Publications of the Korean Astronomical Society
30: 103 ∼ 105, 2015 September

pISSN: 1225-1534
eISSN: 2287-6936
http://dx.doi.org/10.5303/PKAS.2015.30.2.103

AN UPDATE ON THE MOPRA SOUTHERN GALACTIC PLANE CO SURVEY

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(Received November 30, 2014; Reviced May 31, 2015; Aaccepted June 30, 2015)

ABSTRACT

The 22 m diameter Mopra telescope in Australia is being used to undertake an improved survey of the CO $J = 1$–0 line at 3 mm along the 4th quadrant of the Galaxy, achieving an order of magnitude better spatial and spectral resolution (i.e. 0.6 and 0.1 km/s) than the Dame et al. (2001) survey that is publically available for the Southern Galactic plane. Furthermore, the Mopra CO survey includes the four principal isotopologues of the CO molecule (i.e. ^{12}CO, ^{13}CO, C^{18}O and C^{17}O). The survey makes use of an 8 GHz-wide spectrometer and a fast mode of on-the-fly mapping developed for the Mopra telescope, where the cycle time has been reduced to just 1/4 of a second. 38 square degrees of the Galaxy, from $l = 306$–$344°$, $b = \pm0.5°$ have currently been surveyed, together with additional 9 sq. deg. regions around the Carina complex and the Central Molecular Zone.

We present new results from the survey (see also Burton et al., 2013, 2014). The Mopra CO data are being made publically available as they are published; for the latest release see the project website at www.phys.unsw.edu.au/mopraco.

Key words: Galaxy: structure — Galaxy: kinematics and dynamics — ISM: clouds — ISM: molecules — radio lines: ISM — surveys

Most of the star formation occurring in galaxies takes place in the cores of Giant Molecular clouds (GMCs), which gradually condense from diffuse gas and dust clouds under the influences of gravity, turbulence and magnetic fields. Surveys of the molecular component of the interstellar medium are essential to our understanding of GMC, core and star formation processes, and it is through surveys of carbon monoxide (CO), that the locations of molecular clouds and the conditions within them are most readily studied. CO is used because the $J = 1$–0 transition of CO at 2.6 mm has an energy 5 K above ground that is well suited to excitation at the 10–100 K temperatures found in molecular clouds, unlike the more abundant H_2 molecule, which has its first transition at 510 K above ground and is therefore rarely excited in cool molecular clouds.

The Mopra Southern Galactic Plane CO Survey is an improved survey of the $J = 1$–0 line of ^{12}CO, as well as its principal isotopologues ^{13}CO, C^{18}O and C^{17}O over the 4th quadrant of the Galaxy, from $l = 300$–$350°$, $b = \pm0.5°$, at 35″ spatial and 0.1 km/s spectral resolution, undertaken using the 22 m diameter Mopra telescope (Burton et al., 2013). In addition to the main survey, two 9 square degree regions have also been mapped around the Carina complex and the Central Molecular Zone, as well as two single square degree regions around RXJ0852 and RXJ1713. The data have an order of magnitude better spatial and spectral resolution than the publically-available Dame et al. (2001) survey of the ^{12}CO emission, as can be seen in Figure 1, which compares the two in the first 10 square degrees of the Mopra CO survey, from $l = 310$–$320°$ integrated over the velocities $v = [-40, -30]$ km/s.

CO mapping data can be used to better determine the structure of the spiral arms of the galaxy, as can be seen in the position-velocity diagram in Figure 2. The red molecular emission highlights complex structures, primarily within the spiral arms, in contrast to the smoother blue atomic (HI) gas from the Southern Galactic Plane Survey (McClure-Griffiths et al., 2005). With data from multiple isotopologues, it is possible to measure the distribution of GMC masses and sizes, and high resolution kinematic information can be used to interpret dust continuum data where the various emission regions cannot easily be separated out.

When used in conjunction with surveys of atomic gas (i.e. HI), and of carbon in its ionized and neutral forms (i.e. of C$^+$ and C), large-scale CO surveys can be used to probe "missing" molecular gas (see e.g. Burton et al., 2014), particularly that inferred from gamma-ray observations. The future Cherenkov Telescope Array (CTA; Actis et al., 2011) will provide arcminute-scale resolution gamma-ray maps of the galactic plane, which require similar scale molecular gas surveys to identify the TeV gamma-ray sources and probe the fundamental transport properties of cosmic rays in molecular clouds

