FIGGS: Faint Irregular Galaxies GMRT Survey

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1 Introduction

HI 21cm aperture synthesis observations of spiral galaxies is a mature field with over two decades of history – probably something of the order of a thousand galaxies have already been imaged. However, the observations have tended to focus on bright ($\sim L_*$) galaxies with HI masses $\sim 10^9$ $M_\odot$. Dwarf galaxies ($M_B \widetilde{>} -17$) require substantial investments of telescope time, and have hence not been studied in similar numbers.

To start addressing this imbalance, we have been conducting an HI imaging study of faint dwarf galaxies – the Faint Irregular Galaxies GMRT Survey (FIGGS). The immediate goal of FIGGS is to obtain high quality observations of the atomic ISM in a large, volume limited sample of faint, gas rich, dwarf irregular galaxies. Here we briefly describe the survey and discuss some of the science that we anticipate can be done with this data set.

1.1 FIGGS Sample

The FIGGS galaxies form an HI flux limited subsample of the Karachentsev et al.(2004) catalog of galaxies within 10 Mpc. Specifically, the FIGGS sample consists of 65 faint dwarf irregular (dIrr) galaxies with $M_B \widetilde{>} -14.5$, HI flux integral $\widetilde{>}$ 1 Jy kms^{-1} and optical sizes $\widetilde{>}$ 1 arcmin. The FIGGS galaxies represent the extreme low-mass end of the dIrr population, with a median $M_B \sim -13$ and a median HI mass $\sim 3 \times 10^7$ $M_\odot$. Fig. 1 compares the distributions of gas fraction, luminosity and dynamical mass of the FIGGS galaxies with that of existing samples of galaxies with HI aperture synthesis observations. As can be seen, the FIGGS survey substantially extends the region of parameter space which has largely gone untouched by previous HI imaging studies.

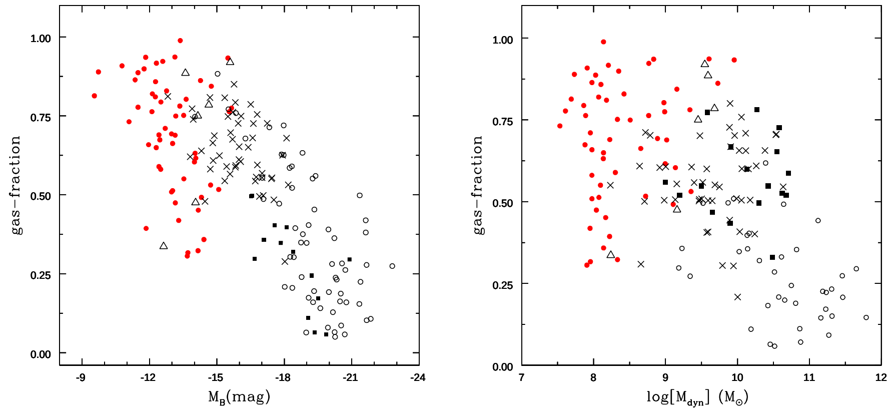

Fig. 1. The gas fraction of FIGGS galaxies (red points) and previously studied galaxies (black points) plotted as functions of absolute blue magnitude (left) and dynamical mass (right). Note how the GMRT FIGGS sample extends the coverage of all three galaxy properties.

The typical GMRT integration time per source for most galaxies is $\sim 5-6$ hours, which gives a typical rms of $\sim$ 2-3 mJy/Beam per channel. It is worth emphasising that our observations used a relatively high velocity resolution ($\sim$1.6 kms^{-1}, i.e. $\sim$ 4 times better than most earlier interferometric studies of such faint dwarf galaxies). This high velocity resolution is crucial to detect large scale velocity gradients in the faintest dwarf galaxies. Our observations show that, (unlike what one is lead to believe from coarser velocity resolution observations, e.g. Lo et al. 1993), most faint dwarf irregular galaxies in fact have large scale systematic patterns in their velocity fields (Fig. 2, see also Begum et. al. 2006). Galaxies from the FIGGS sample are the faintest known galaxies to show such regular kinematics.

