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The Canadian Galactic Plane Survey

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Abstract: The Dominion Radio Astrophysical Observatory (DRAO) is carrying out a survey as part of an international collaboration to image the northern Milky Way, at a common resolution, in emission from all major constituents of the interstellar medium; the neutral atomic gas, the molecular gas, the ionised gas, dust and relativistic plasma. For many of these constituents the angular resolution of the images (1 arcmin) will be more than a factor of 10 better than any previous studies. The aim is to produce a publicly-available database of high resolution, high-dynamic range images of the Galaxy for multi-phase studies of the physical states and processes in the interstellar medium. We will sketch the main scientific motivations as well as describe some preliminary results from the Canadian Galactic Plane Survey/Releve Canadien du Plan Galactique (CGPS/RCPG).

Keywords: surveys — ISM — the Galaxy — radio continuum — radio lines

1 Contributions to Project by the Consortium and DRAO

The international collaborative effort of 46 scientists at 20 institutions will make possible a publicly-available database of high resolution, high-dynamic range images of the Galaxy. Table 1 lists each observational contribution and indicates the relevance to multi-phase studies of the interstellar medium (ISM).

One of the factors which brought about the leading role of the Canadian scientists in this project was the upgrade of the Dominion Radio Astrophysical Observatory's Synthesis Telescope (DRAO ST) to seven 9-metre antennas. One of the strategies which distinguishes the DRAO observations from those of other interferometers is that the U–V plane is fully sampled. This allows an unambiguous transformation to the plane of the sky. As well, single dish (zero-spacing) data, which contains emission on large angular scales, will be incorporated in order to ensure complete flux density measurements can be made for all modes of the DRAO ST observations.

The DRAO ST project is surveying the region $75^\circ < l < 145^\circ$, which runs along the Perseus arm in one direction and the Cygnus arm in the other, with an angular resolution of $\sim 1'$ at 1420 MHz. The survey has a width in latitude, about the Galaxy mid-plane, of 9° at 1420 MHz and 15° at 408 MHz.

2 Examples of the Scientific Motivation

Since the Milky Way is composed of complex and interdependent elements, the scientific motivations are not only numerous but also inter-related. The

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Table 1. Contributions to the CGPS/RCPG dataset

Frequency wavelength	Telescope	Comments
151 MHz (190 cm)	**MRAO CLFST** The Mullard Radio Astronomical Observatory's Cambridge Low-Frequency Synthesis Telescope	• Continuum emission images • **Ionised and relativistic plasmas** • First phase of observations nearing completion
232 & 327 MHz (130 & 92 cm)	**BAO** Beijing Astronomical Observatory	• Continuum emission images • **Ionised and relativistic plasmas** • *Potential contributors*
408 & 1420 MHz (74 & 21 cm)	**DRAO ST** Dominion Radio Astrophysical Observatory Synthesis Telescope with zero spacings from previous surveys for the continuum data and the DRAO 26 metre dish for the H I line data	• HI 21 cm line, continuum at 1420 and 408 MHz, polarisation at 1420 MHz • **Neutral hydrogen intensity and velocities** from HI cubes (256 channels; $1\cdot2$ km s^{-1} per channel) • **Ionised and relativistic plasmas**; spectral indices will allow the distinction between synchrotron emission and thermal emission • **Magnetic field information** by using all 4 Stokes polarisation parameters • Begun March 1995 and will run about 5 years • Pilot project has been completed; mosaics are currently becoming available without zero spacings
115 GHz (2·6 mm)	**FCRAO** University of Massachusetts' Five Colleges Radio Astronomy Observatory	Emission from CO($J = 1$–0) rotation transition • **Surrogate tracer of H_2** • Multi-feed, focal plane detector array and spectrometers generating dataset cubes • Observations 1994 to March 1997; data available late 1997.
3 & 5 THz (100 & 60 μm)	**IRAS** Infrared Astronomical Satellite	• **Radiation from dust** • Images reprocessed for higher resolution using **HIRES** (IPAC-JPL/Caltech) • Images now in the public domain

consortium has set up science teams to focus on specific elements. However, these teams will analyse the data in parallel, meet annually, and communicate regularly. Although the motivations highlighted below can be organised into simple categories, these bins are actually intertwined and we expect that a global but detailed picture will emerge. In the sections below, we highlight a few of the numerous scientific motivations.

