Molecular Cloud Formation and ISM Phases in G333

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1. Introduction

The interstellar medium (ISM) is turbulent with several different phases (of temperature, density, neutral vs ionised, atomic vs molecular) interacting, and interconverting (Hennebelle & Falgarone, 2012). The molecular ISM is largely H_2, but transitions of CO are commonly used as a proxy tracer. However, different molecules form from the atomic ISM under different conditions, and so there is molecular material not traced by CO.

We are using the hydroxyl molecule, OH, as another complementary tracer of the molecular ISM. A three-way comparison of HI, OH and CO lines is expected to show molecular features in OH which are not traced by CO, but which highlight the transition from atomic gas (seen in the HI line) to molecular gas.

This project is a pilot for the future Galactic plane survey (GASKAP) with the Australian Square Kilometer Array Pathfinder (ASKAP) in HI and OH lines (Dickey et al., 2013) and complements the current SPLASH project to map OH lines in the southern Galactic Plane with the Parkes telescope.

The target area is the Giant Molecular Cloud (GMC) complex G333, at a distance of 1.6 kpc, which we have been studying in a range of tracers, including 3-mm lines of ^{13}CO (Bains et al., 2006), C^{18}O (Wong et al., 2008) and dense gas tracers such as HCN (Lo et al., 2009).

2. Observations and Data Reduction

Observations with the 64-m Parkes radio telescope were made of the four OH lines at 1612, 1665, 1667 and 1720 MHz, with on-the-fly mapping, and reduced with LIVEDATA and GRIDZILLA packages.

Observations with the Australia Telescope Compact Array (ATCA) were made with three different configurations (H75, EW352 and 1.5D) to cover a range of spatial scales (and simulate ASKAP coverage) in the four OH lines and HI at 1420 MHz. The ATCA data were reduced with the MIRIAD package and combined with the single-dish Parkes data. Single dish HI data were obtained from the Southern Galactic Plane Survey (SGPS) of McClure-Griffiths et al. (2005).

3. Results

In order to study the lines both for the low surface brightness diffuse emission, and the small scale structure, we analyse cubes and continuum (Fig. 1) from Parkes data at $\sim$ 13 arcmin resolution, and combined Parkes and ATCA data at full 30 arcsec resolution and intermediate 2.5 arcmin resolution.

In practice, for the G333 area (which is selected as a prominent GMC, so may not be typical of the whole Galactic Plane) we find that a lot of the emission in all four of the OH lines is from masers (Fig. 2) These masers are best identified in the 30 arcsec cubes, but confuse the diffuse OH in the cubes at the lower spatial resolutions.

We present in Figs 3 and 4 spectra of the four OH lines, HI absorption and ^{13}CO emission of two areas (without strong masers) from the 2.5 arcmin resolution cubes, with strong continuum and hence good absorption in the main OH lines at 1665 and 1667 MHz.

