SKA Studies of HI

- The History of HI in the Universe
- Studies of Galaxies and Galaxy Interactions
  - Structures
  - Spin Temperatures
- SKA Possibilities
The $\text{H I}$ History of the Universe

**Top Graph:**
- $\log x = \frac{n(\text{H})}{n(\text{H}_0)}$
- Time scale: $1+z$
- Events:
  - Recombination
  - Reionization
  - Galaxy formation

**Bottom Graph:**
- Milky Way Star Formation History
- $\log \rho_{\text{H I}} = \log \rho_{\text{H I}_0}$
- Time scale: $1+z$
HI Mapping of:

- Galaxy Interactions
- Galaxy Mergers
- Galaxy Formation


HI in the M81 Group
Mapping ISM Structure

- The 21-cm line is good for mapping big things because HI is so widespread.
- The 21-cm line generally traces the column density directly \( T_B = C_o N_H \).
- The HI shows the transition from discrete, deterministic structures to stochastic, turbulent dynamics.
An HI shell in the outer galaxy
Supershell Identification

Glon: 292.29891
Glat: -1.6000725
Parkes plus ATCA image of east side of G278 bubble
An HI shell in the fourth quadrant:

$b = +3$

$V = -2.1 \text{ km/s}$

$b = 0$

$I = 330$

$b = +3$

$I = 326$

$b = 0$

$V = -3.0 \text{ km/s}$
Interstellar shells, bubbles, and chimneys

- Sizes range from a few pc to almost a kpc.
- Velocities range from stalled to ~50 km/s.
- Dynamical ages are up to $2 \times 10^7$ years.
- Kinetic energy implied can be $10^{53}$ ergs.
- Mass flux to the halo maybe $>10^4$ per event.
The SKA is good for Low Surface Brightness objects observed with resolution 1\" to 10\" at 21-cm

- In a 3 hour integration the SKA can map the HI line with
  - sensitivity \(\sim 1\) K
  - angular resolution \(\sim 3\)"
  - velocity resolution \(\sim 1\) km/s.
• The SKA can map ISM tracers like
  - the 21-cm line of HI,
  - the 18-cm lines of OH,
  - and the 9-cm lines of CH
  over large areas with \( \sim \)arc second resolution.

• The VLA B-array has a filling factor of \( 2 \times 10^{-4} \) while the SKA will have a filling factor of \( 10^{-2} \) over the same area.
HI Absorption - Emission Studies of $T_{\text{spin}}$
Absorption Studies at cm-waves are limited by the scarcity of strong background sources.

- We cannot map the spatial distribution of the HI optical depth as we map the emissivity.
- Interesting objects never have a background source behind them!
More Background Sources!

- The SKA will allow sensitive absorption spectra ($\sigma_\tau \sim 0.05$) to be measured toward background sources as faint as 200 $\mu$Jy.

- This means there will be 500 times more background sources (extragalactic continuum sources) available than for the VLA.

- The density of these background sources is $\sim$ one per 4 square arc minutes.
Conclusions:

The SKA will improve Galactic spectroscopy of cm-wave lines by nearly two orders of magnitude in brightness sensitivity.

The SKA will allow us to study the HI optical depth, $\tau$, and excitation temperature, $T_{\text{spin}}$, wherever we like!