

The DRAO Synthesis Telescope in the post-CGPS Era

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Abstract. The DRAO ST was used for the past 15 years as the primary instrument for the Canadian Galactic Plane Survey (CGPS, Taylor et al. 2003). This has been a spectacularly successful project, advancing our understanding of the Milky Way Galaxy through panoramic imaging of the main constituents of the Interstellar Medium. Observations for the CGPS are now complete and the Synthesis Telescope at DRAO (Landecker et al. 2000) has returned to proposal-driven mode.

The Dominion Radio Astrophysical Observatory invites astronomers to apply for observing time with the DRAO Synthesis Telescope. The DRAO ST provides radio observations of atomic hydrogen and radio continuum emission, including the polarized signal, with high spatial dynamic range and arcminute resolution. Imaging techniques developed for the CGPS have made the telescope into a front-line instrument for wide-field imaging, particularly of polarized emission. We will discuss telescope characteristics, show examples of data to demonstrate the unique capabilities of the ST, and explain where and how to apply for observing time.

1. The DRAO Synthesis Telescope

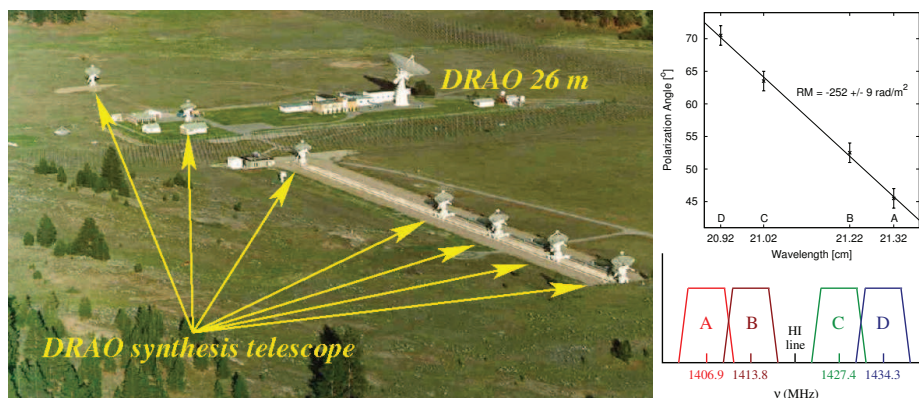


Figure 1. Aerial picture of the Synthesis Telescope and the 26m telescope at DRAO (left) and the distribution of the four frequency bands around 1420 MHz (right).

The DRAO Synthesis Telescope (ST, Fig. 1, Landecker et al. 2000) provides radio observations of atomic hydrogen and radio continuum emission at 1420 and 408 MHz, including the linearly polarized signal at 1420 MHz, with high spatial dynamic range. The ST is a seven element east-west interferometer providing full uv-coverage between a maximum spacing of 617 m and a minimum spacing of 12.9 m. This translates to a spatial frequency coverage from 1' to 45' at 1420 MHz and 2.8' to 2.6° at 408 MHz. The four separate bands (see Fig. 1 right) available around 1420 MHz allow precise determination of rotation measure. Low spatial frequency information can be provided by the DRAO 26 m radio telescope (see Fig. 1 left) upon request. Imaging techniques developed for the CGPS (Willis 1999) have made the telescope into a front-line instrument for wide-field imaging, particularly of polarized emission. Main characteristics of the DRAO Synthesis Telescope are listed in Table 1.

Table 1. Characteristics of the DRAO Synthesis Telescope

Frequencies	1420 MHz	408 MHz
Field of View	2.65°	8.22°
Angular Resolution	58'' × 58'' cosec(δ)	2.8' × 2.8' cosec(δ)
Spatial Frequencies	1' to 45'	2.8' to 2.6°
System Temperature	45 K	105 K + T _{sky}
Continuum Sensitivity	180 μ Jy/beam	3.0 mJy/beam
Rotation Measure Determination	4 bands, $\delta(f) = 7.5$ MHz see Fig. 1 right	
Mosaicking Sensitivity	45 μ Jy achieved	confusion limited
H I sensitivity	2.5B ^{-0.5} sin δ K	
H I bandwidths	B = 0.125, 0.25, 0.5, 1.0, 2.0, 4.0 MHz	

2. Large Structure Matters!

Information about the large structure is important to get a complete picture. The boomerang-shaped object in the top left of Fig. 2 is a pulsar wind nebula and a γ -ray emitter. The CGPS image reveals a large extended object, the associated supernova remnant G106.3+2.7, which is not visible in the Northern VLA Sky Survey (NVSS, Condon et al. 1998) image because the VLA cannot detect large structure.

The “Boomerang” is a young pulsar wind nebula with a strong mG magnetic field (Kothes et al. 2006). The environment of this system is revealed by the right image in Fig. 2 of H I (green) and CO (red). The progenitor star, located in the shell of a stellar wind bubble, is likely the result of triggered star formation (Kothes et al. 2001).

