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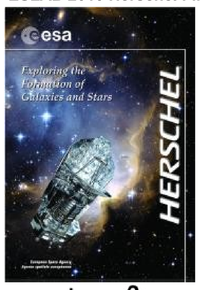

got c+?

CII, HI, and CO Emission in a Sample of Transition Clouds from the GOT C+ Survey

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Our Goal

- *Study the diffuse interstellar medium (ISM) by observing with HIFI the [CII] ($^2P_{3/2}$ - $^2P_{1/2}$) fine structure line emission and absorption at 1.9 THz (158 μm) over 500 lines of sight (LOSs) in the Galactic disk.*
- *Characterize the ISM properties in the purely atomic clouds and atomic to molecular cloud transitions*

Importance of C^+ in Diffuse Atomic and Molecular Clouds

- C^+ is a major ISM coolant, and its 158 μm line is an important tracer of the properties of the diffuse atomic and diffuse molecular gas clouds.
- CII line traces a so-far poorly-studied stage in cloud evolution - the transitional clouds going from atomic HI to molecular H_2
- Diffuse molecular clouds (HI < H_2 and CO < C^+) are difficult to study using standard tracers. But can be studied well in C^+
- "Dark gas" in diffuse clouds - an evolutionary stage with no or little HI, consisting of the hydrogen gas converted to molecular hydrogen but with insufficient shielding of UV to allow CO to form which may be best traced by C^+

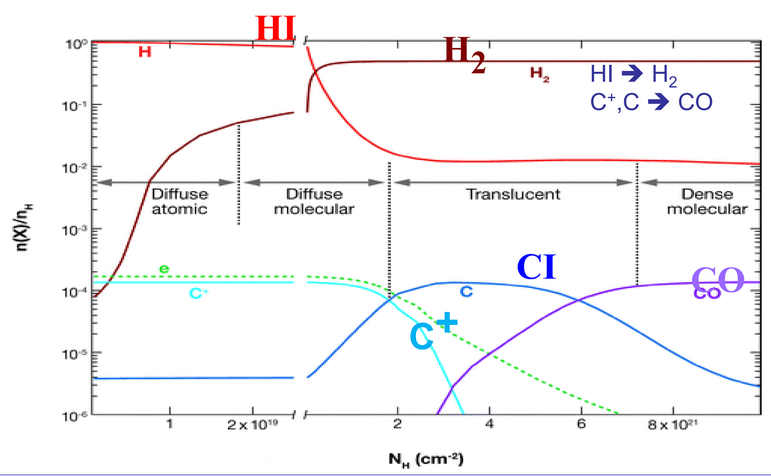

Fig. 1 A schematic representation of the ISM components. Transition of hydrogen from HI to H_2 and carbon from C^+ to CI and CO as a function of depth into a cloud (Snow & McCall 2006).

- *In the transition zone from HI to H_2 the C+ abundance decreases but the CII intensity increases with the increase in density and such transitions are easily detected in CII*

ISM Diffuse clouds in the inner Galaxy as traced by CII emission: First Results from GOT C+

Diffuse ISM Cloud Sample

- Preliminary results from HIFI PVP/SDP/PSP data
- Velocity resolved CII emission features along 16 LOSs
- LOSs passing through several Galactic environments (Fig. 2)
- Use ancillary HI, ^{12}CO, ^{13}CO and $C^{18}O$ data (see Table 1)
- Finding diffuse CII emission clouds
  - –Identify all CII emission features (clouds) by multiple Gaussian fitting to the velocity profile
  - –Identify dense clouds/PDRs by detection of 13CO emission in them
  - – Separate CII emission regions between PDR/dense molecular clouds and diffuse ISM (without13CO emission) (See Fig.4)
- Identified total 110 CII clouds
  - – 46 as dense molecular clouds with 13CO counterparts
  - – 64 Diffuse ISM clouds: No ^{13}CO but may have ^{12}CO