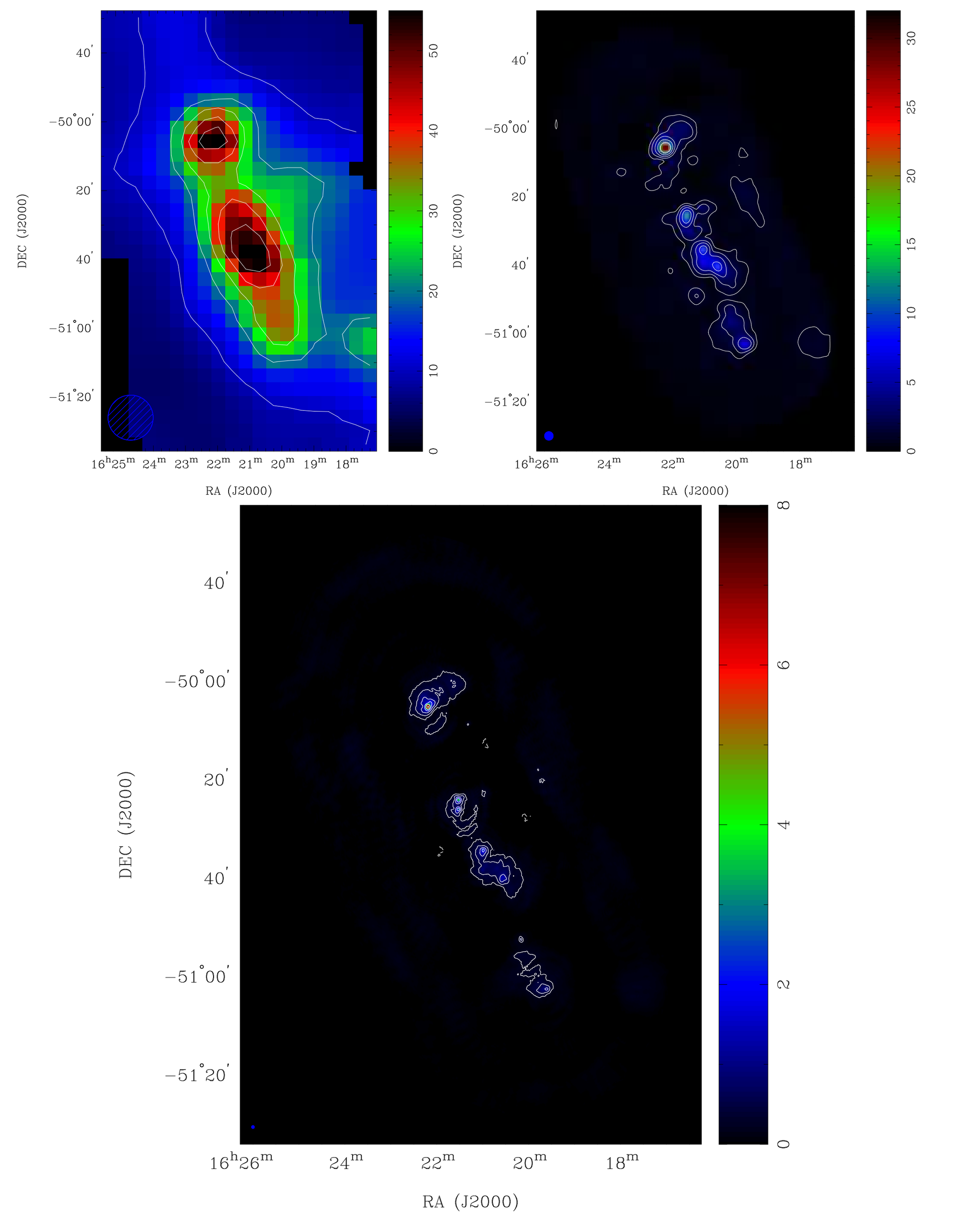

Figure 1: *The continuum emission in the G333 complex from Parkes observations (top left) at 13.1 arcmin resolution and combined ATCA and Parkes observations at 2.5 arcmin (top right) and 30 arcsec (bottom) resolution.*

