HI Observations of MaNGA Galaxies with the Green Bank Telescope

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Introduction

Neutral hydrogen (HI)

Emits an observable radiation at 21 cm and is not absorbed throughout its path.

Image credit: Benjamin Winkel for the HI4PI collaboration (Argelander-Institut für Astronomie/Max-Planck-Institut für Radioastronomie)
Radio telescope

Green Bank Telescope (GBT): The largest fully steerable single dish in the world, 100 x 110 m
(c) National Radio Astronomy Observatory / Associated Universities, Inc. / National Science Foundation
Targets selection

- SDSS Data Release 13
- Stellar mass greater than $10^9$ solar mass
- No pre-selection on galaxy type
- Average redshift of the sample is $z \approx 0.03$. 

Mapping Nearby Galaxies at Apache Point Observatory
Methods

- GBT observations
- Perform quick inspection
- Remove GPS signal
- Perform a full reduction
- Measuring galaxy’s HI mass

HI detection justification

Data combination
- Removing RFI and smoothing data
- Baseline subtraction and Normalization
Measuring galaxy’s HI mass

- HI detected galaxy

\[
\frac{M_{HI}}{M_{\odot}} = 2.356 \times 10^5 \left( \frac{D_L}{Mpc} \right)^2 \left( \frac{F_{HI}}{Jy \cdot km/s} \right)
\]

(Roberts, 1962)

- HI non-detected galaxy

assuming rms in mJy

assuming a range of widths is equal 200 km/s

\[
\frac{F_{HI}}{Jy \cdot km/s} = rms \times \frac{width}{1000}
\]

(Masters et al, 2014)
Observational results

8568-12702

8568-12702

HI detection

Non-detection
Galaxy classification with HI Detection %

- Spirals: 62%
- Ellipticals: 21%
- Uncertain: 14%
- Lenticular: 3%

- Detected HI
- Non-Detected HI
Unexpected detection of HI gas in elliptical – supposedly “red and dead galaxies why?”

### Velocity of HI (Km/s) vs. Flux (mJy)

**7957-6103**
- **Detection at**: 8524.91 km/s
- **Flux**: 0.020

**8611-3704**
- **Detection at**: 8733.81 km/s
- **Flux**: 0.006
Methods

HI detection justification + Photometric data (DRPall)

Color-magnitude diagram with HI detection

Absolute magnitude g-band, r-band

Plot g vs. g-r

Mark the detection and the non-detection galaxy
Color-Magnitude Diagram with HI Detection

Red sequence

Blue cloud

Redder

Bluer

Fainter

Brighter
Methods

HI detection justification + Photometric data (DRPall)

Separate a region

Calculate a detection fraction

Plot $g$ vs. $g-r$

Mark the detection and the non-detection galaxy

Color-magnitude diagram with HI detection

Color-magnitude diagram with HI detection fraction

Detection fraction = \( \frac{\text{# of HI detected galaxies}}{\text{# of total observed galaxies}} \)
Methods

HI detection justification

Photometric data

HI mass

Separate a region

Calculate a HI gas fraction

Plot g vs. g-r

Color-magnitude diagram with HI gas fraction

HI gas fraction = \frac{\text{Average HI mass}}{\text{Average (MHI + stellar mass)}}
Active galaxy

Driving gas out and affect stars formation in galaxy

Image credit: NASA and The Hubble Heritage Team (STScI/AURA)
Methods

HI detection justification

+ Optical line flux data

Plot log \([\text{OIII}/\text{H}_\beta]\) vs. log \([\text{NII}/\text{H}_\alpha]\)

Baldwin-Phillips-Terlevich (BPT) diagram

\[
\log(\text{[OIII]/H}_\beta) = 0.61/\log(\text{[NII]/H}_\alpha) - 0.47 + 1.19 \quad (3.8)
\]

\[
\log(\text{[OIII]/H}_\beta) = 0.61/\log(\text{[NII]/H}_\alpha) - 0.05 + 1.3 \quad (3.9)
\]

Figure 3.2: Baldwin-Phillips-Terlevich (BPT) diagram
Image credit: Kewley et al. 2006
BPT Diagram with HI Detection, Ke01 and Ka03

Extreme starburst line

AGN
Galaxy classification with AGN Indication

- Spirals
- Ellipticals
- Uncertain
- Lenticular

AGN Indication

Galaxy classification with AGN Indication %

- Spirals
- Ellipticals
- Uncertain
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AGN Indication %
Color–Magnitude Diagram

Red sequence

No detection
Detection
AGN
Conclusions

Spiral galaxy  \rightarrow  normally HI detected galaxy

Elliptical galaxy  \rightarrow  normally HI non-detected galaxy

The incidence of AGN  \rightarrow  HI gas properties.

Most of AGN found in the red sequence
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