2·1 Large Scale Characteristics of the Milky Way

The high spatial resolution will aid in determining the topological structure of the ISM. We can improve estimates of volume filling factors and the resolution of features in the vertical direction away from the mid-plane. Multi-wavelength comparisons will help illuminate the physics. We can contrast polarisation effects with the distribution of cosmic rays. The high resolution and our ability to separate the emission into thermal and non-thermal components could allow us to investigate the origin of the far-infrared/radio continuum correlation.

2·2 Stars and Compact Objects

Multi-waveband comparisons will allow us to catalogue and statistically classify objects such as H II regions, Wolf-Rayet stars and pulsars and will also identify candidates, such as variable or highly polarised sources, for further study. Supernova remnants in particular will allow us to test many apparent correlations (e.g. that between the ISM density and synchrotron emission intensity).

2·3 Exchanges of Energy

We will be able to systematically study, on a parsec scale, the interaction of stars with the ISM. Of particular interest are shells and superbubbles around OB associations. Godbout, Joncas & Drissen (1998, present issue p. 60) describe a supplemental project which uses Fabry–Perot Hα observations to study diffuse nebulae associated with older H II regions. They hope to determine whether the region's energy input could produce turbulence on the scales necessary to affect the shape of H I features. Studies of vertical H I features emanating from the disk should indicate how the gas in the Galaxy's halo is replenished and the halo's energy input is maintained.

3 Progress to Date

The progress of the consortium as a whole is described in Table 1. The DRAO portion of the survey has begun to produce useful mosaics and to distribute them to the consortium. Since

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we are awaiting the zero spacings our results are preliminary. However, detailed plans are in place for the scientific analysis of the CGPS/RCPG data and we have made significant progress to date. We outline a few examples below.

The pilot project observations of the Perseus Arm by Normandeau, Taylor & Dewdney (1996) have been particularly fruitful. These data revealed a cavity in H I associated with the H II region W4. An OB association (OCl 352) exists at the apex of the cavity and dense molecular clouds in the cavity appear to be photo-evaporating. The vertically extended structure of these clouds contribute to the notion that this cavity is currently, or will evolve into, a ‘chimney’ which will facilitate the exchange of energy between the disk and the halo.

Algorithms for distinguishing between filamentary H I features and dissociating regions are being explored by a team, headed by Joncas and Ghazzali, at Université Laval. The resulting techniques will allow both the detection and classification of these features.

Fich and Johnstone are creating a determination of the velocity–distance relationship as reliable as