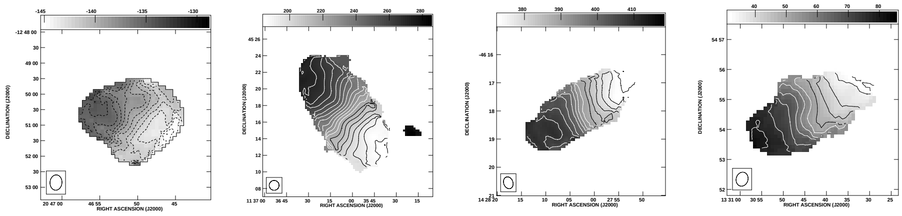

Fig. 2. The regular velocity fields of some of the faintest FIGGS galaxies.

The GMRT HI images are supplemented by single dish HI observations, HST V and I band imaging of the resolved stars and ground based Hα imaging using 6-m BTA telescope. Distances accurate to $\sim$ 10% are available for most of the galaxies in our sample − the FIGGS sample is the first large sample of faint dIrr for which interferometric data is available and distances are accurately known. Additionally, the HII region abundances and Hα rotation curves are being obtained on the WHT, INT telescopes on La Palma and 6-m BTA telescope respectively.

Science Drivers for FIGGS

One of the main goals of FIGGS is to use the HI images in conjugation with the optical data to study the interplay between the neutral ISM and star formation in the faintest, lowest mass, gas rich dIrr galaxies. The FIGGS data will enable us to study the ISM of most of our sample galaxies at a linear resolution of $\sim 15 - 150$ pc − i.e. comparable to the scales at which energy is injected into the ISM through supernova and stellar winds. FIGGS thus provide a unique opportunity to study the feedback of star formation in low mass, gas rich galaxies, which in turn will allow us to understand the processes driving star formation in these galaxies. Examples of GMRT HI maps at $3''$ resolution (corresponding to linear scale of $\sim 30-90$ pc) are shown in Fig. 3.

The second major aim of this survey is to extend the Baryonic Tully Fisher relation (Mcgaugh et. al. (2000)) to a regime of very low mass/luminosity that has not yet been well explored. While for the brighter galaxies W_{50} (the velocity width at 50% emission), once corrected for random motions and instrumental broadening, is a good measure of the rotational velocity of the galaxy (Verheijen 1999), this is not true in the case of faint dwarf galaxies where random motions could be comparable to the peak rotational velocities (e.g. Begum et al. 2003). For such galaxies, it is important to accurately correct for the pressure support ("asymmetric drift" correction) for which one needs to know both the rotation curve as well as the distribution of the HI gas, both of which can only be obtained by interferometric observations such as in FIGGS.

Our final objective is to use the HI kinematics of FIGGS galaxies, in conjunction with the Hα rotation curves to accurately determine the density distribution of the dark matter halos of faint galaxies. Serendipitous discoveries are an added bonus – for example, FIGGS has discovered some very extended HI disks around dwarf galaxies e.g. GMRT HI images of NGC 3741 ($M_B \sim -13.0$) showed it to have an HI extent of $\sim$ 8.3 times $R_{\rm Ho}$ (Holmberg radius) (follow-up WSRT+DRAO+GMRT observations found $\sim$8.8 $R_{\rm Ho}$) − NGC 3741 has the most extended HI disks and we could derive a rotation curve upto a record of 38 times the disk scale length. NGC 3741 has $M_{\rm D}/L_{\rm B} \sim 107$ − which makes it one of the "darkest" irregular galaxies known (Begum et al. 2005).

As a service to the community, calibrated (u,v) data, data cubes, MOMNT maps, rotation curves etc. from the FIGGS survey will be publicly released at the end of our survey.

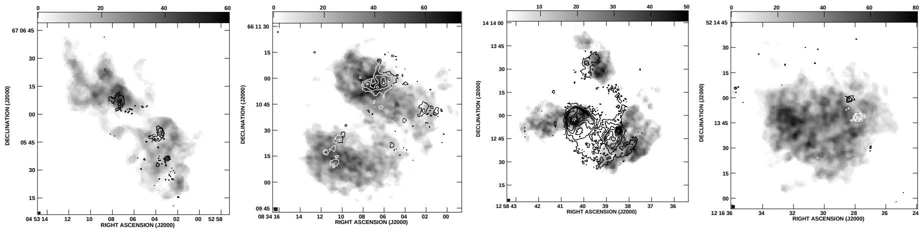

Fig. 3. GMRT integrated HI images of some of FIGGS galaxies (greyscales) at $3''$ resolution (corresponding to a linear scale of $\sim$ 30-90 pc) overlayed on Hα images (contours).

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