HIDEEP: a deep blind HI survey with the Parkes telescope

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Background

- HI surveys were until a few years ago limited by single beam and correlator velocity range
- New Multibeam instruments and correlators have now made large surveys possible
  - HIPASS - all sky up to dec +22 (450s per beam)
  - HIJASS - northern sky down to +22 (350s per beam)
- Parallel to HIPASS:
  - HIDEEP: “The HI equivalent of the Hubble Deep Field” - (9000s per beam)
HIDEEP: The Basics

- 4 by 8 degrees region in Centaurus
- centered on $\alpha = 13^h40^m00^s$, $\delta = -30^o00'00"$
- velocity range: -1280 to 12,7000 km/s, 1024 ch at 13.2 km/s spacing
- velocity resolution 18 km/s
- beam size ~14', pixel size 4'
- includes Cen A group and outer parts Cen cluster
- not instrumentation noise limited: noise $\sim 1/\sqrt{t}$
- noise = 3.2 ± 0.2 mJy
**HIDEEP: The Detections**

- Data cube searched 3 times:
  - 2 humans and 1 computer
  - only objects detected 2 out of 3 times retained
- 173 detections
- profiles and positions extracted and quantified
- selection limits:
  - peak flux and velocity width limited
  - limits are 9.6 mJy and 4 ch = 52.8 km/s
  - completeness limit at ~18 mJy
HIDEEP: Optical Follow-Up

- HIDEEP field imaged with UK Schmidt telescope at Siding Spring, Australia
- 8 1hr exposures in R-band on Tech-Pan plates
- Digitised using SUPERCOSMOS
- 6 by 4 degrees overlap with HI field
- limiting surface brightness is 26.5 R (27 to 28 B)
- 96 HI sources in field
  - 59% known galaxies, z known
  - 24% known galaxies, z unknown
  - 17% uncatalogued galaxies
  - no HI without optical....
**HIDEEP: Galaxy Properties**
*(a personal and biased selection)*

**Large Scale Structure:**
- HIDEEP lies in the super galactic plane
- For $z<10,000$ km/s, good correlation between optical LSS and HI LSS
- Beyond 10,000 km/s, HI sources appear to populate void
  - Is this real or due to HI/optical selection effects?
**HIDEEP: Galaxy Properties**
*(a personal and biased selection)*

**Surface Brightnesses:**
- Large fraction of sample has LSB
- KS test: late-type ESO-LV and HIDEEP surface brightness parent distribution differ at 99%
- Galaxies in HIDEEP are more gas-rich
HIDEEP: Column Densities - Theory

- Column density sensitivity of radio-telescope
- HIDEEP: $T_{sys} = 26 K$, $t_{obs} = 9000 s$, $\Delta V = 13.2 \text{ km/s}$
- $N_{HI} > 2.1 \times 10^{16} \Delta V \text{ cm}^{-2}$
- For $\Delta V = 200 \text{ km/s}$, $N_{HI} \sim 4 \times 10^{18} \text{ cm}^{-2}$

\[
T_B = \frac{\lambda^2}{2k \Delta \Omega} \frac{S_V}{\Delta V}
\]

\[
T_A \geq \frac{T_{sys}}{\sqrt{t_{obs} \Delta V}}
\]

\[
N_{HI} = 1.8 \times 10^{18} T_B \Delta V \text{ cm}^{-2}
\]

\[
N_{HI} \geq 2.75 \times 10^{17} \frac{\sigma T_{sys}}{\sqrt{t_{obs} \Delta V_{ch}}} \Delta V
\]

$5\sigma$
HIDEEP: Column Densities

- What is distribution of HI column densities?
- No resolved imaging yet, so use mean column densities
- Have HI mass, need HI size
- Cut-off in distribution of column densities
- Need systematic underestimate of $r_{HI}$ of factor 3

$\rho_{HI}$

Salpeter & Hoffman (1996): $r_{HI} = (2.34 \pm 0.14) r_{25}$

ESO-LV: $r_{25} = (2.15 \pm 0.67) r_e$

$18\text{ mJy completeness limit}$
There don’t appear to be any low-column density galaxies in HIDEEP.

Distribution is consistent with constant column density:
\[ \log \sigma = 20.65 \pm 0.38 \]

But previous surveys indicate:
\[ \sigma \sim \mu \ldots \]

Open questions:
- selection effects?
- why would HIDEEP field be different?
- KS test of resampled ISIB96 inconclusive

But low column density galaxies still absent from both data sets.
HIDEEP: Conclusions and Questions

- HIDEEP shows that deep HI surveys are feasible and not limited by instrumental problems.
- All HI sources are associated with optical counterpart - no "dark galaxies"...?
- There is a lack of low-column density galaxies in HIDEEP.
- If real, what causes this lack? Why different from some other surveys?
  - ionisation?
  - "frozen disks" ($T_{\text{spin}} \sim T_{\text{CMB}}$)?
  - environment?