in the right-hand panel.

(20–30 kpc) far larger than any optical images in the nearby field.

Optical images of VIRGOHI21 and VIRGOHI27 are shown in Figure 2, where one 2MASS source can be seen within the outlines of the latter H I cloud. There do not seem to be any objects that can convincingly be assigned to the two detections.

This is not the first claim to have discovered isolated H I clouds in the Virgo cluster: the much more extended (24′ long) and massive (M_{HI}=4 × 10^9 $M_\odot$) cloud found by Giovanelli & Haynes (1989) is now thought to be associated with a subsequently found dwarf irregular galaxy, however (McMahon et al. 1990). We intend to obtain H I synthesis observations and deep CCD images of the clouds in order to further study their properties and nature.

1.1. Notes on individual objects

VIRGOHI4: the line of sight towards this detection at 2129 km/s lies through M 86 (V = –244 km/s) and no optical counterpart can be seen.

VIRGOHI13: surprisingly, this strong HIJASS signal at 1274 km/s was not detected at any of the 16 positions observed at Arecibo. Although, in principle, it could be a quite extended low column density source, it could also be a Jodrell Bank side lobe detection of two H I-rich spirals in the vicinity.

VIRGOHI21: this relatively weak HIJASS signal at 1966 km/s was clearly detected at 5 of the 16 positions observed at Arecibo. Its center position lies about 3′ west of the HIJASS position and the dimensions of the source are about $5 \times 8'$.

VIRGOHI27: this strong, narrow (W_{20} = 45 km/s) HIJASS signal at 1652 km/s was detected at 3 of the 10 positions observed at Arecibo. Its center position lies about 3.5′ east of the HIJASS position and the diameter of the source is about 4′. Besides the main Gaussian component we also detected a much weaker component at 1570 km/s at Arecibo at two positions.

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