Investigating star formation using far-infrared [C II] and [N II] emission line spectral maps from GUSTO

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Galactic / Extragalactic ULDB Spectroscopic Terahertz Observatory - GUSTO

- NASA Explorer Mission of Opportunity: 57-day stratospheric balloon flight at altitude of 37 km over Antarctica
- Mapped far infrared [C II] 158 μm and [N II] 205 μm fine structure emission lines in Milky Way and LMC to ~0.1 K rms in 4 km/s channels
- ~45" angular resolution and < 1 km/s velocity resolution

Survey Strategy

- 62 sq. deg survey of the Galactic Plane and targeted surveys of star-forming regions like NGC6334, NGC3603, RCW120, etc
- 2 sq. deg survey of the LMC (including 30 Doradus)

Science Goals

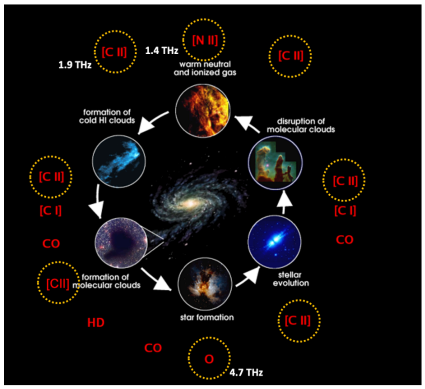
- Determine the constituents and life cycle of interstellar gas in the Milky Way
- Study the formation, destruction, and dynamics of star-forming clouds
- Investigate the interplay of star formation, stellar winds, and radiation in the Milky Way and LMC

Data Analysis Methods

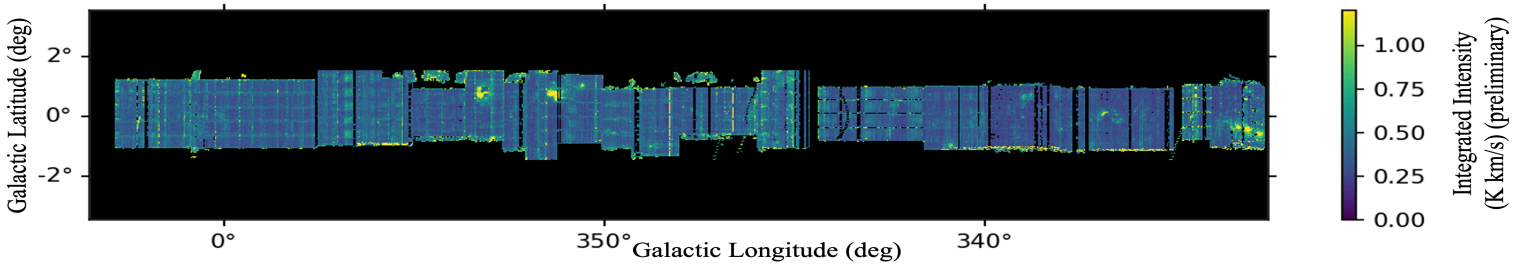
- PDR modelling: Derive density, FUV field strength, temperature, and pressure using intensity ratios from iterative models (like PDR Toolbox and Meudon PDR Code)
- Non-LTE radiative transfer modelling (RADEX): Constrain column densities using atomic and molecular data from LAMDA database.
- Kinematic analysis: Use position–velocity (PV) diagrams and channel maps to trace gas dynamics and decompose velocity components

[C II] and [N II] as tracers of ISM phases

- ISM phases: neutral atomic (HI), molecular (H_2), and diffuse ionized gas.
- Stellar feedback: UV radiation and stellar winds create H II regions and PDRs, disrupting surrounding molecular clouds.
- [C II] 158 μm (1.9 THz) and [N II] 205 μm (1.4 THz): fine structure transitions in ground electronic state
- [C II]: dominant ISM cooling line, emitted from H II regions, PDRs, diffuse ionized gas and atomic clouds
- [N II]: traces highly ionized gas primarily from H II regions and diffuse ionized medium

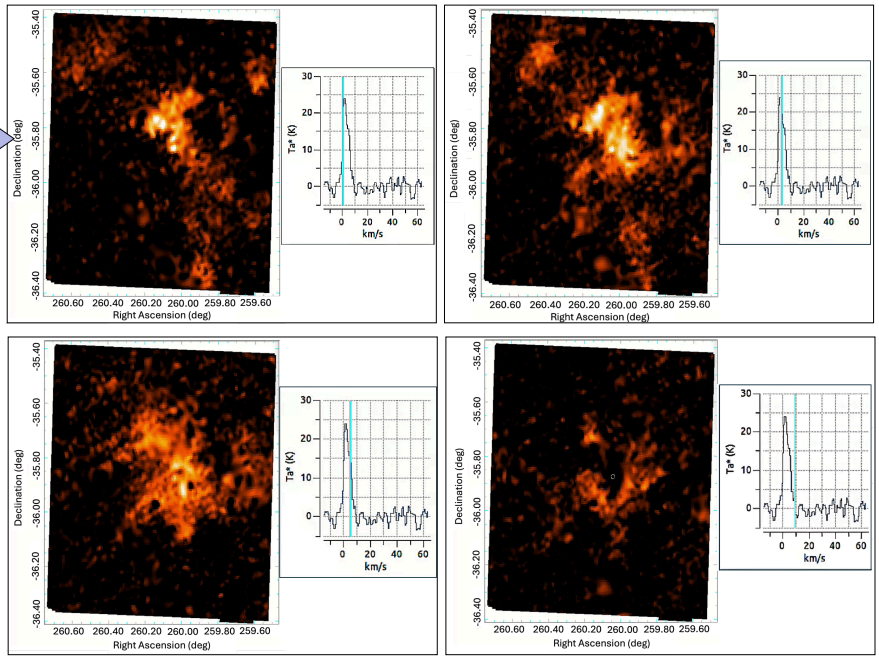


Galactic Plane Survey : Integrated Intensity of [C II] Emission



Targeted Survey of NGC6334

- . Giant emission nebula with multiple H II regions and PDRs powered by OB stars. Distance ~1.3 kpc.
- · [C II] channel maps at four different velocitites (v_{LSR}) as indicated by the blue vertical line on each spectrum to the right



Analysis Plan

- Analyze [C II] alongside 8 μm PAH and 70 μm dust emission: study global heating and radiation balance
- Identify feedback-driven structures (shells, bubbles, protrusions) : use Gaussian Mixture Models and Machine Learning to explore 3D structures
- Quantify radiative vs. mechanical feedback : analyse gas kinematics with PV diagrams and Channel Maps
- Use PDR models to constrain gas density and radiation field
- Fit CO, HI, [C II], and [N II] with RADEX (using LAMDA) to estimate masses of different ISM phases
- Compare star forming regions in Milky Way and LMC (N158 – N160, N11)