

Tracing cold gas with the largest bound atoms in space

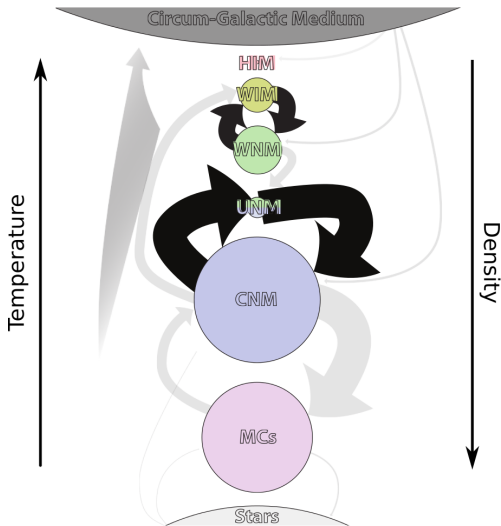
Pedro Salas



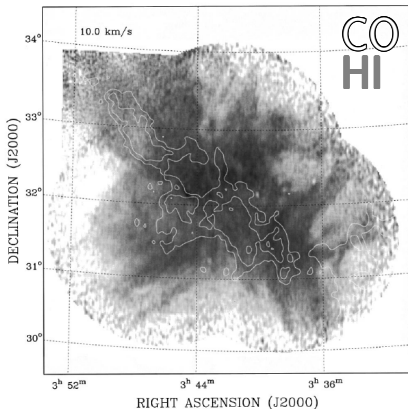
K. Emig, L. Morabito, F. Salgado, C. Toribio, R. van Weeren,
J. B. R. Oonk, H. Röttgering, X. Tielens

The Local Truth - Asilomar, 18th October 2016

Cold clouds and interstellar recycling



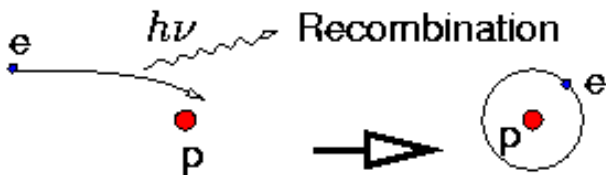
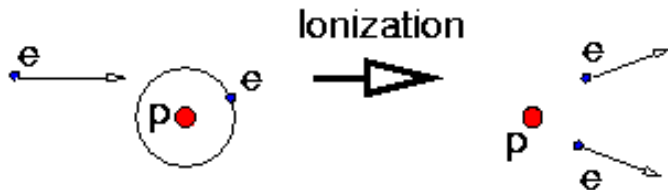
Galactic Science with the SKA & Its Pathfinders, 2014