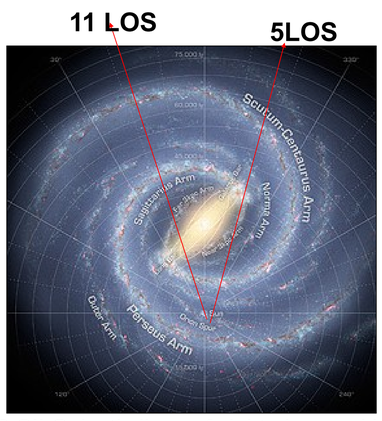

Fig. 2 CII Galactic lines of sight observed by HIFI

Table 1

Observation	Survey/ Telescope	Beam	Velocity Resolution Km/s	Sensitivity K/channel	Reference
CII	Herschel HIFI: GOT C+	12 ″ X 12 ″	1.0	0.1	Langer et al. (2010)
HI	SGPS VGPS	132″ X 132″ 60″ X 60″	0.84 0.84	1.6 2.0	McClure-Griffiths , et al (2005) Still et al. (2006)
12CO	Mopra 22m	33″ X 33 ″	0.8	0.6	This work
13CO			0.8	0.1	This work
C18O			1.6	0.1	This work

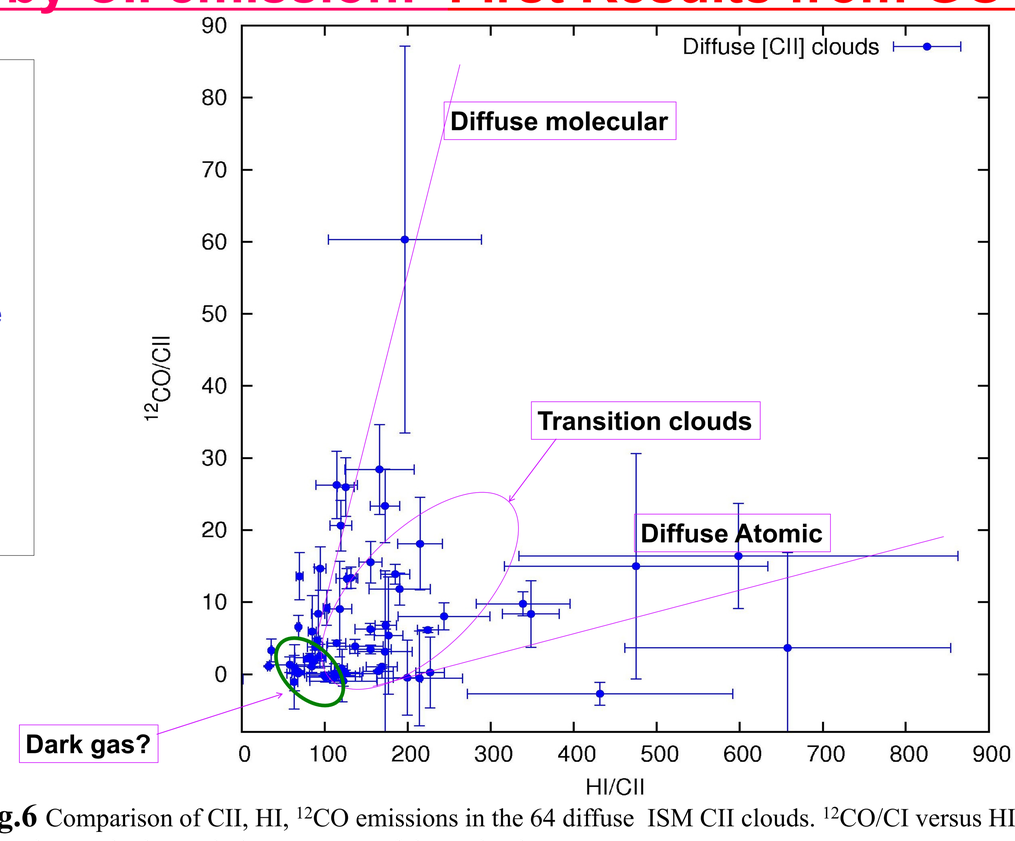

Fig.6 Comparison of CII, HI, ^{12}CO emissions in the 64 diffuse ISM CII clouds. ^{12}CO/CI versus HI/CII intensities are plotted to study the evolutionary status of these clouds.

