Future Canadian Prospects in the Galactic Neutral Atomic Medium

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Why Galactic HI?

- It’s (almost) everywhere
- Most of the mass of the ISM
- Two orders of magnitude in temperature and density
- Sub-parsec scale structure (10” ↔ 0.1 pc @ 2 kpc)
- Physics that cannot be addressed in extragalactic work (opacity, spin temperature, phases)
- Tracer for interstellar extinction

Movie credit: J. Peek, GALFA consortium
Cold HI
Continuum Absorption

Astrophysics:
- Galactic distribution and opacity of cold HI
- Tracer of spiral arms
- Kinematic distances of Galactic continuum sources (HII regions, SNRs)

Point source sensitivity proportional to third power of angular resolution.

Instrumentation:
- High angular resolution (< 10") ngVLA strength
- Modest UV coverage
- No short spacings required, unless structure in HI in front of extended sources (Leahy & Ranasinghe)
Cold HI
HI Self Absorption (HISA)

Astrophysics:
- Structure of cold HI clouds
- Transition state to or from molecular gas
- Resolve near/far ambiguity in kinematic distances of molecular clouds
- Relation to cold dust, molecular filaments (0.1 pc scale requires ~ 10” resolution at few kpc)

Instrumentation:
Wide range of spatial scales
Short spacings required
Complete UV coverage with 0.2 K sensitivity on baselines up to ~ 5 km.

Magnetism
Zeeman effect, filaments

Astrophysics:
- Local strength of (line of sight component of) magnetic field.
- Similar magnetic field strength in cold and warm HI?
- Magnetic field in IVC/HVC
- Relation to molecular filaments?
- Absorption or emission

Instrumentation:
µG field detectable in emission with DRAO 26m telescope in a few hours
Single dish or interferometer.
No short spacings necessary?
Polarization purity in Stokes V and stray radiation (single dish).
Beam squint problem in JVLA because of off-axis feeds.

Also:
Van Eck et al. (2016)
Not just 21 cm
Radio Recombination Lines of C⁺ (CRRL)

Astrophysics:
- C⁺ can exist where H is neutral
- Main source of cooling in HI regions in crucial temperature and density range, T < 100 K, Aᵥ = 1-5 mag.
- CRRL probe electron temperature, density, and line-of-sight depth.

Detection of cold HI independent of background illumination

For example:
C272α at 327 MHz
C441α and C555β at 76 MHz
C575α at 34.5 MHz
Roshi & Kantharia (2013)

Instrumentation:
Low-frequency interferometer
Stellar Feedback

Astrophysics:
- Stellar wind bubbles, SNRs, Superbubbles
- Broad wings of HI spectra
- Disk-halo interface
- Mechanical energy input over life time of a star cluster
- Conditions for outflow into the halo

Instrumentation:
- Wide range of spatial scales + short spacings
- Good signal to noise and dynamic range
- Complete UV coverage

Image credit: Jayanne English et al. Normandeau et al. (1996), Nat 380, 687

Stil & Irwin (2001)

VGPS
Galactic Halo

Astrophysics:
- Dynamics of halo gas
- Structure and kinematics of intermediate-velocity and high-velocity clouds
- Interaction of disk with infalling gas

Instrumentation:
Wide range of spatial scales + short spacings
Good signal to noise and dynamic range
Complete UV coverage
Beware stray radiation from bright Galactic plane in single dish surveys.
Astrophysics:
- Bird’s eye view of stellar feedback on ISM in best possible detail.
- Structure and relation to other phases of the ISM in a low-metallicity environment.
- Dynamics of accretion of matter on galaxies

Instrumentation:
SKA. Match angular resolution and spatial dynamic range of optical/IR surveys
Conclusions

Galactic HI and other spectral lines probing the neutral atomic medium are essential for detailed observation of many astrophysical phenomena

- Stellar wind bubbles and Supernova remnants
- Magnetism
- Molecular cloud formation and phase transitions in the ISM
- Disk-halo connection, dynamics of halo gas

- Significant progress with 15” resolution, good spatial and intensity dynamic range
- Many (not all) applications require a 50 - 100 m single dish to fill short spacings (Baseline < 15m): Arecibo, FAST, GBT, Parkes, ....
- Most applications do not require full sky coverage
- Location: LMC/SMC favor SKA (but M31 favors ngVLA)
- Circular polarization capability for Zeeman effect

Check out the THOR survey, JVLA 18” resolution HI in first quadrant (JVLA C-array + VGPS)