Hunting for Neutral Hydrogen emission of galaxies in the MIGHTEE survey

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What is HI?

Hydrogen is the most common element in the Universe. It illuminates structures not traced by stars. Due to a hyperfine transition (see Fig.1 below), neutral hydrogen (HI) emits radio waves at 1.4 GHz in frequency which only is detectable by radio telescopes.

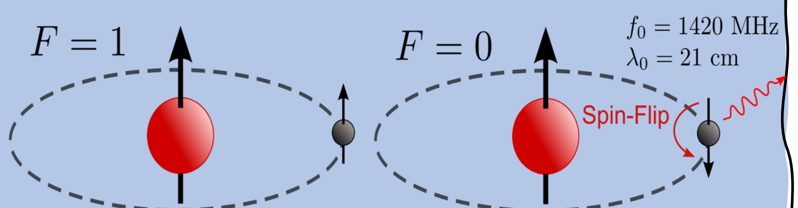


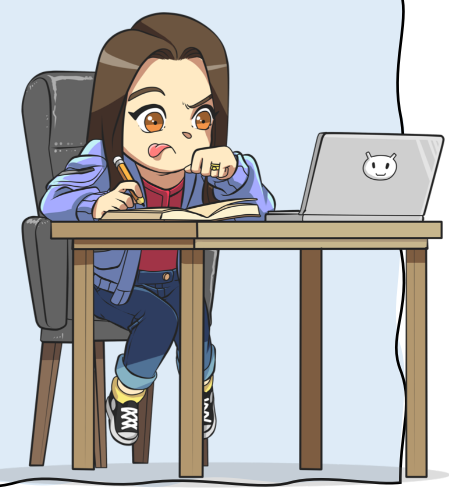
Fig 1: The Hydrogen 21-cm Line

Doppler shift

The distance of HI sources can be measured from the change in frequency of their 21cm line due to their relative motions. Usually measured in **redshift, z**, we will use the object distance, D, in units of **Giga light-years** (Gly) inferred from z.

Challenges

HI emission is very faint. Up to now, our knowledge from direct HI detections of galaxies is based on the very local Universe only (D < 1.45 Gly). Little is known for galaxies at higher distances due to technical limitations: frequency coverage, lack of sensitivity, and resolution.



We have the solution!!

MIGHTEE: The MeerKAT International GHz Tiered Extragalactic Exploration survey

(Survey designed to collect radio continuum, spectral line and polarization information over 20 square degrees of the sky)

Why HI?

HI imaging has been used to understand the gas content in galaxies, their masses, their star formation rate over time, and is an excellent environmental tracer.

Instrument: the new, powerful telescope **MeerKAT,** an SKA precursor, currently the most sensitive telescope for HI studies to date (Jonas+18)

MIGHTEE-HI Goals: detect HI emission lines from the rare, most HI-massive galaxies out to D~7.2 Gly in order to extend the current HI view (Jarvis+16).

Fig 2: The MeerKAT telescope in the Karoo desert, South Africa
Credit: SARAO

MIGHTEE = Resolution + Sensitivity + Large frequency coverage

How can we trust the flux values that we get with a new telescope?

- **The project:** Investigation of the HI content of all galaxies within a 2°x2° pointing of one of the MIGHTEE fields for distances D < 0.86 Gly.
- **Goals:** Imaging quality assessment and verifying whether HI masses are consistent with existing previous measurements.

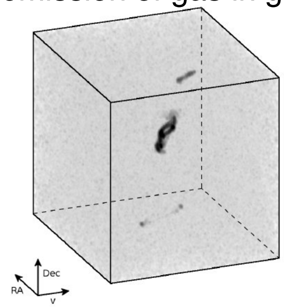
Analysis steps

Blind HI observations

Raw data

- Data Calibration
- Continuum subtraction
- Median Filtering
- Primary beam correction

HI data cube (Position RA & DEC, velocity of emission of gas in galaxies)



(Credit: Serra+15)

