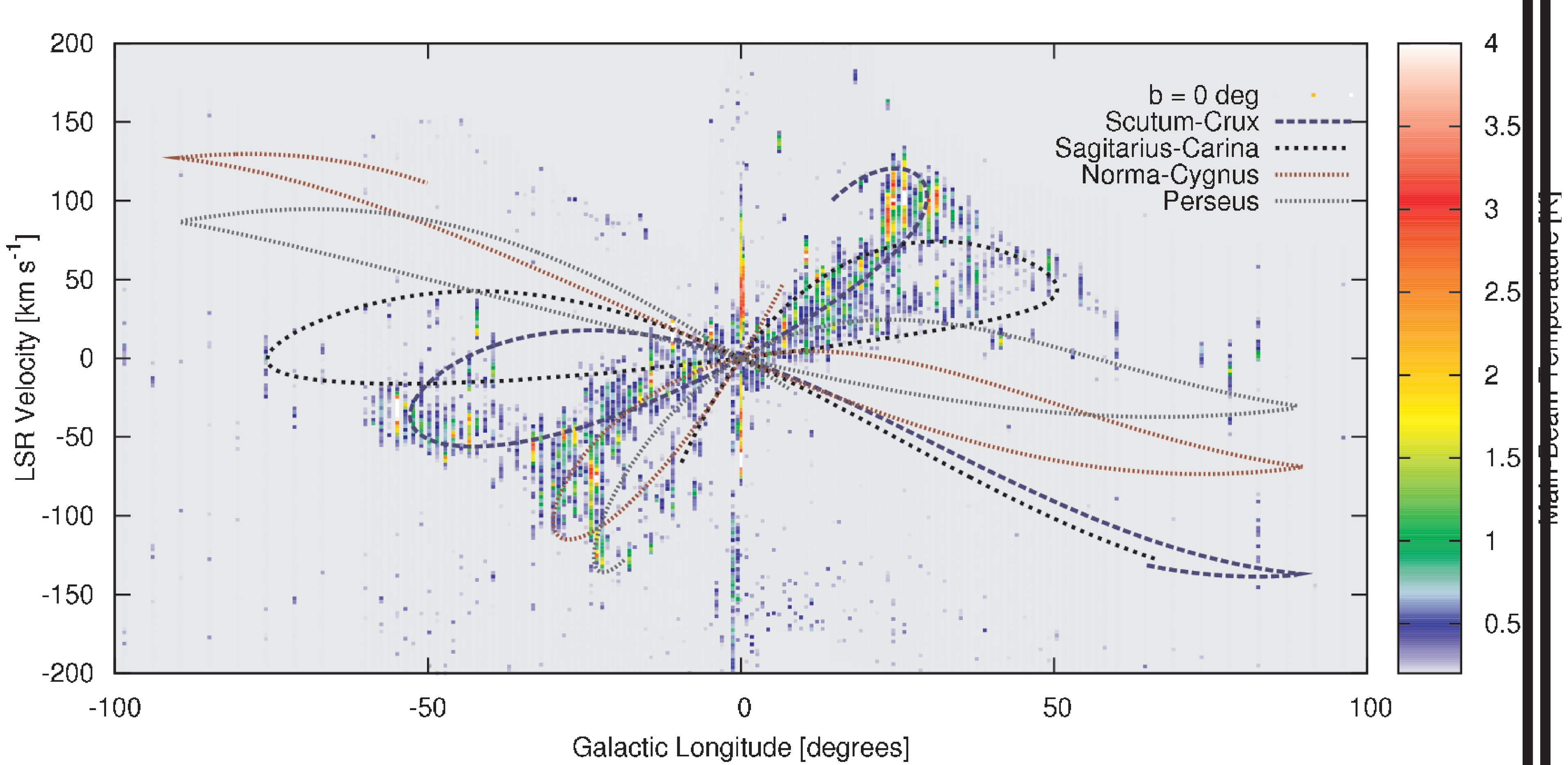
The Lifecycle of the Interstellar Matter and Star Formation in the Galactic Plane revealed by the [CII] 158um Line