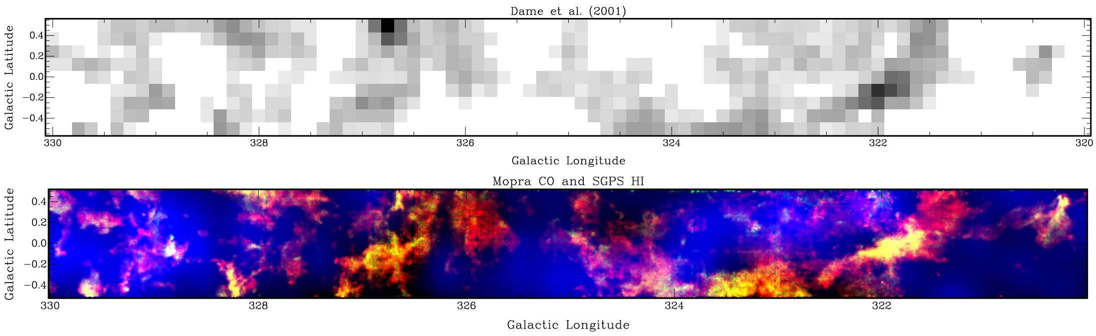

Figure 1. Integrated intensity images from the Dame et al. (2001) CO survey and the Mopra CO survey between $l = 320$–330° and $b = \pm 0.5^\circ$ over the velocity range $V = -40$ to -30 km/s. The lower map shows Mopra CO data for ^{12}CO (R) and ^{13}CO (G) smoothed with a $60''$ FHWM Gaussian beam; also shown is the HI Southern Galactic Plane Survey (B; McClure-Griffiths et al., 2005) data at ~ 1 arcmin resolution.

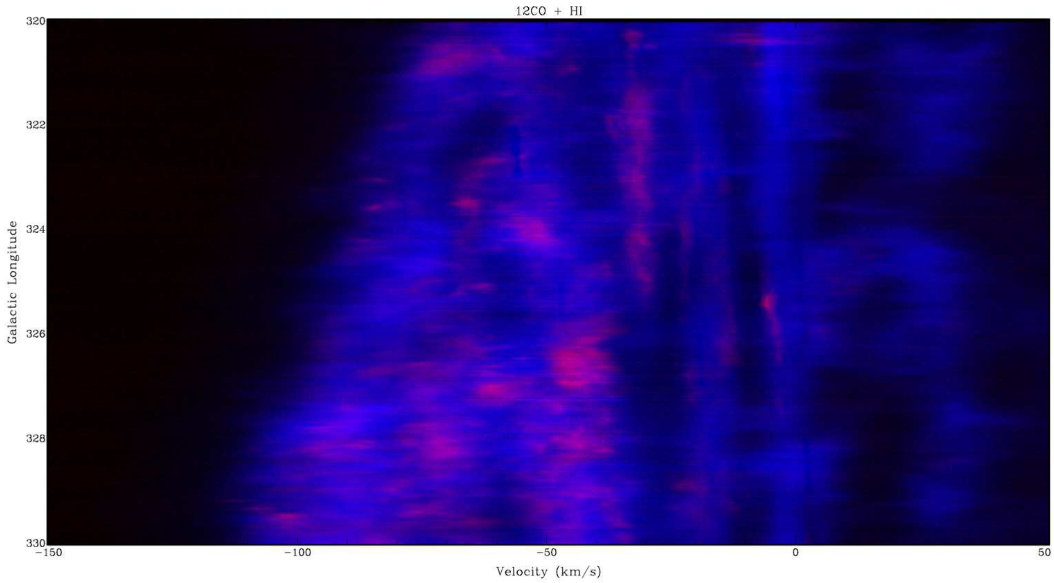

Figure 2. Position velocity image from the Mopra CO survey for the ^{12}CO line (R), summed over Galactic latitudes $|b| < 0.05^\circ$, together with the corresponding 21 cm HI data from the SGPS (B; McClure-Griffiths et al., 2005). V_{LSR} velocities are plotted against the Galactic longitude, $l = 320$–330°. Several bands are seen running across the image at roughly constant velocities; these are associated with spiral arms crossing along these sight lines through the Galaxy (the Sagittarius-Carina arm is located around -20 km/s, Scutum-Crux arm at around -50 km/s and the Norma-Cygnus arm at around -80 km/s).

(see Rowell et al., this volume).

The Mopra CO mapping survey of the southern Galactic plane is producing a comprehensive data set in two lines (^{12}CO and ^{13}CO), with the C^{18}O and C^{17}O lines detected only at the brightest locations. For instance, it has been shown that in the first square degree of the survey along the $l = 323^\circ$ sight line of the Galaxy there is $\sim 2 \times 10^6\,M_\odot$ of molecular gas within the Solar circle, distributed in 6 GMC-complexes (Burton et al., 2013). These complexes have average densities $\sim 0.1\,M_\odot/\mathrm{pc}^3$ ($n \sim 1\,\mathrm{cm}^{-3}$), are spaced 1 kpc apart and extend for ~ 300 pc along the sight line. The survey data is being made available online as it is published, along with 3D renderings that clearly show the gas structure and dynamics and movies showcasing the increased velocity resolution of this survey.

ACKNOWLEDGMENTS

The Mopra radio telescope is part of the Australia Telescope National Facility. Operations support was provided by the University of New South Wales and the University of Adelaide. The UNSW Digital Filter Bank (the MOPS) used for the observations with Mopra was provided with financial support from the Australian Research Council (ARC), UNSW, Sydney and Monash universities. We also acknowledge ARC support through Discovery Project DP120101585.

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