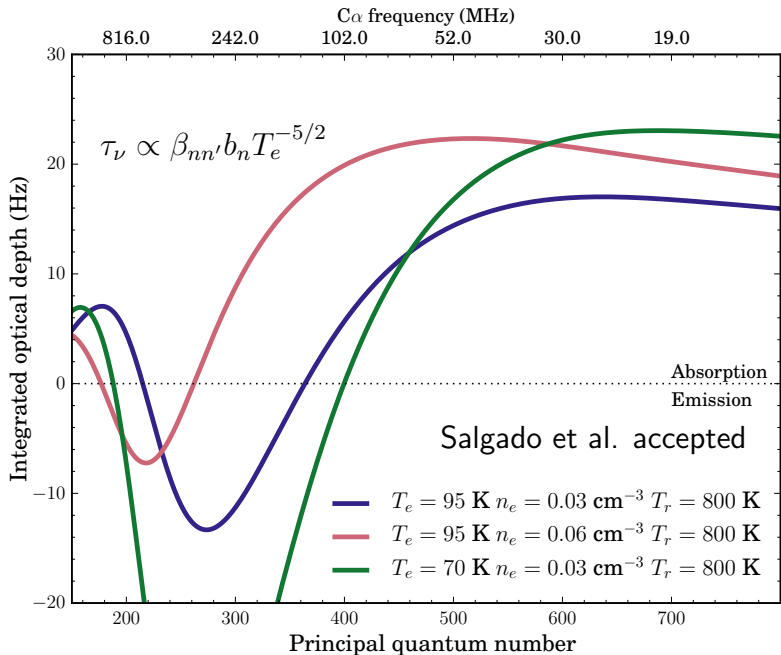


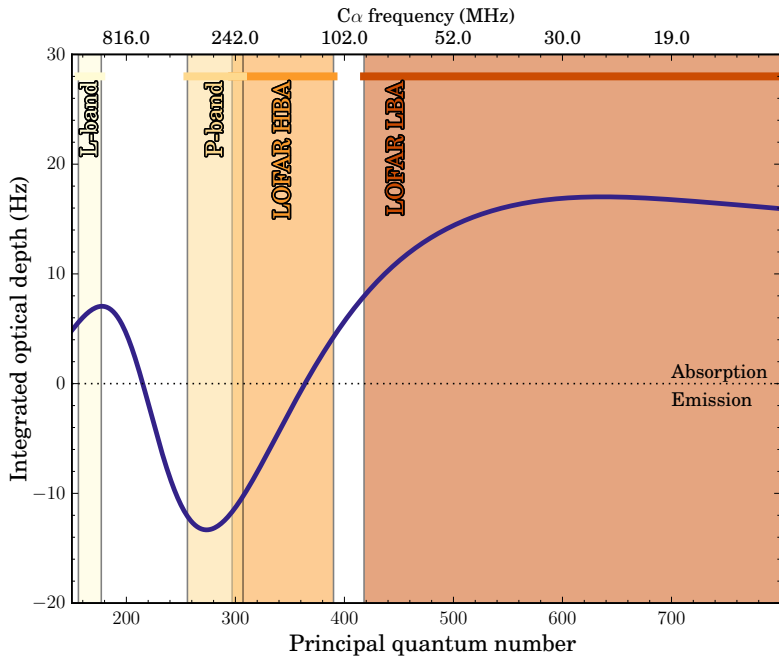
Moriarty-Schieven

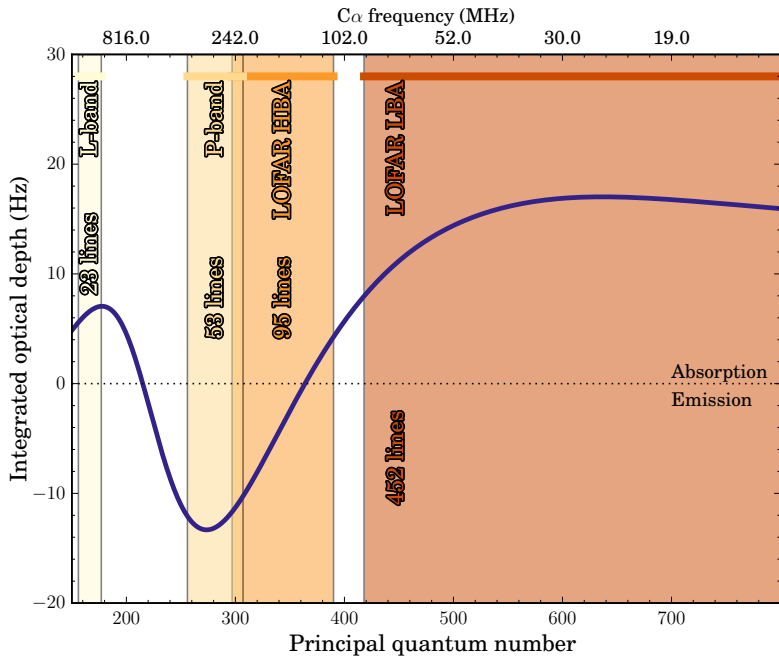
Carbon Radio Recombination Lines

2 flavors: discrete (HII regions) and diffuse.
Ionization potential of carbon 11.2 eV.

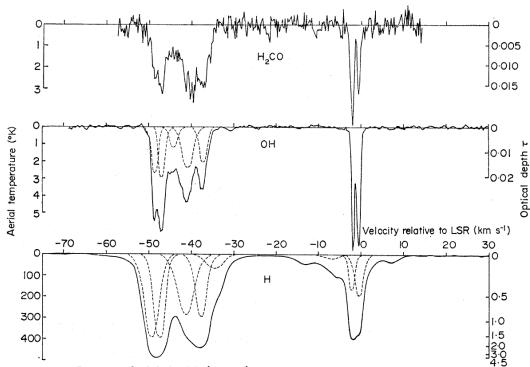
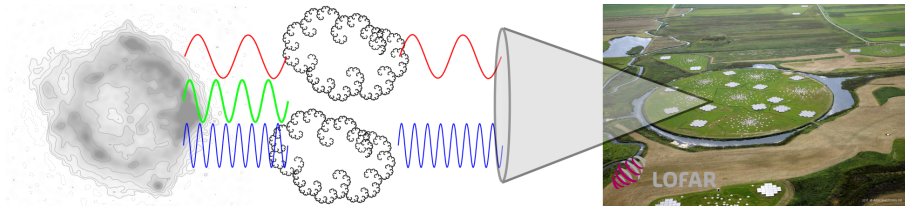






