CHILES, the COSMOS HI Large Extragalactic Survey

1002 hours JVLA B array

SKA Science and a path finder for the path finders
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USA, South Africa, Germany, Australia, The Netherlands, Korea
Unique aspects of VLA among SKA path finders

• **Strengths**
  - It is up and running
  - Correlator is more powerful
  - Sensitivity comparable to MeerKAT
  - Baseline distribution, angular resolution of 5”
  and most collecting area at spacings > 2 km

**Weaknesses**
- It is a multi user instrument and it will be harder to schedule large amounts of time
- Relatively small FOV

Uniquely suited to do deep imaging at high redshifts
Main scientific motivation for CHILES

HI morphology as function of location in underlying large scale structure

note that even at $z=0.45$ we will probably be able to say whether HI is inside or outside a galaxy

HI content, morphology and kinematics of individual galaxies
HI mass function as function of $z$ and environment
Cosmic neutral gas density as function of $z$
Evolution of Tully Fisher relation

Very deep continuum studies (sub microJy)
  source counts, star formation versus AGN

Transients.. Good overlap with transient surveys at other wavelengths, i.e. PanSTARSS
HI imaging of galaxies $z=0$ to $z=0.45$

Evolution of Star Formation Rate Density (Hopkins and Beacom 2006)

Gas is the fuel for star formation  Images tell how galaxies get and lose their gas
We (sort of) understand how large scale structure grows, but how galaxies form and evolve is less well understood.

Hierarchical galaxy formation in “standard” LCDM, used to make galaxies grow by merging, but the importance of gas accretion was underestimated and the physics misunderstood.

There are two ways for galaxies to grow

1) Merging with smaller galaxies can add gas and stars

2) Smooth accretion of cool gas dominates gas accretion at all z, dominates total accretion at z>1

Keres et al 2005, Dekel and Birnboim 2006, Binney 1977
The void galaxy survey

A polar disk

Stanosik et al 2009

Kreckel et al 2012  void galaxies are small  and show many hints that they are still accreting gas

HI Images tell how galaxies get their gas
Galaxies in around the Virgo cluster   VIVA

Chung et al, 2009

HI Images tell how galaxies lose their gas
HI surveys

EVLA HI DEEP FIELD SURVEY

EVLA HI DEEP FIELD PILOT

WRST OBSERVATIONS OF ABELL 963 & 2192 (VERHEIJEN ET AL. 2007)
A pilot for an EVLA HI Deep Field

One pointing in COSMOS field

Fernandez, Hess, Momjian, Pisano, Oosterloo, JvG (the human calibration pipeline)
Popping, Chung, Henning, Verheijen, Schiminovich, Scoville

60 hours in B array (5 arcsec at z=0), data taken in 2011.. 2.5 Tbyte

32 sub bands 16384 channels (1420-1190 MHz; z=0 to 0.2) vel resolution 3.3 km/s

Detection limits $z=0.07\, 7\times 10^8\, M_{\text{sun}}$

$z=0.13\, 4\times 10^9\, M_{\text{sun}}$

$z=0.2\, 1.3\times 10^{10}\, M_{\text{sun}}$

Column density sensitivity $3 \times 10^{19} \, \text{cm}^{-2}$

Resolution 350 pc at 16 Mpc 17 kpc at z=0.2

FOV 150 kpc 7.5 Mpc
2 sq. degrees!

590 orbits ==> 2 square degrees
-- 9 x any previous HST image

2 million galaxies at z ~ 0.2 to 5 (SDSS at high z)

EVLA HI Deep Field
Primary beam ~0.5 deg

Additional coverage by:
Spitzer, GALEX, XMM, Chandra
Subaru, VLA, ESO-VLT, UKIRT, NOAO, CFHT, CSO, CARMA, IRAM, Magellan
(Herschel, ALMA, APEX)
HI Mass Sensitivity

\(~\text{Virgo, 16 Mpc}\)

\[\begin{align*}
5\sigma \text{ M} &= 1.8 \times 10^6 \ M_\odot \\
7 \times 10^8 \ M_\odot & \quad \text{z=0.07} \\
4 \times 10^9 \ M_\odot & \quad \text{z=0.13} \\
1.3 \times 10^{10} \ M_\odot & \quad \text{z=0.2}
\end{align*}\]
Results of pilot survey  Fernandez et al 2013
Stacked signal of 80 galaxies in the wall

Average HI mass \(1.8 \times 10^9 \, M_{\odot}\)
RFI in L-band

- PILOT
- AIRPORT
- VLA MODEM
- GLONASS & RADARS
- RADARS

FREQ (MHz)
Now we realize JVLA really is the best!
CONCLUSIONS from PILOT

A real JVLA HI Deep Field is now possible

We have 33 detections over entire redshift range
Detections follow the large scale structure as defined optically

RFI is the main challenge

Observing in B array mitigates the issue (avoid short spacings)
Automatic flagging algorithms work reasonably well
RFI will get worse.

Algorithms need be optimized to reduce data volume at every step
example baseline dependent time averaging
A real HI deep field

VLA is perfect telescope for this

B array has optimal distribution of spacings correlator allows to probe $z=0$ to $z=0.45$ with $3.3 \text{ km/s}$ velocity resolution

JVLA is up and running now (Thanks NRAO!!)

in 1000 hours on COSMOS..

mass limit $3 \times 10^{10} \ M_{\text{sun}}$ at $z=0.45$
Full Survey

We aim to have same mass limit at $z=0.45$ as we had in pilot at $z=0.2$
Expected detection rates for 1000 hour project

We expect about 300 direct detections... i.e. HI IMAGES

Estimate based on HI mass function

Estimate based on photometric gas fraction
Spatial distribution of predicted 5 sigma detections
We are up and running! We already got 160 hours with 31000 channels to $z=0.45$

In the meantime, we really are not wasting telescope time

COMMENSAL OBSERVING by CHRIS HALESS et al

Chiles con polarization