Jorge L. Pineda, William D. Langer, and Paul F. Goldsmith

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

The Distribution of [CII] Emission in the plane of the Milky Way

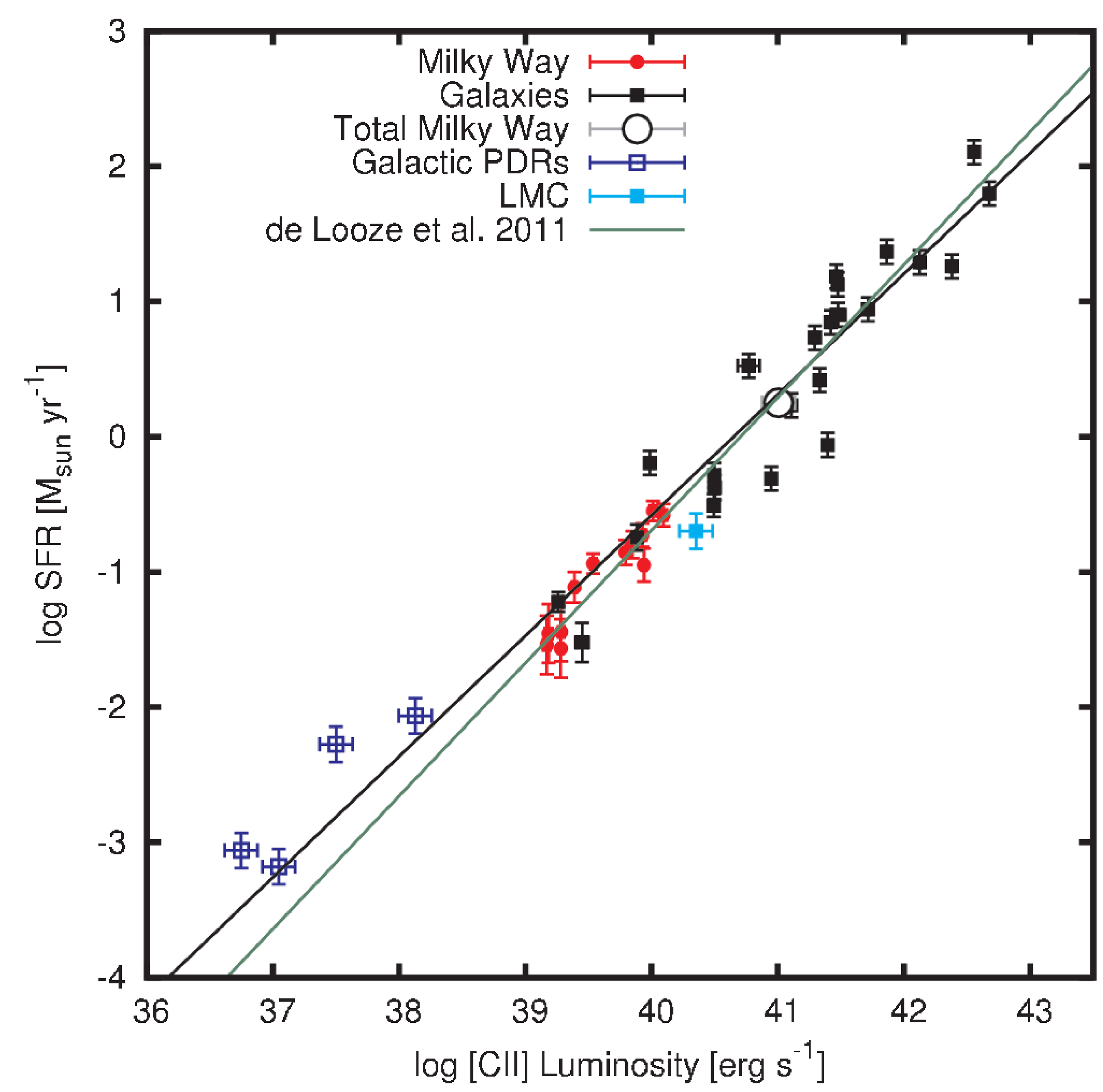


The Galactic Observations of Terahertz C+ (GOTC+) project is devoted to surveying the [C II] 158μm line over the entire Galactic disk with velocity–resolved observations obtained using the HIFI instrument on Herschel.