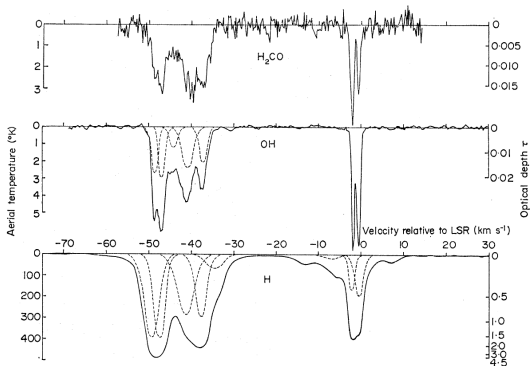
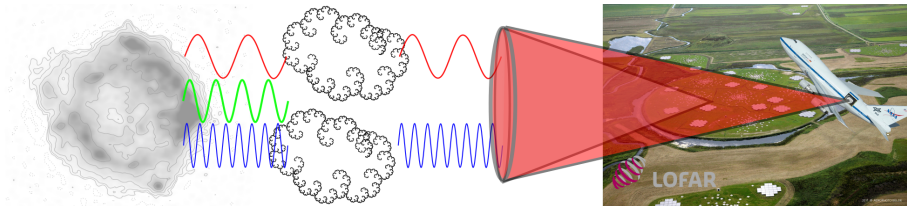


The line of sight towards Cassiopeia A

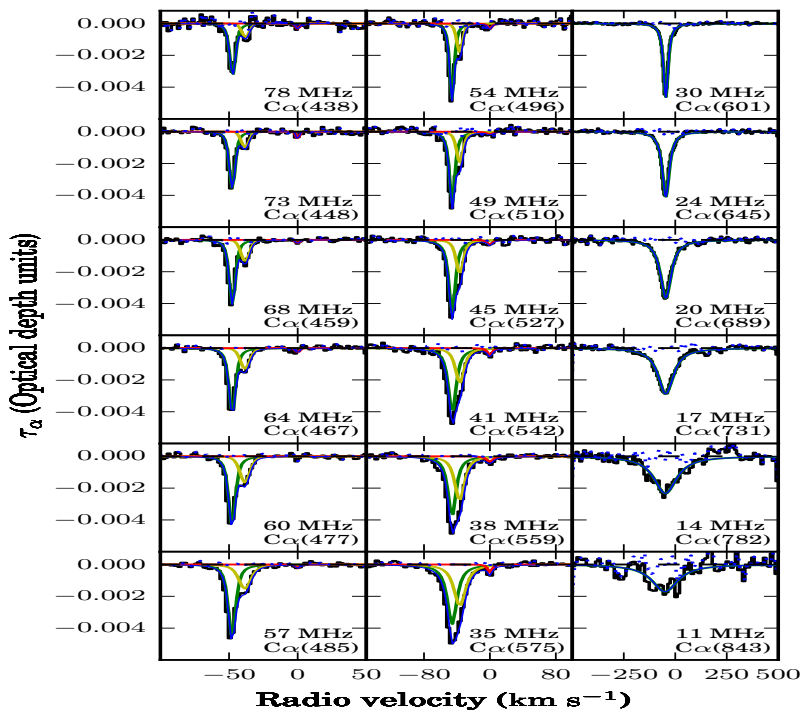


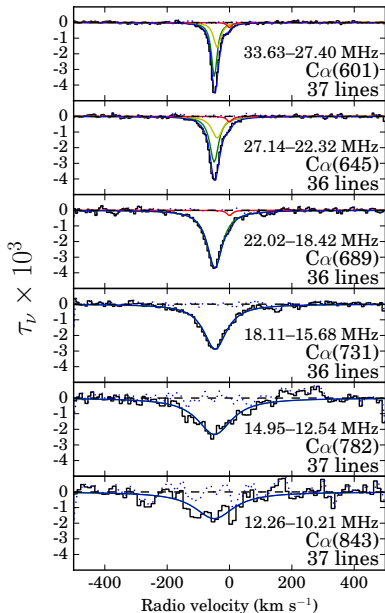
Davies & Mebold (1972)