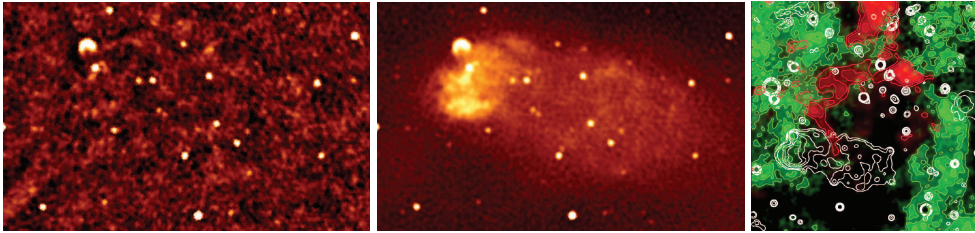


Figure 2. Left: Stokes I image from the NVSS. Centre: Stokes I image of the same area as left taken from the CGPS. Right: Combined CO (red) and H I (green) image of the area around the SNR G106.3+2.7, indicated by the white contours.

3. Polarization Imaging

The CGPS 1420 MHz Stokes I and polarized intensity images displayed in Fig. 3 combine data from the DRAO ST with single antenna observations to truly represent all structure from the largest scales down to the resolution limit of about $1'$. 1420 MHz is close to the ideal frequency for radio polarization imaging, showing both emission and Faraday rotation features. The DRAO ST is currently **THE** world leading radio telescope for imaging linearly polarized emission at that frequency through unique capabilities to correct for instrumental polarization (Reid et al. 2008) and accurately combine single antenna and aperture synthesis data.

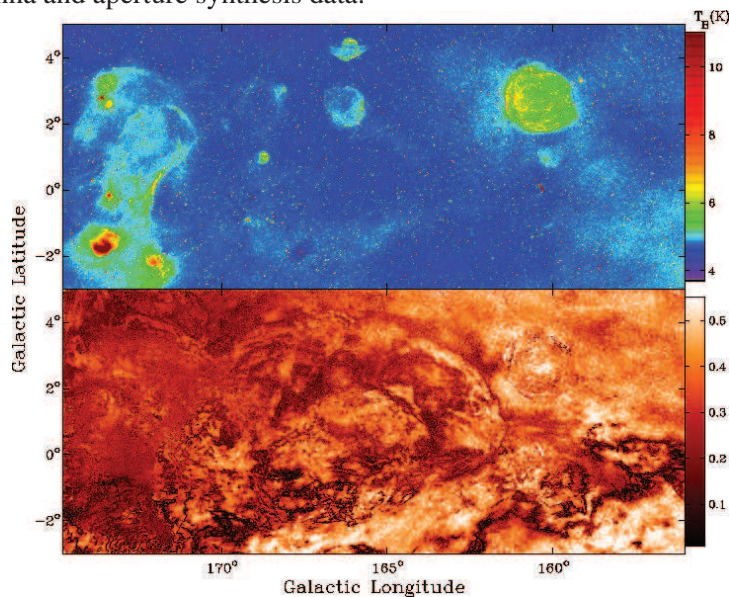


Figure 3. CGPS Stokes I image (top) and polarized intensity (bottom) at 1420 MHz of an area close to the anti-centre region of our Galaxy.

The image in Fig. 3 shows a large stellar wind bubble that was discovered through its Faraday rotation imprint on the polarized background emission. It also may have commenced a star burst in the Outer Galaxy as indicated by the presence of numerous very young and massive stars and clusters close to its boundary (Kotthes et al., in prep.).

4. H I in Nearby Galaxies

The results of new deep H I observations of the nearby galaxy M 31 are shown in Fig. 4. This deep H I imaging led to the discovery of a faint external spiral arm (labeled EA) and new disk extremities (SE, N 1, and N 2) (Chemin et al. 2009) as can easily be seen in the projection of the data cube onto the photometric major axis (Fig. 4, left).

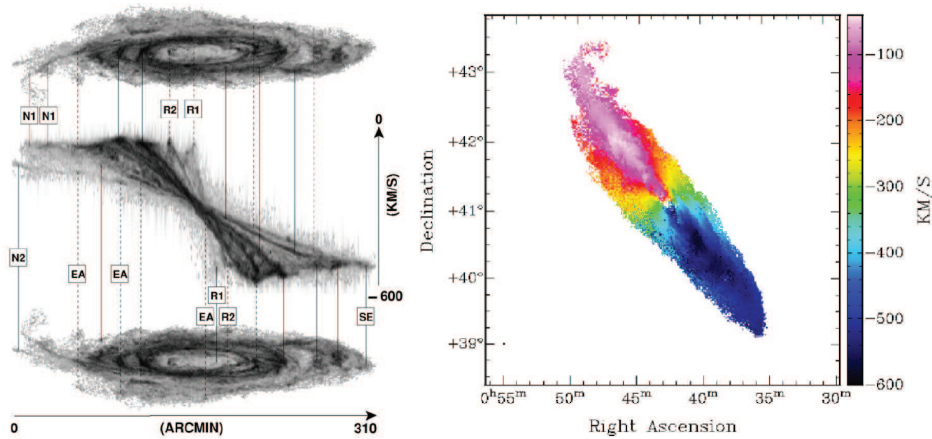


Figure 4. Integrated H I images of M 31 and the projection of the H I data cube onto the photometric major axis (left) and the H I velocity field of M 31 (right).