Visual inspection

Source list

Data Products

- Cubelets extracted for each detection
- Spectra (flux vs. v) and moment maps
- HI property derivation (flux density, integrated flux, HI mass, HI size, linewidth, rms noise)

Results

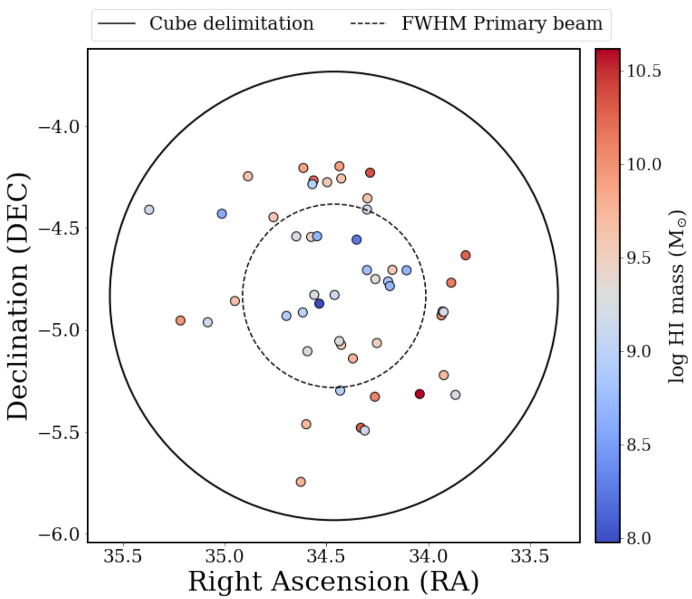


Fig 3: Distribution of the HI detections in the cube (each dot = a detected galaxy)

- 50 detections found visually within frequency range of 1330-1420 MHz (Fig. 3)
- Most detections are found at D~0.6 Gly.
- Their mean log HI mass is 9.4 (Fig. 4)
- The pointing center of the telescope beam is more sensitive to low mass galaxies (< 10^9 solar mass), while the edge is almost only sensitive to massive nearby galaxies (Fig. 3).

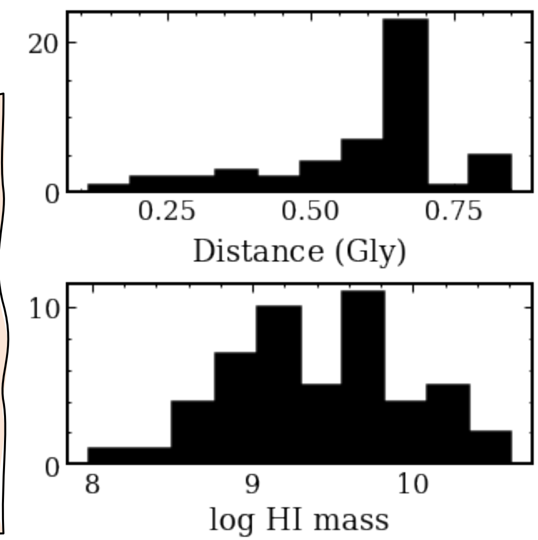
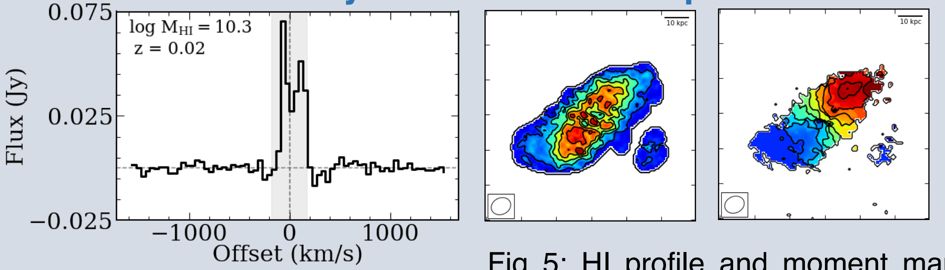