The line of sight towards Cassiopeia A



Davies & Mebold (1972)

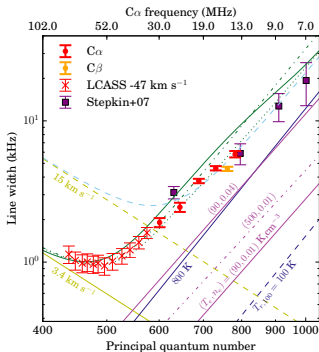




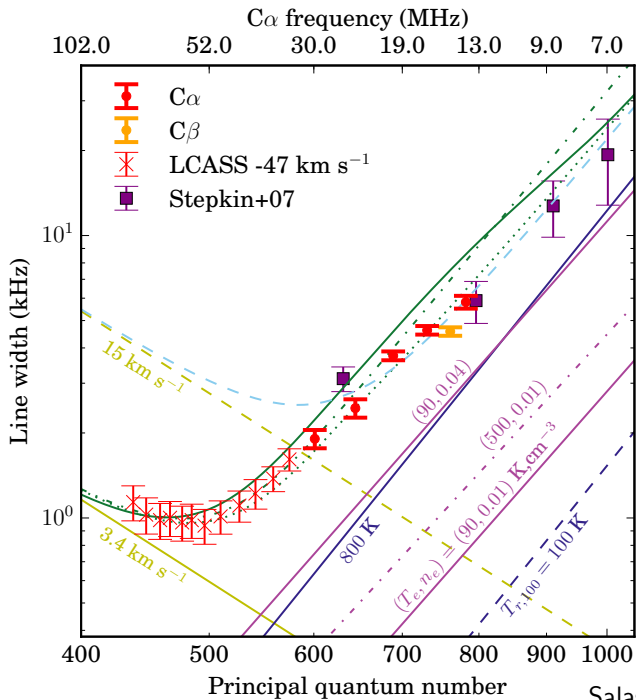
The lines get broadened by collisions with electrons and the presence of a radiation field.

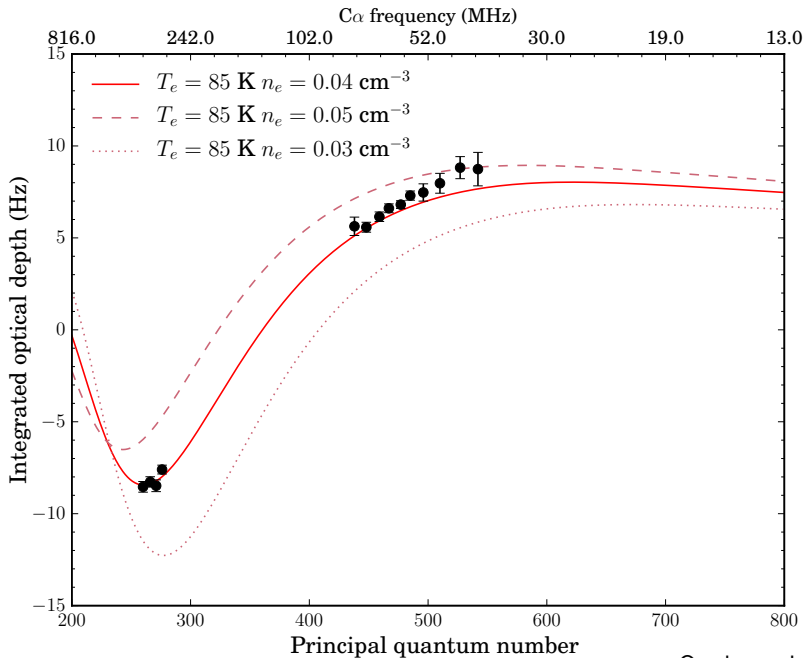
$$\Delta v \propto T_{rad} n^{5.8} + n_e T_e n^{\gamma_c},$$