We present the first longitude–velocity maps of the [CII] emission for Galactic latitudes b = 0°, ±0.5°, and ±1.0°. We combine these maps with those of HI, ^{12}CO, and ^{13}CO to separate the different phases of the ISM and study their properties and distribution in the Galactic plane.

[CII] emission is mostly associated with spiral arms, mainly emerging from Galactocentric distances between 4 and 10 kpc. It traces the envelopes of evolved clouds as well as clouds that are in transition between atomic and molecular.

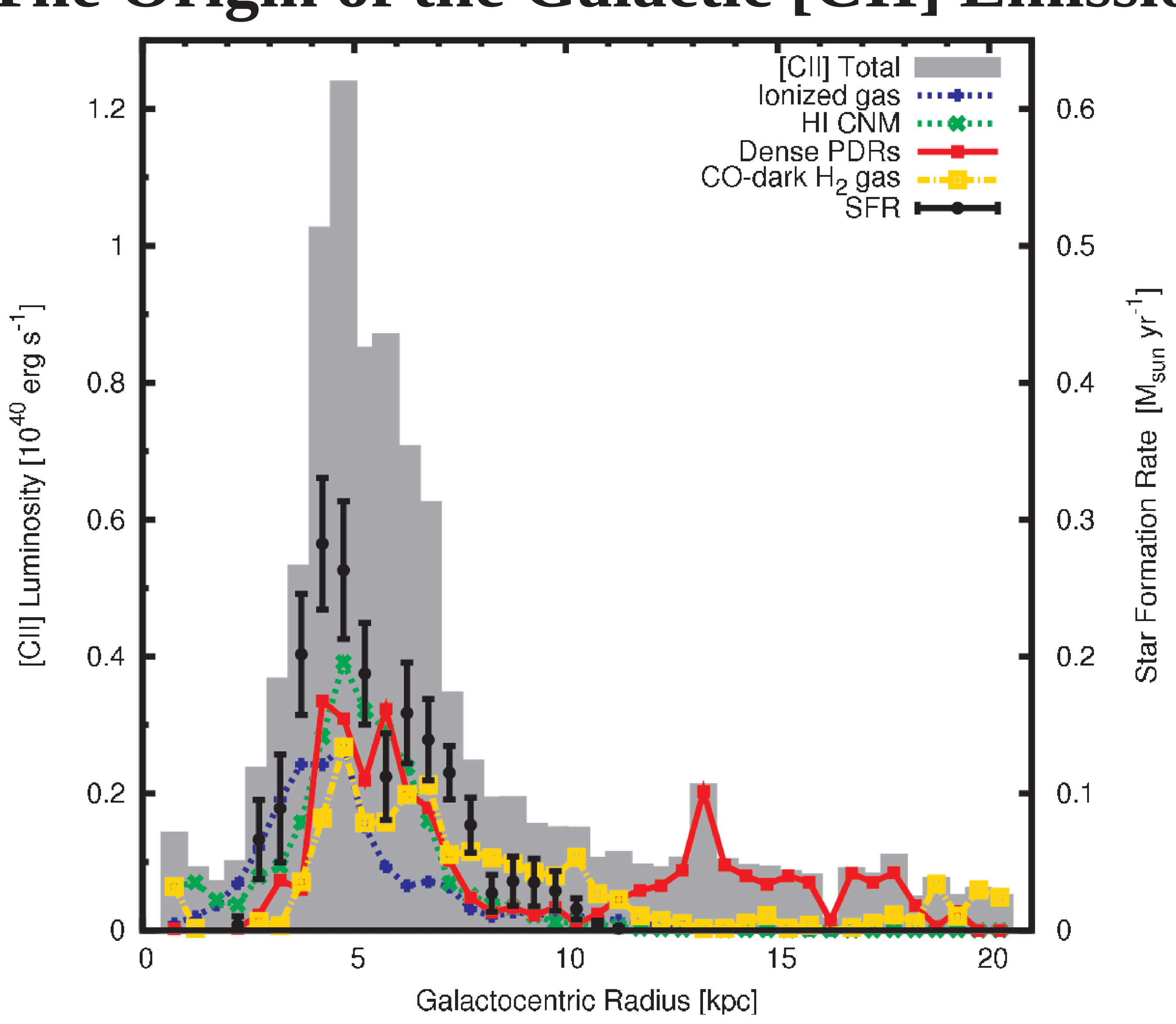
[CII] as a Tracer of Star Formation



We compared the distribution of the [CII] luminosity of the Milky Way with that of the star formation rate derived from radio continuum observations.

The [CII] and SFR are well correlated at Galactic scales with a relationship that is in excellent agreement with that found for external galaxies. By combining [CII] and SFR data points in the Galactic plane with those in external galaxies and nearby star forming regions, we find that a single scaling relationship between the [CII] luminosity and SFR applies over six orders of magnitude.