Fig 4: Distance and HI mass distribution

Lessons learnt

Galaxy with satellite companion



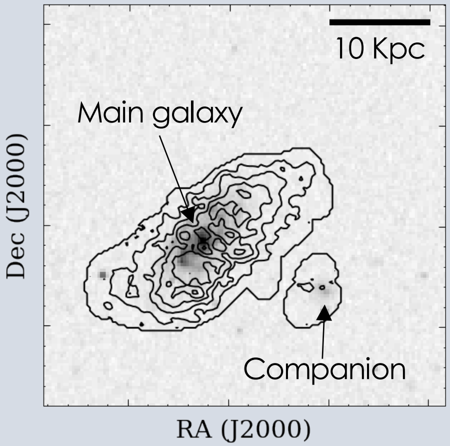


Fig 5: HI profile and moment maps revealing the presence of a dwarf satellite companion next to the main large spiral galaxy. This source was previously found by Meyer+04 with the single dish Parkes telescope, which could not resolve the object into its two components.

Telescope	log(M_{HI}) ($M_\odot$)		
MeerKAT	10.3	**Main Galaxy**	10.2
		Companion	9.1
Parkes	9.90		

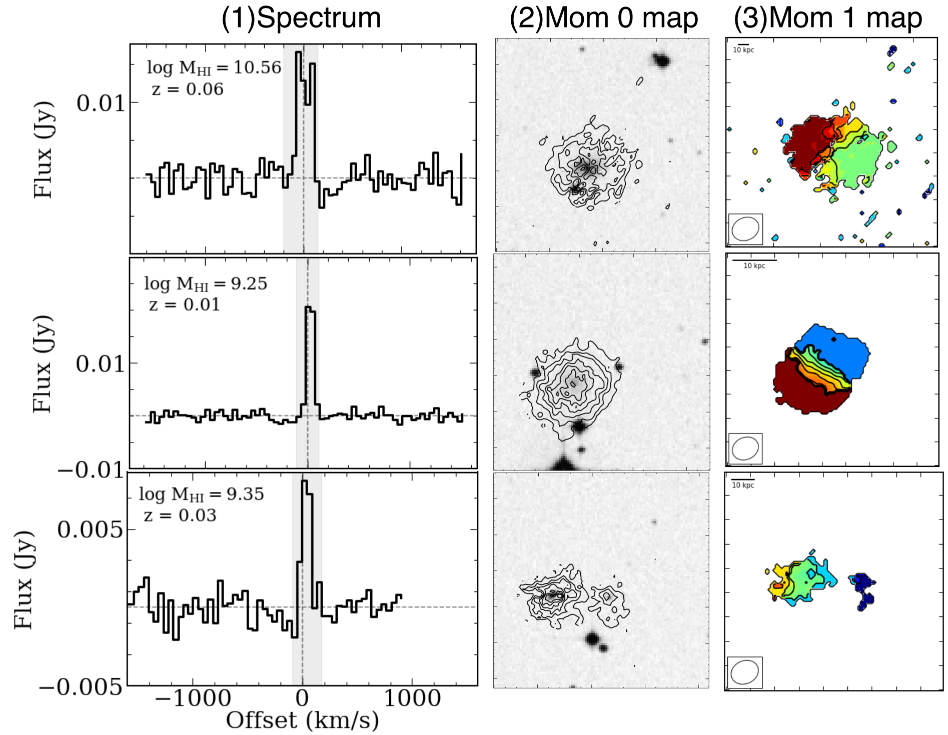


Fig 6: Example of data products from the early survey. Left Panel (1): the grey region indicates the emission line. Middle Panel (2): HI intensity map showing the overall gas distribution overlaid on its optical POSS2/UKSTU blue-band image. Right Panel (3): the velocity map, gas motion. Blue color indicates rotation toward the Earth while red indicates rotation further away from us.

Conclusion

- Finding of groups of galaxies, interacting systems such as gas ripped out of the galaxy.
- With MeerKAT's excellent spatial resolution and sensitivity, some sources are better resolved, and some found to be composed of a main galaxy and a satellite companion.
- The data products will be compiled into a catalogue listing the detections; this allows an assessment of the reliability of the MIGHTEE-HI data

References

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