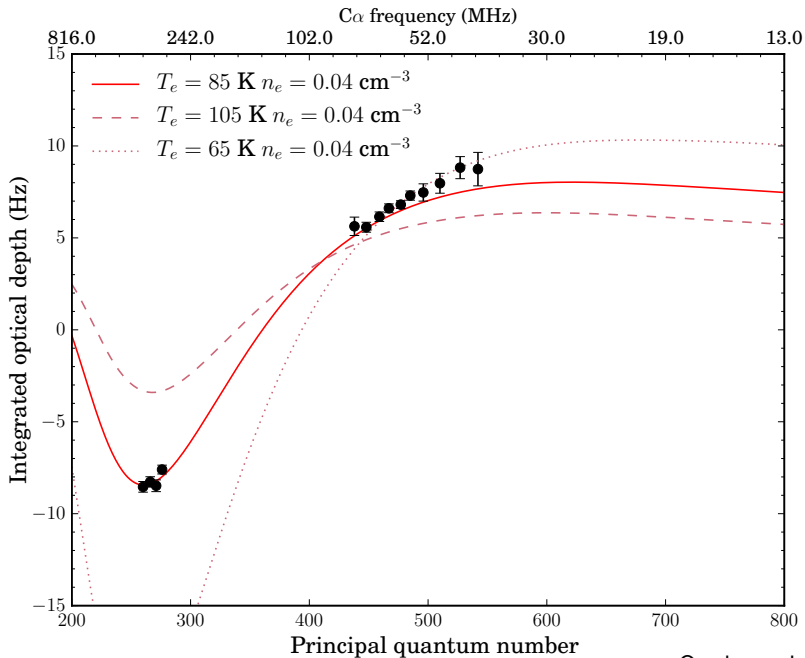
$$4.28 \leq \gamma_c \leq 5.48$$



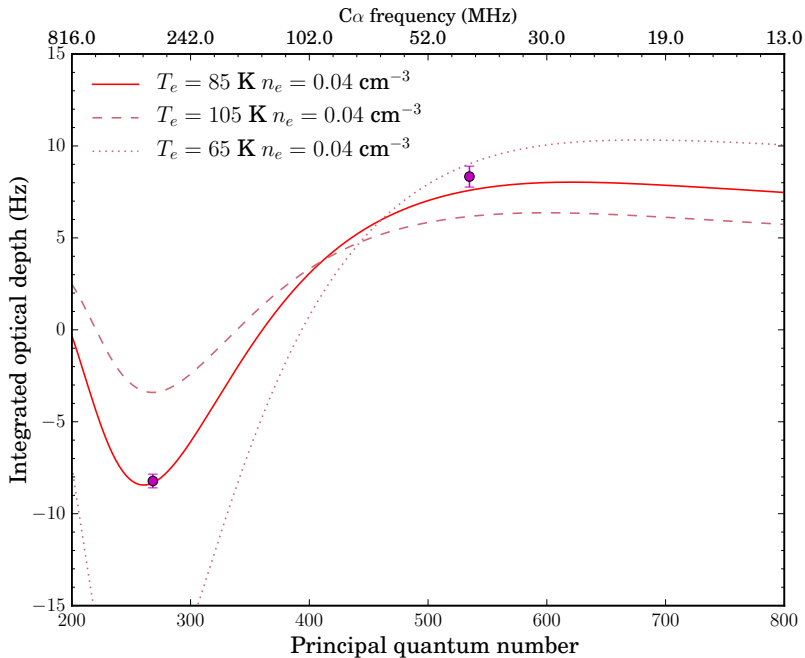
Salas et al. subm.