The Origin of the Galactic [CII] Emission



We used the [CII], CO, and HI emission and a model for the electron distribution of the galaxy (NE2001; Cordes & Lazio 2002) to separate the diffent phases of the interstellar medium that contribute to the observed [CII] emission.

The [CII] emissivity at b=0 degrees is mostly produced by dense photon dominated regions (47%), with smaller contributions from CO-dark H2 gas (28%), cold atomic gas (21%), and ionized gas (4%).

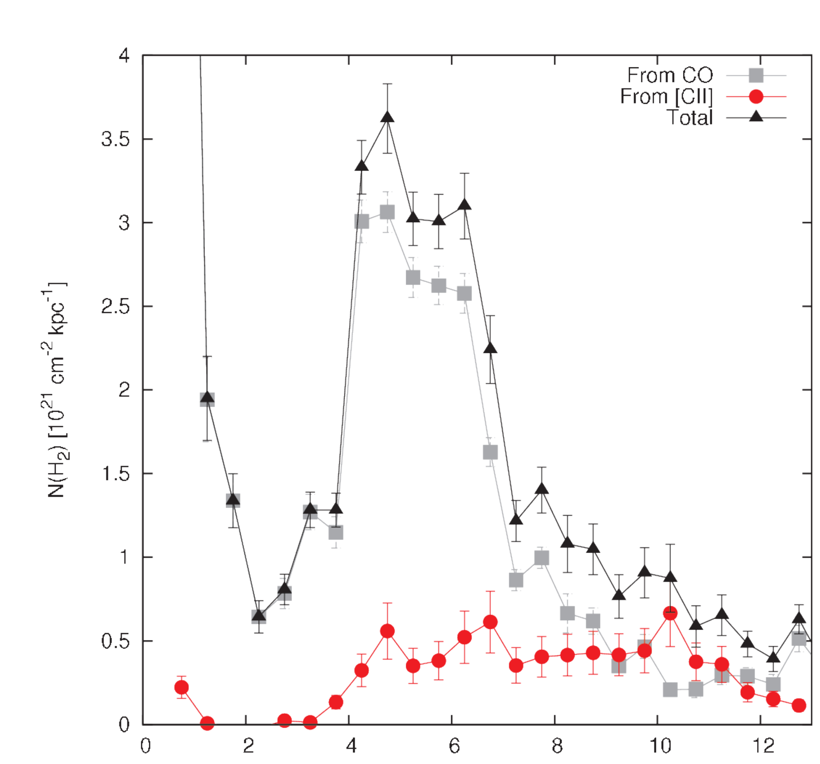
However, these ISM components have roughly comparable contributions to the Galactic [CII] luminosity: dense PDRs (30%), cold HI (25%), CO-dark H2 (25%), and ionized gas (20%). The difference between the percentages of the [CII] luminosity and that of the [CII] emissivity at b=0 are due to the different scale heights of the different ISM phases.

