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[CII] Studies of PDRs Towards Molecular Clouds

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Introduction

• The [CII] fine-structure line at 158μm, is an excellent tracer of the warm diffuse gas and Photon Dominated Regions (PDRs) interface between the molecular clouds and their surrounding atomic envelopes.

• Here we present the first results on the molecular cloud-atomic cloud interface from the Galactic Observations of Terahertz C+ (GOT C+), a Herschel Key Project study of [CII] emission in different environments in our Galaxy.

• We have collected data along a dozen lines of sight passing through the inner Galactic disk between longitudes 330 degrees and 25 degrees.

• Since the [CII]/^{12}CO and [CII]/^{13}CO ratios are predicted to be very sensitive to the strength of the FUV field and H_2 volume density, we use our observations together with a grid of PDR models to contrain the physical conditions of the observed regions.

Conclusions

• We identify forty six [CII] components that are associated with dense molecular clouds as traced by the ^{13}CO emission in our CO survey using the Mopra telescope.

• We combine [CII], ^{12}CO, ^{13}CO, and C^{18}O observations to derive the physical conditions of the [CII]-emitting regions in our sample of dense clouds using a PDR model grid.

• Our results suggest that CII emission is a good tool to differentiate between regions of massive star formation (high densities/strong FUV fields) and regions that are distant from massive stars (lower densities/ weaker FUV fields).

• In this unbiased sample we find that most of the [CII] emission from PDRs come from weak FUV radiation field regions.

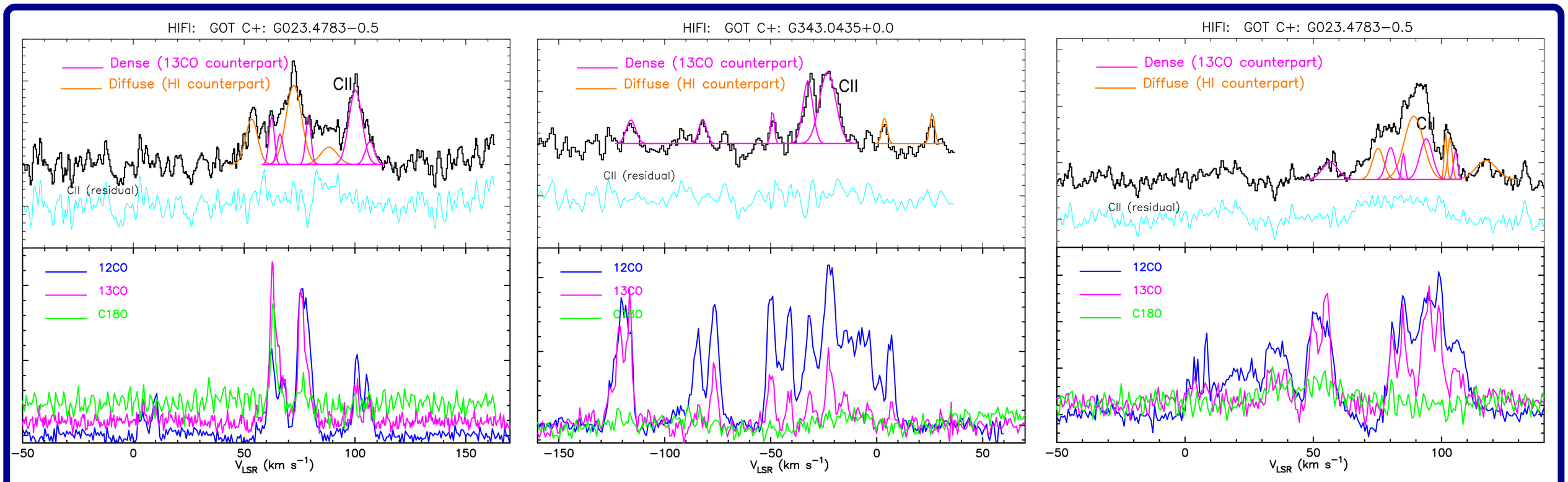


Figure 1: (Upper Panel) Example Hershel/HIFI [CII] spectra showing Gaussian fits of the identified components with and without ^{13}CO counterparts. (Lower Panel) Mopra ^{12}CO, ^{13}CO and C^{18}O spectra observed towards the [CII] lines-of-sight.

[CII] Components Associated with Dense Molecular Clouds

• We select [CII] components associated with dense molecular gas by searching for ^{13}CO counterparts.

• We combine the [CII] data with observations of ^{12}CO, ^{13}CO and C^{18}O taken with the Mopra 22m telescope in Australia.

• We find 46 [CII] components with ^{12}CO and ^{13}CO counterparts. Of those, 12 also show C^{18}O emission.