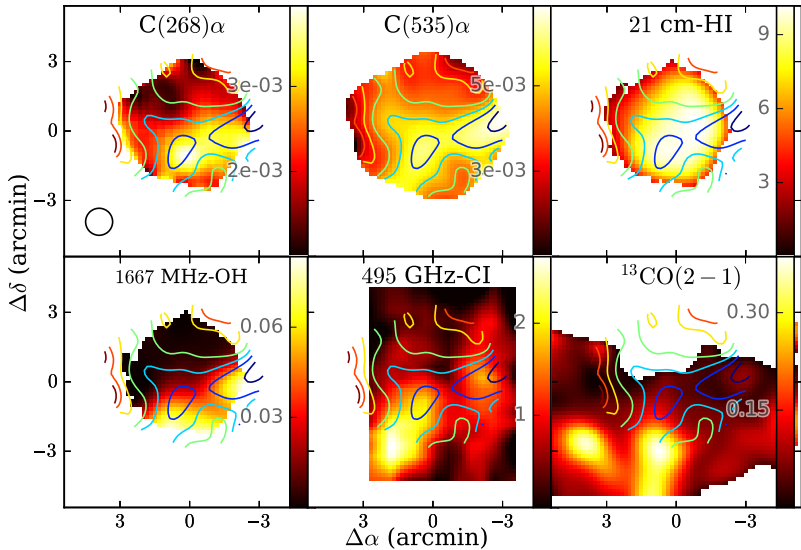


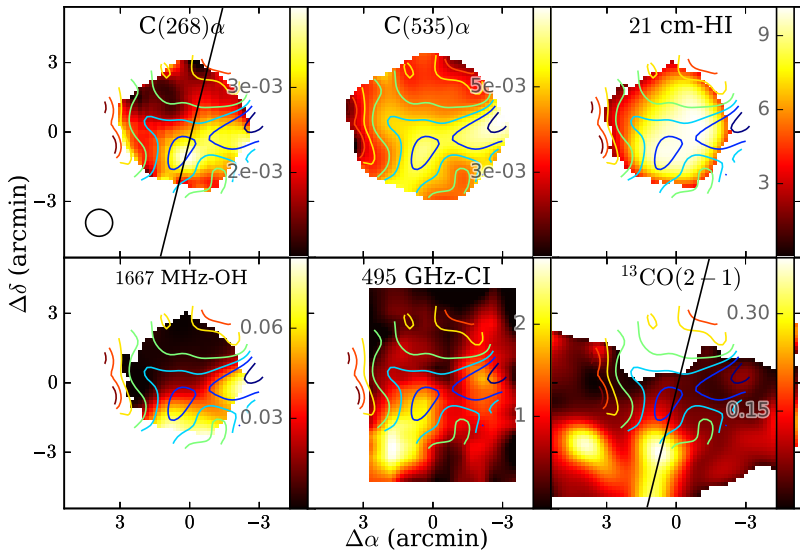


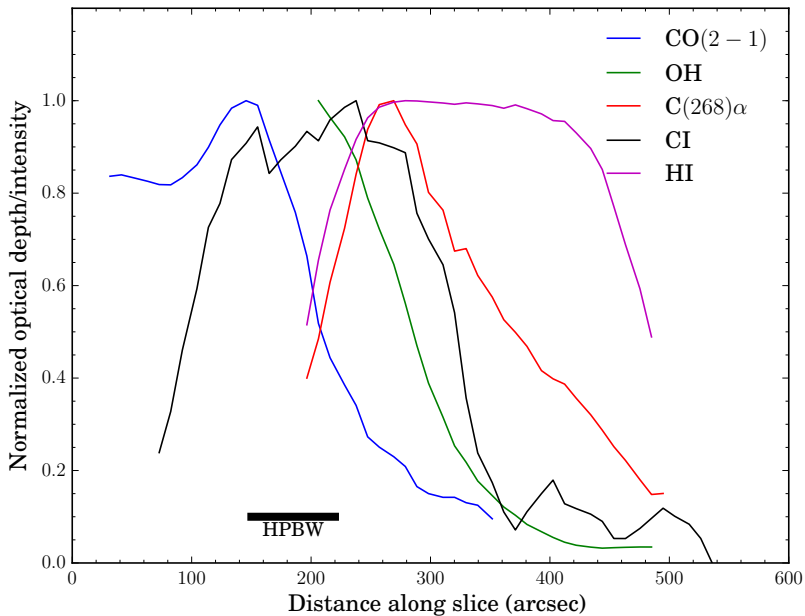


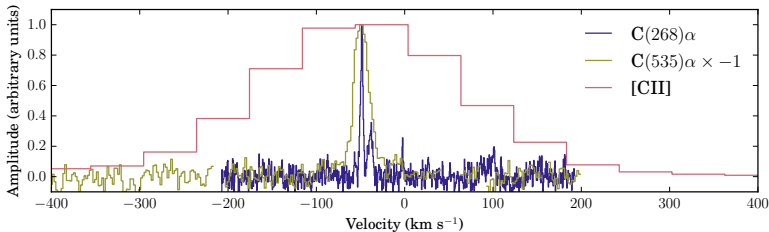
Parameter	unit	-47 km s ⁻¹	-38 km s ⁻¹
T _{R,100}	[K]	1400 (1351 ± 83)	1600 (1507 ± 128)
T _e	[K]	85 ± 5	85 ± 10
n _e	[cm ⁻³]	0.040 ± 0.005	0.040 ± 0.005
L _{CII}	[pc]	35.3 ± 1.2	18.6 ± 1.6
EM _{CII}	[cm ⁻⁶ pc]	0.056 ± 0.014	0.030 ± 0.008
N _{CII}	[cm ⁻²]	(4.4 ± 0.6) × 10 ¹⁸	(2.3 ± 0.3) × 10 ¹⁸
N _H	[cm ⁻²]	(3.1 ± 0.4) × 10 ²²	(1.6 ± 0.2) × 10 ²²
n _H	[cm ⁻³]	286 ± 36	286 ± 36
P _{thermal} /k	[K cm ⁻³]	(2.4 ± 0.5) × 10 ⁴	(2.4 ± 0.5) × 10 ⁴
P _{turbulent} /k	[K cm ⁻³]	(1.9 ± 0.1) × 10 ⁵	(7.6 ± 1.0) × 10 ⁵
P _{magnetic} /k	[K cm ⁻³]	(1.8-4.5) × 10 ⁴	—
ζ _H	[s ⁻¹]	(0.3 ± 0.05) × 10 ⁻¹⁷	—





