Millimetre molecular lines in Planck cold clumps

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1. Introduction

Galactic cold clumps have been identified from the Planck data (Planck Collaboration et al., 2011a,b, 2015) as 10 342 cold (7 - 19 K) sources that stand out against a warmer environment, with the Early Cold Cores (Fig. 1) as a subsample of 915 most reliable detections.

As shown in Fig. 2 there is CO emission associated with the PCCs, which has been observed with ground-based radio telescopes at higher resolution (Wu et al., 2012; Liu et al., 2014).

A subset of Planck Cold Clumps (PCCs) have been observed with Herschel at higher resolution, as shown in Fig. 3 for G206.33-25.94.

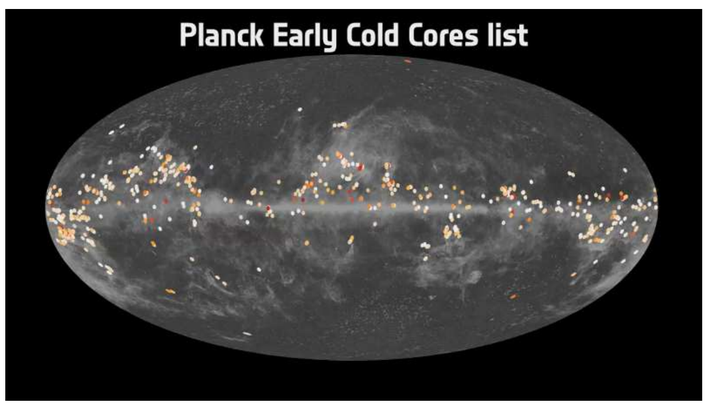

Figure 1: *The sky distribution of the Early Cold Cores, plotted on the Planck dust emission.*

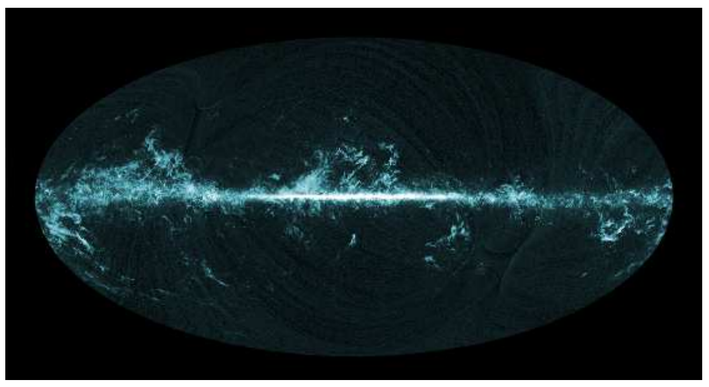

Figure 2: *The All-Sky CO emission from Planck.*

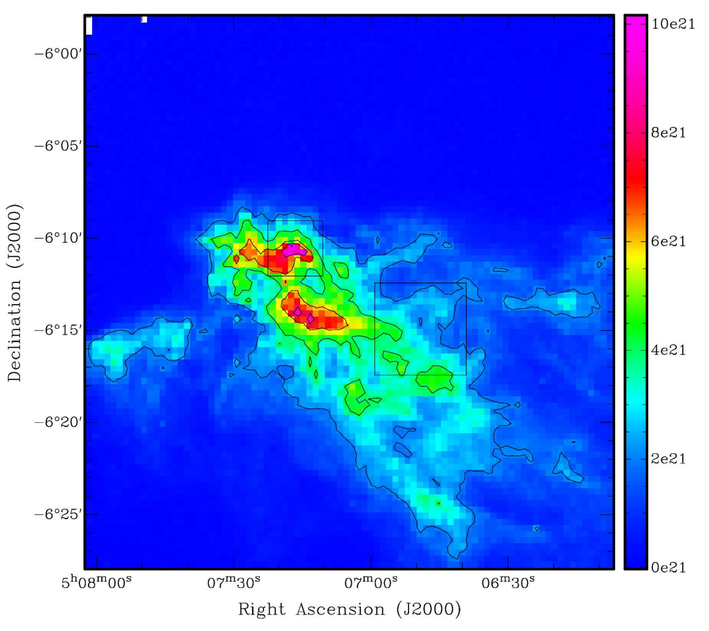

Figure 3: *Hydrogen column density image derived from Herschel observations of the dust for G206.33-25.94*

2. Mopra millimetre line observations

A southern sub-sample of the PCCs has been observed with the Mopra 22-m telescope to study the molecular gas. The Mopra telescope has 3-mm, 7-mm and 12-mm bands, with broadband correlator configuration 8-GHz wide with 0.27-MHz channels, or multiple zoom bands 137-MHz wide with 33-KHz channels, within the 8 GHz.

During the 2013 southern winter season we observed 10 clumps. This included observations in the 3-mm band of ^{12}CO, ^{13}CO and C^{18}O and lines around 89 GHz (e.g. HCN, HCO$^+$ and HNC), in the 7-mm band (e.g. CS) and in the 12-mm band (e.g. NH_3). Sample spectra are shown in Fig. 4. These observations were heterogenous, with sources selected by LST in gaps between observations of other projects, and band chosen by weather (i.e. in conditions unsuitable for higher frequencies, lower frequency bands were observed).

During the 2014 season we observed 34 positions in 22 clumps, with zoom mode observations of lines around 89 GHz. Sample spectra are shown in Fig. 5. This was a more well-defined sample of sources.