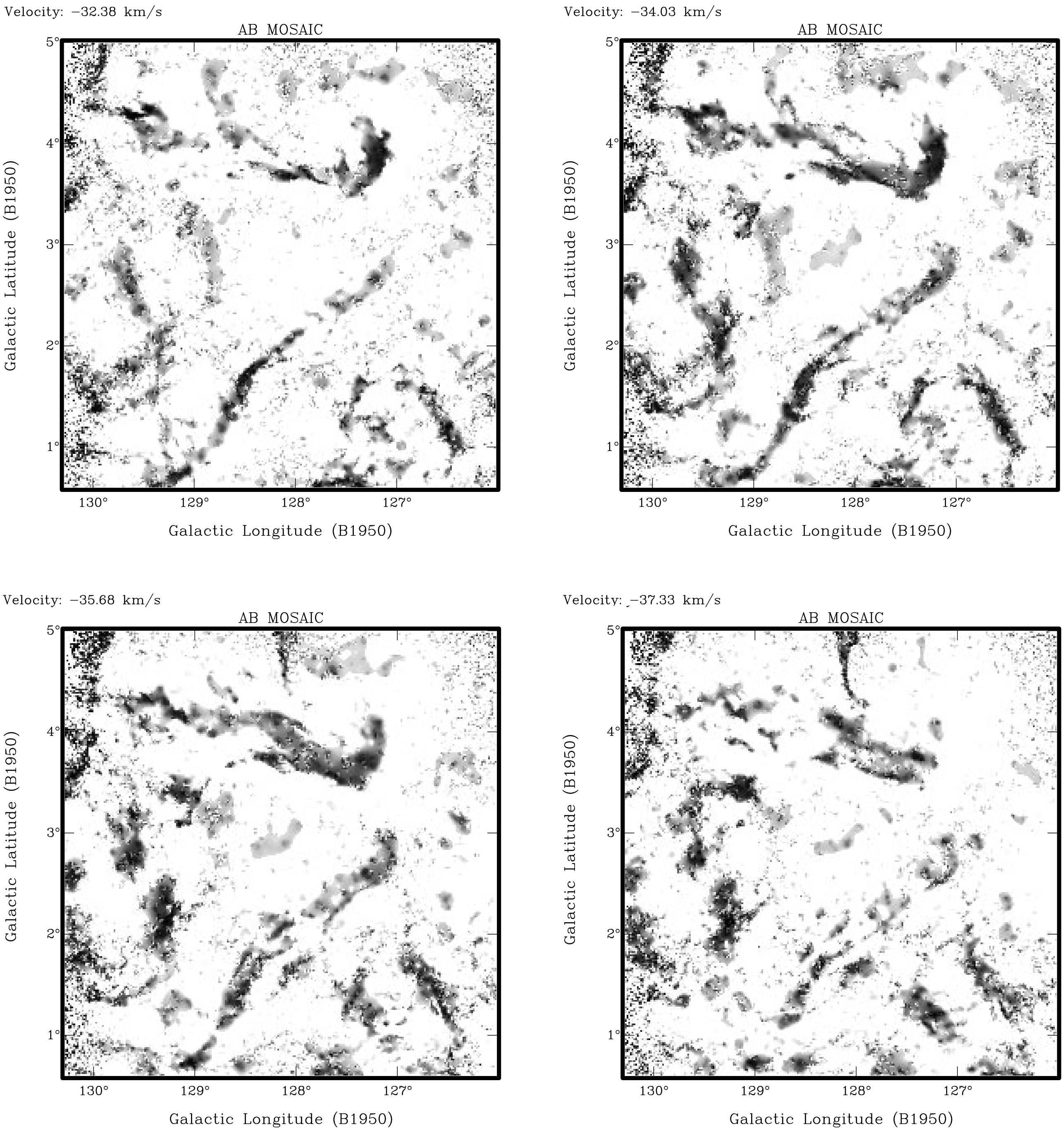

Figure 1—Filamentary Feature: These panels have been made using a preliminary mosaic of H I data from the DRAO survey. A subsection of the spectral line datacube has been block averaged over two pixels and median filtered to reduce both noise and the negative bowl artefacts due to the lack of zero spacings.

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possible. Their software for mapping observed spatial and velocity coordinates to distances will incorporate spiral streaming motions, known distances to objects with known velocities, uncertainty due to random motions of clouds, and other considerations. It will also output error estimates.

The Australia Telescope National Facility Karma package has been adopted as the preferred visualisation software. Both English and Gibson have produced preliminary visualisations. Figure 1 shows a typical H I filamentary feature at four velocity steps in a version of a CGPS/RCPG data cube that has been block averaged (over two pixels in each direction) and median mask filtered. More images are available at

http://www.ras.ucalgary.ca/GPS_pub.html

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