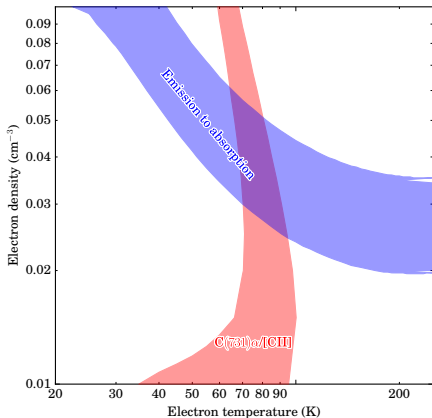


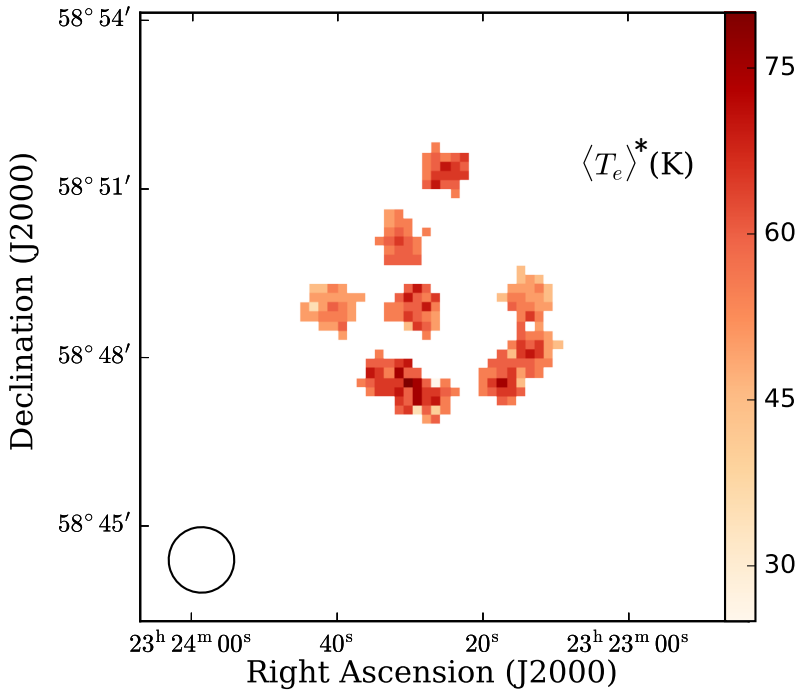


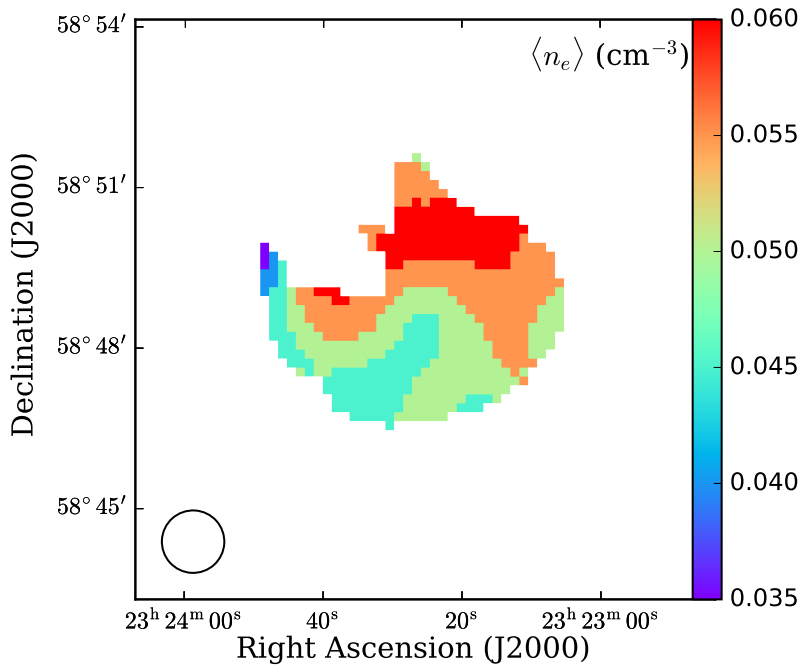


$\text{C}(n)\alpha/[\text{CII}]$ is a powerful thermostat for $n \gtrsim 450$.

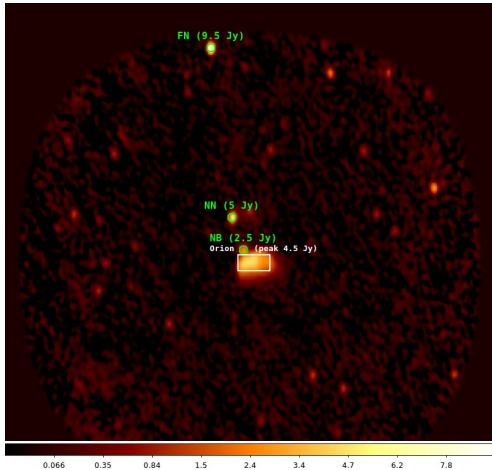
Ratio between lines in emission and absorption constrains n_e for a given temperature.



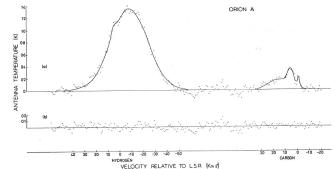
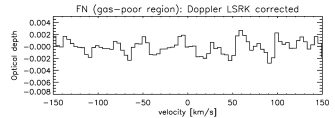
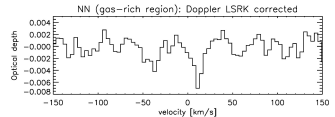
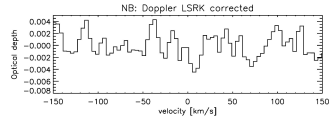
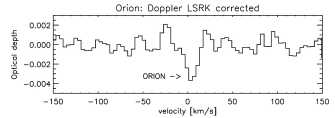