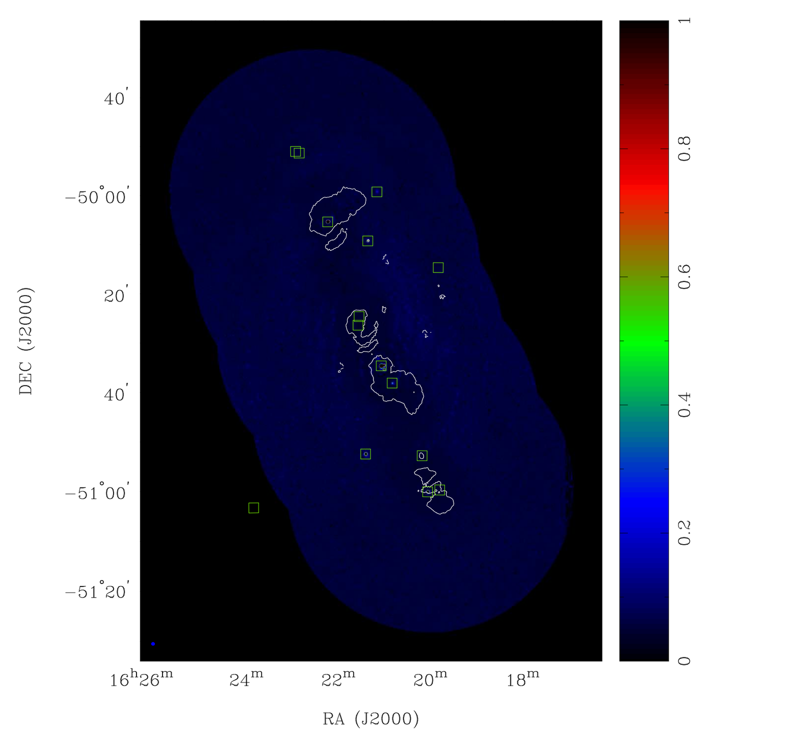

Figure 2: *Positions of the 15 OH masers detected, plotted on the peak 1667 MHz OH emission image, with a low contour of the continuum emission. Note that most of the masers are in the star-formation regions, so non-thermal OH maser emission may confuse the OH spectra.*

The satellite OH lines at 1612 and 1720 MHz are conjugate (opposite sign) due to IR pumping in the star formation regions. The main OH lines at 1665 and 1667 MHz are in absorption, as expected for thermal conditions of the OH cloud, with the bright radio continuum behind, but the ratio of 1667 to 1665 line strength is not always close to the ratio 1.8 expected for the simple LTE case.

The main OH line absorption highlights a strong OH cloud component at around -40 km/s which corresponds to only a very weak part of the line wing in ^{13}CO emission and is not an obvious feature in the HI absorption. This does indicate parts of the molecular ISM not well traced by CO.

References

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Wong T., et al., 2008, MNRAS, 386, 1069