5. Sensitivity Through Deep Integration

A mosaic of 40 pointings was observed towards the ELAIS N1 field to achieve the most sensitive wide-field image of linear polarization at 1420 MHz ever observed (Fig. 5). A sensitivity for Stokes I of $55 \mu\text{Jy}/\text{beam}$ and for Stokes Q and U of $45 \mu\text{Jy}/\text{beam}$ was achieved. Further observations of the ELAIS N1 area are underway to reach even higher sensitivity of around $30 \mu\text{Jy}/\text{beam}$ for Stokes Q and U .

The images shown in Fig. 5 are the basis for new results on counts of faint polarized extragalactic sources. A higher degree of fractional polarization was found for sources with fainter Stokes I than for brighter sources. This highly polarized faint source population seems to be dominated by radio galaxies (Grant et al. 2010).

6. Imaging Galactic H I at Arcminute Resolution

Fig. 6 shows an image of H I emission towards the massive W3/4/5 H II region complex taken from the Canadian Galactic Plane Survey Data base. Data from the DRAO Synthesis Telescope and 26-m Telescope have been combined. The data from the Canadian Galactic Plane Survey are available at the Canadian Astronomical Data Centre at: <http://cadc.hia.nrc.ca/cgps>

In Fig. 6 filamentary structure is seen down to the resolution limit of the CGPS. The narrow, dark shadows reveal cold foreground HI absorbing emission from brighter

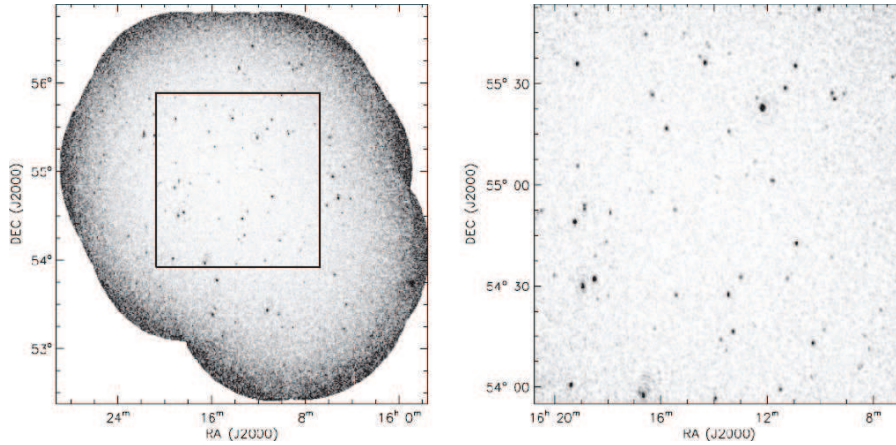


Figure 5. A 40-pointing mosaic of polarized intensity at 1420 MHz of the ELAIS N1 field. The images show polarized intensity with a grayscale from 0 to 1 mJy/beam for the whole area (left) and for the central region (right).

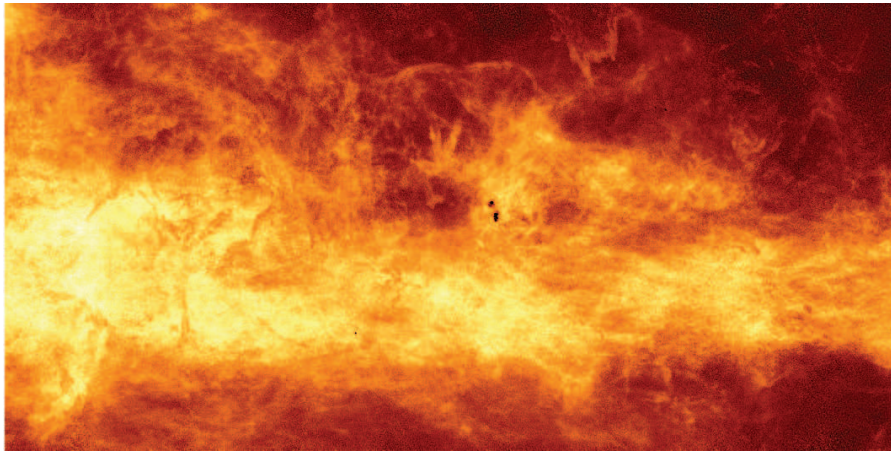


Figure 6. Image of hydrogen emission over an area $20^\circ \times 9^\circ$ in size centered at $\ell = 135^\circ, b = 1^\circ$, showing H I gas at Perseus arm velocities.

and warmer, more distant gas. These H I self absorption structures (HISA) are very common in the CGPS. This is cold atomic hydrogen recently compressed by the passage of a spiral shock on its way to forming molecules. We are seeing the first step in forming stars (Gibson et al. 2005).

7. Observing with the DRAO Synthesis Telescope

There is currently no proposal deadline for the DRAO Synthesis Telescope, proposals are received and refereed throughout the year. If you wish to learn more about observing at DRAO, please contact our Operations Manager at:

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