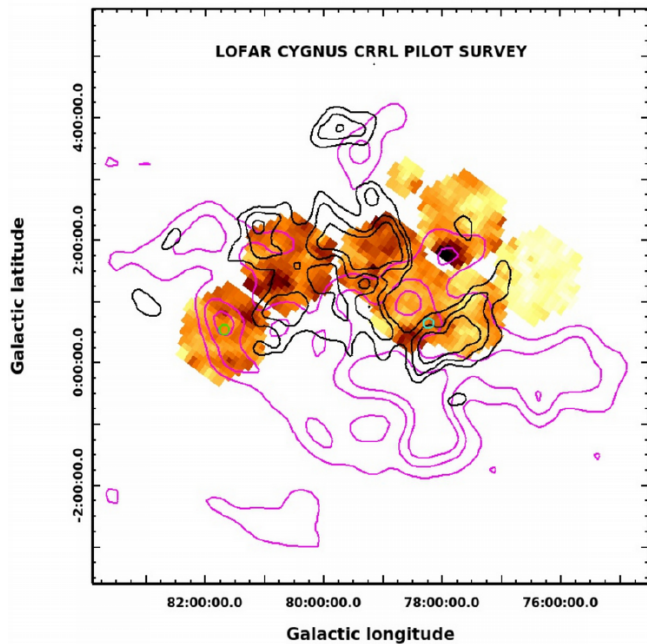
Orion



In combination with: GBT L-band, SOFIA [CII], CO(2-1) and more.



CRRL survey



Summary

- Low frequency CRRLs are a powerful probe of the ISM physical conditions.
- The combination of SOFIA and CRRLs will enable us to study the gas heating and cooling.
- LOFAR surveys of CRRLs:
 - ▶ Medium resolution survey: probing the $\gtrsim 10'$ scales.
 - ▶ Pinhole survey: probing scales $\lesssim 10'$.
 - ▶ Extragalactic survey: unlocking the CRRL universe. (Morabito, Emig, Toribio)



Stay tuned!