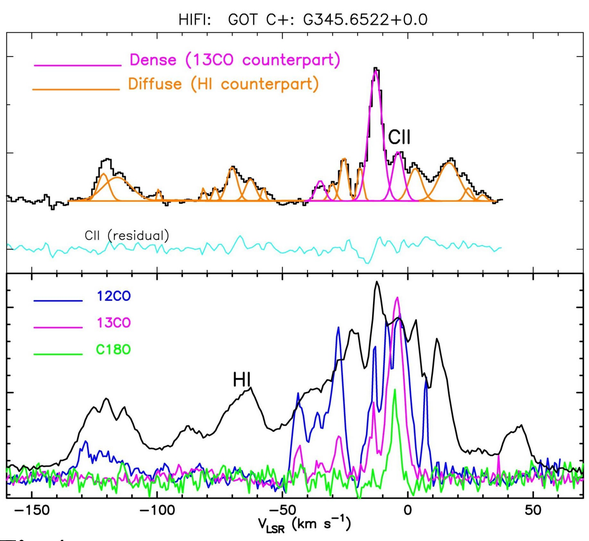

Fig.4 Examples of CII spectra along with HI, CO emissions; the Gaussian fits show CII velocity components and their identification as dense or diffuse clouds.

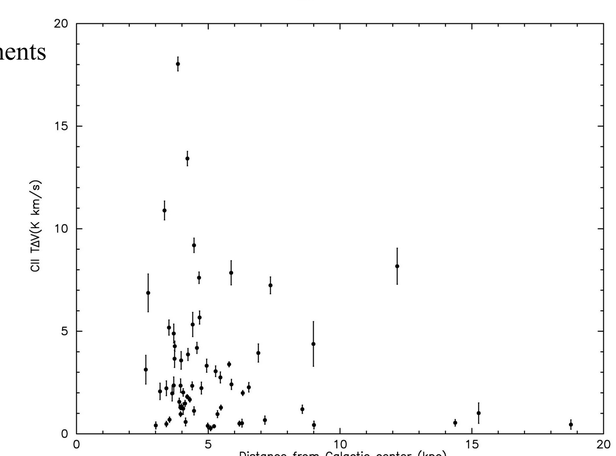

Fig.5 Distribution of 64 diffuse ISM CII clouds detected in the HIFI PVP/SDP/PSP observations of GOT C+ in the Galaxy are shown as function of distance from Galactic center.

Diffuse Cloud Properties

- The relative intensities of HI and ^{12}CO with respect to CII shown in Fig. 6 delineate the diffuse clouds into:
  - – two extreme populations of pure diffuse atomic (low ^{12}CO/CII and HI ∝ CII) and diffuse molecular clouds (high ^{12}CO/CII and low HI/CII)
  - – a large fraction of transition clouds in different evolutionary stages on their way from HI to H_2 and C^+ to CI and/or CO
  - – about 10 diffuse clouds , tentatively identified as dark gas by the signature of CII intensity and low intensities of both HI and ^{12}CO
- The spread in the distribution of the clouds in the HI/CII- ^{12}CO/CII intensity plot represents the density and/or UV radiation in them (Higher the density or the UV radiation the clouds move towards the lower left corner).

Future prospects

- Predominance of CII emission from diffuse clouds over dense molecular clouds
  - – Out of total 110 CII emission clouds 64 are from diffuse clouds
- A larger sample (on completion of the GOT C+ with even better sensitivity) will
  - – trace the evolutionary status of transitions clouds and their role in the current models of the ISM describing the thermal and dynamical state of the interstellar gas
  - – estimate the fraction of CII emission from the diffuse ISM clouds and compare with that from molecular clouds in star forming environments.
  - – provide a robust estimation of the fraction CII emission tracing star formation
- Characteristics of the observed CII emission in the Galaxy serve as template for using the CII as probe for star formation rate in external galaxies

References:
McClure-Griffiths , et al 2005, ApJS 158, 178
Snow, T. P., & McCall, B. J. 2006, ARA&A, 44, 367
Still et al. 2006, AJ 132, 176

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