The Galactic Distribution of the CO-dark H_2 gas

Method:

We subtracted the HI, e-, and PDRs, contributions to the total [CII] intensity. We find a 30% excess of [CII] emission, which we attribute to CO-dark H_2 gas.

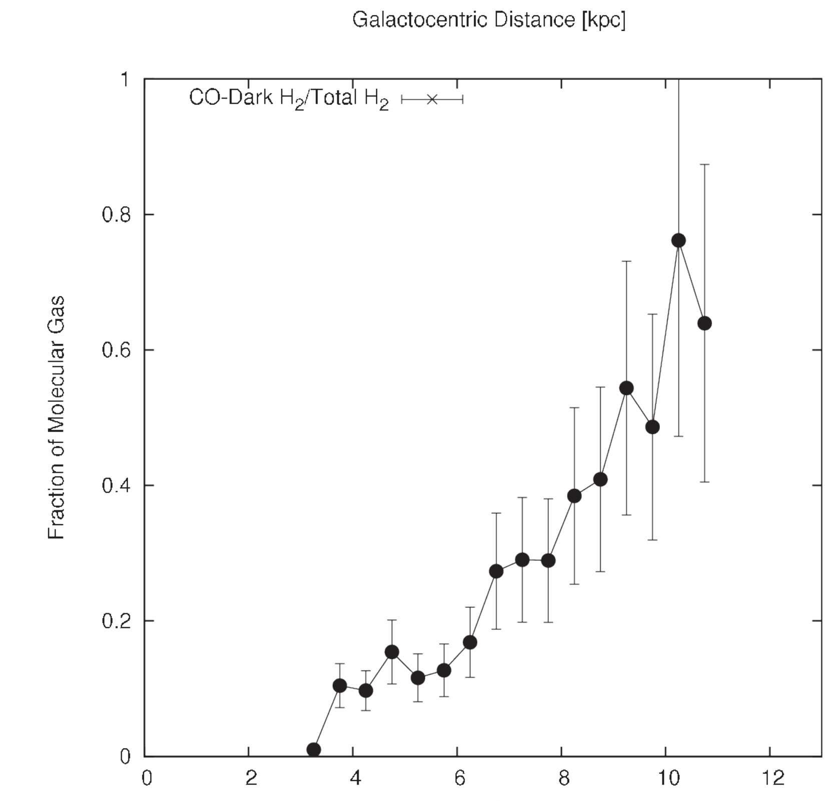
To calculate the column density distribution of the CO-dark H_2 gas from the excess [CII] intensity, we use the thermal pressure gradient from Wolfire et al. 2003 multiplied by a factor 1.5 and we consider the Galactic metallicity gradient.



Results:

The warm and diffuse CO–dark H_2 is distributed over a larger range of Galactocentric distances (4–11 kpc) than the cold and dense H_2 gas traced by ^{12}CO and ^{13}CO (4–8 kpc).

The fraction of CO-dark H_2 to total H_2 increases with Galactocentric distance, ranging from 20% at 4 kpc to 80% at 10 kpc.



On average, CO-dark H_2 accounts for 30% of the molecular mass in the Milky Way.

References

- Cordes, J. M. & Lazio, T. J. W. 2002, ArXiv Astrophysics e-prints
- Wolfire,M. G.,McKee, C. F., Hollenbach, D., & Tielens, A. G. G.M. 2003, ApJ, 587, 278

For details see:
Pineda, J.L. et al. 2013, A&A, 554 A103
Pineda, J.L. et al. 2014, A&A, Submitted

Acknowledgments: Herschel is an ESA space observatory with science instruments provided by European-led Principal Investigator consortia and with important participation from NASA. This work was performed by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and SpaceAdministration. JLP is a Caltech Postdoc at JPL supported by NASA funds.