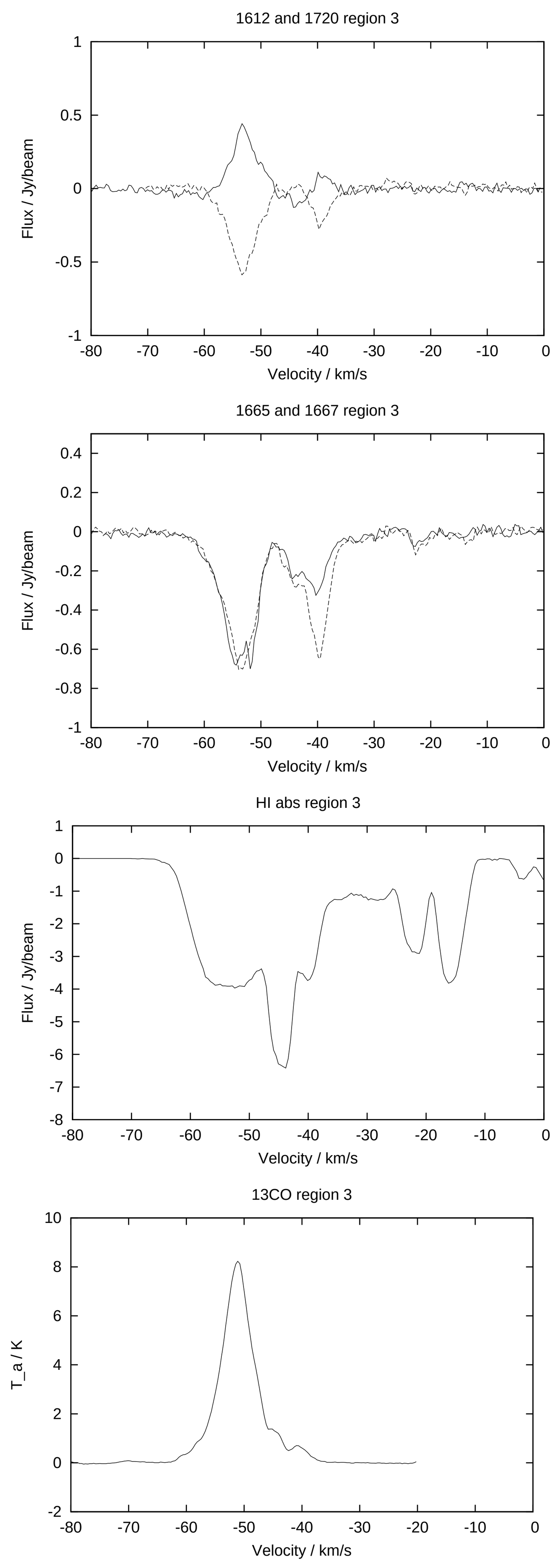

Figure 3: *Spectra of the satellite OH lines (top) at 1612 and 1720 (dotted) MHz, the main OH lines (second) at 1665 and 1667 (dotted) MHz, HI absorption (third) at 1420 MHz and ^{13}CO emission (bottom) at 110.2 GHz.*

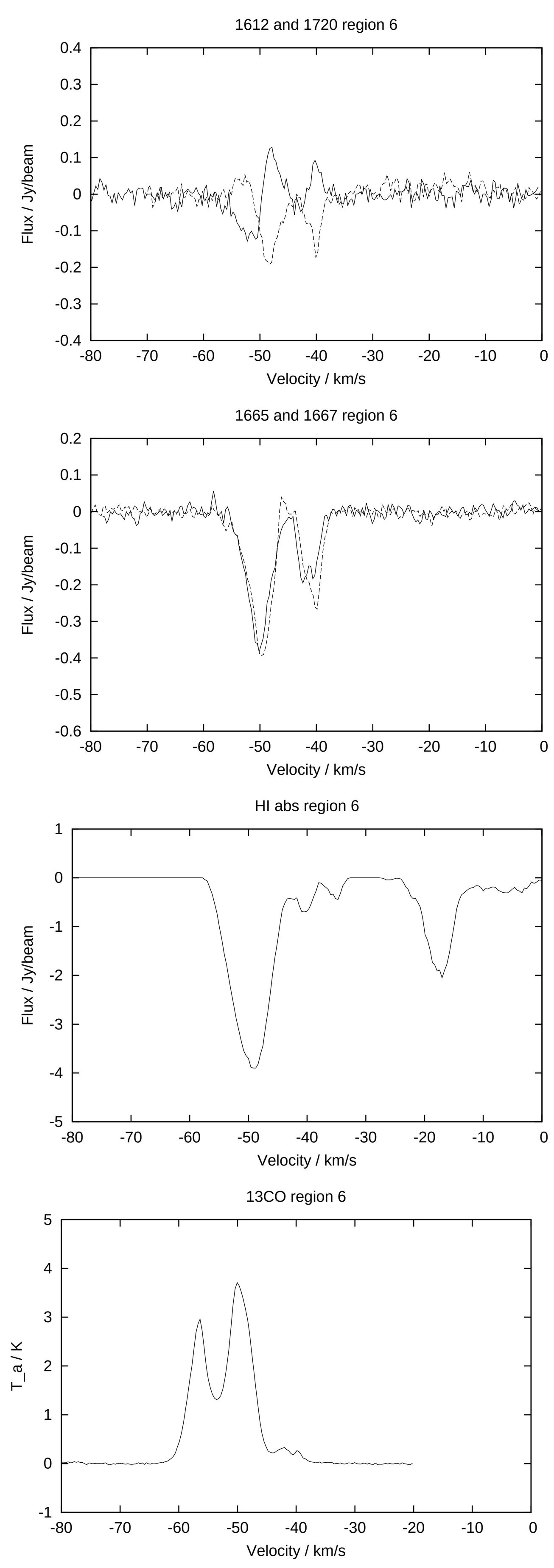

Figure 4: *Spectra similar to Fig. 3 for another selected area.*

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