• In Figure 2, we present the [CII]/^{12}CO, [CII]/^{13}CO and [CII]/C^{18}O integrated intensity ratios for the identified components as a function of the [CII] integrated intensity.

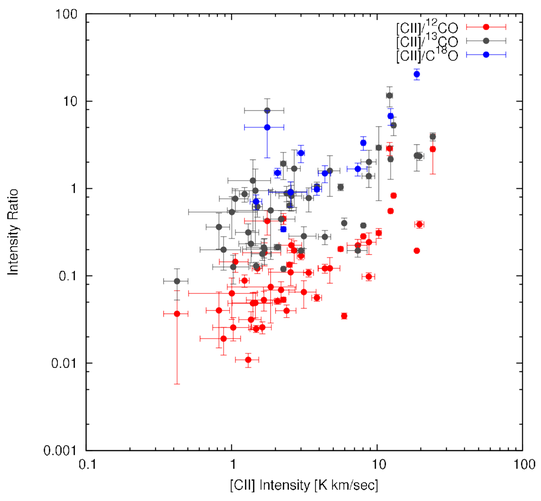
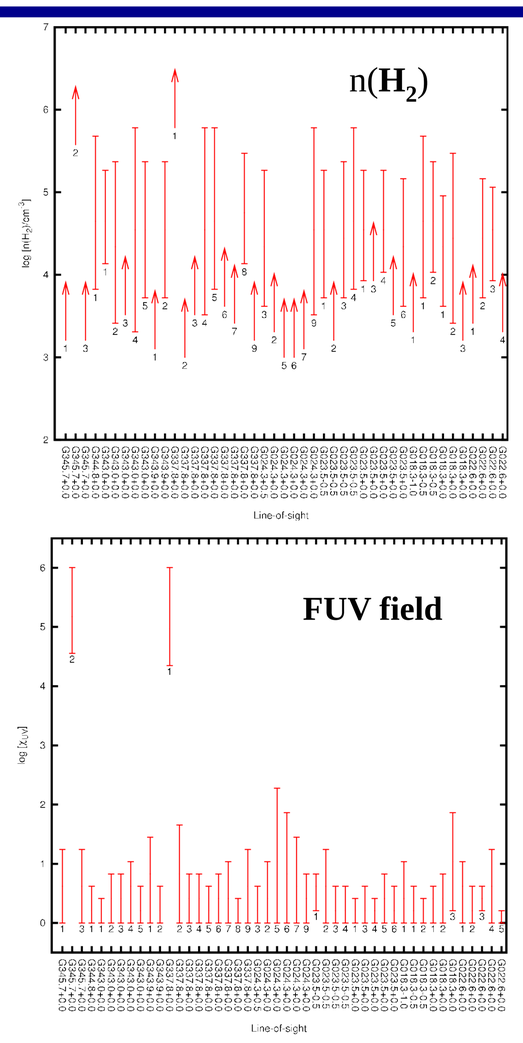


Figure 2: The observed [CII]/^{12}CO, [CII]/^{13}CO, and [CII]/C^{18}O integrated intensity ratios for the sample of [CII] components that are associated with dense molecular clouds.



Comparison with PDR Model Calculations

• We compare the observed [CII]/^{12}CO and [CII]/^{13}CO line ratios with the results of a PDR model grid in order to determine physical conditions of the [CII]-emitting clouds.

• We use the predictions of a grid of spherical PDR models whose input parameters are the clump mass, H_2 volume density at the clump surface, and strength of the FUV radiation field ($\chi_{UV,0}$; in units of the Draine 1978 field). The model grid was calculated using the KOSMA-tau PDR model (Störzer et al. 1996) and is available on-line.

• In Figure 3 we show the constrained values of the H_2 volume density (upper panel) and FUV radiation field (lower panel) for our sample of clouds. The grid provides solutions for M=10^{-3}-100 M$_\odot$. A clump mass of 100 M$_\odot$ always provided the best fit to the observations.

• We find two CII components associated with molecular clouds have high volume densities (>10^5 cm^{-3}) and strong FUV fields (between 10^4-10^6 $\chi_{UV,0}$). The remaining components have more moderate volume densities between 10^3-10^5 cm^{-3} and weaker strengths of the FUV field between 1-100 $\chi_{UV,0}$

Figure 3: Results of the comparison between [CII]/^{12}CO and [CII]/^{13}CO ratios for all identified [CII] components and the PDR model grid showing the constrained ranges in H_2 volume density (upper panel) and FUV radiation field (lower panel).

References

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• Störzer, H., Stutzki, J., & Sternberg, A. 1996, A&A, 310, 592

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