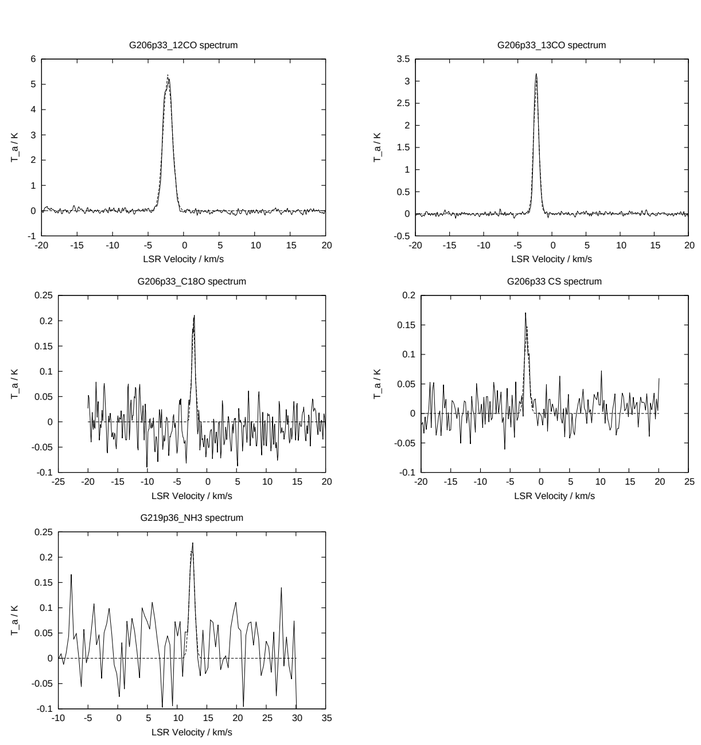

Figure 4: *Example spectra from 2013 observations of ^{12}CO, ^{13}CO, C^{18}O and CS in G206.33-25.94 and NH_3 in G219.36-9.71.*

3. Discussion

The mapping of the CO lines shows good spatial correlation of the CO with the dust column density (Fig. 6). The CO isotoplogues show high optical depth in ^{12}CO and ^{13}CO. The lines of HCN, HCO$^+$ and HNC are weak, but detected in many of the 2014 sample.

We are modelling the line results to determine column densities, excitation temperatures and abundances, using tools such as RADEX (van der Tak et al., 2007).

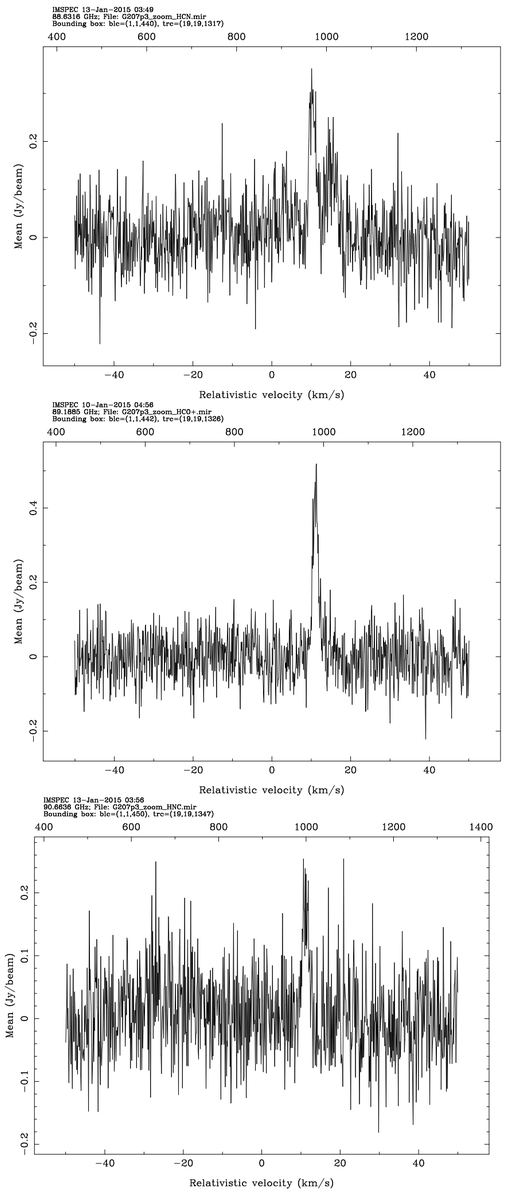

Figure 5: *Example spectra from 2014 observations for HCN, HCO$^+$ and HCN in G207.3.*

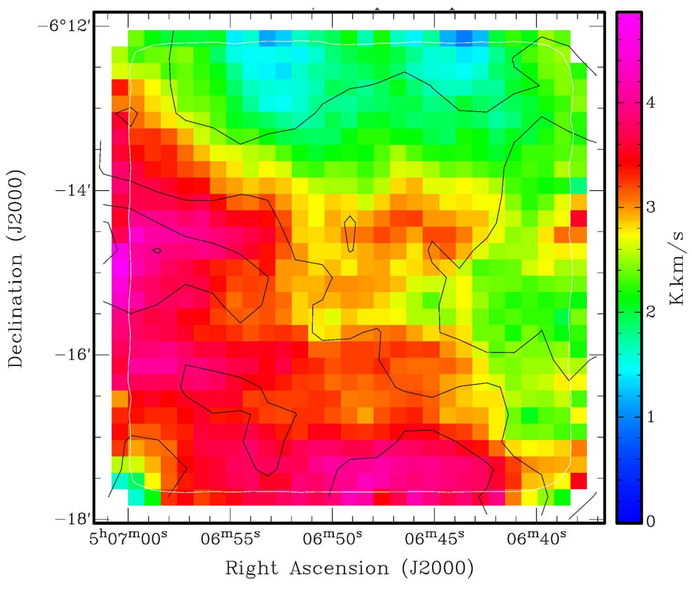

Figure 6: *Integrated ^{13}CO emission for G206.33-25.94, with contours of dust-derived column density, showing the good correlation between gas and dust.*

References

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