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The effect of low-metallicity on the FIR ionized gas tracers [OIII] and [NIII]

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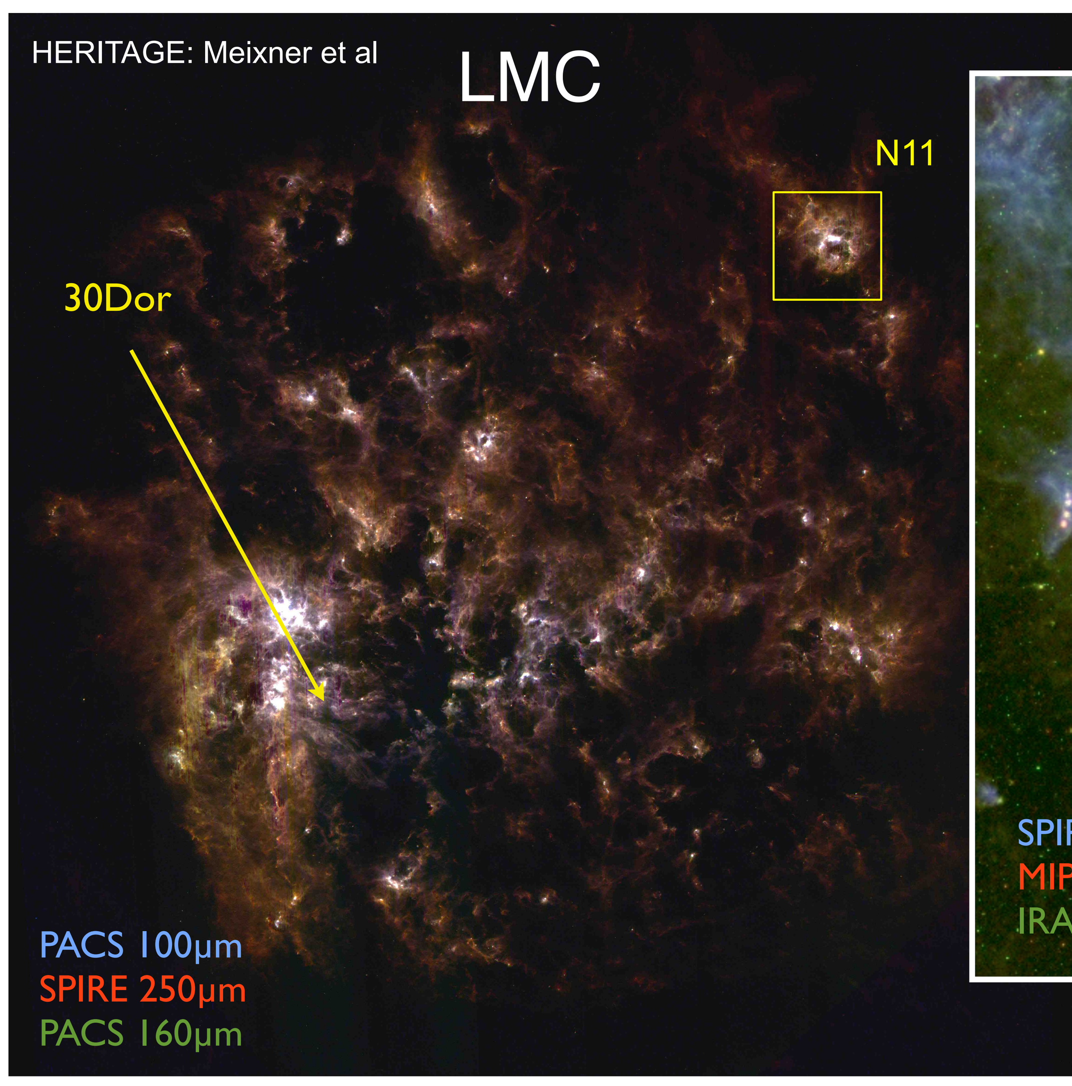
We present the Herschel spectroscopic study of the N11B HII region in the LMC. Spectral lines tracing the photodissociation regions and the ionized gas are observed with the PACS instrument. We present here the first part of our investigation that focuses on the ionized gas properties.

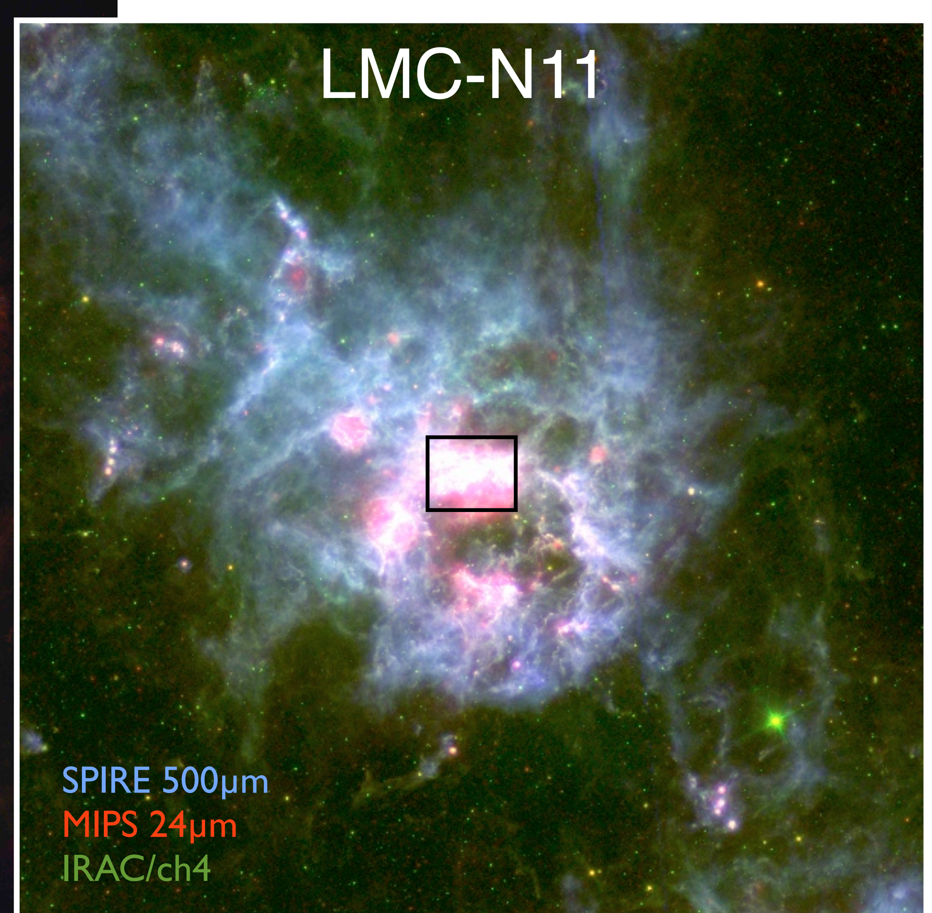
Low-metallicity environments are expected to show a large filling factor of the ionized gas, the FUV photons being able to travel deeper in molecular clouds because of the lower dust abundance. The FIR lines tracing the ionized gas ([OIII] 88μm and [NIII] 57μm) provide a great opportunity to quantify the total amount of ionized gas not obscured by dust. They also enable density diagnostics as well as quantifying the extinction of optical lines.

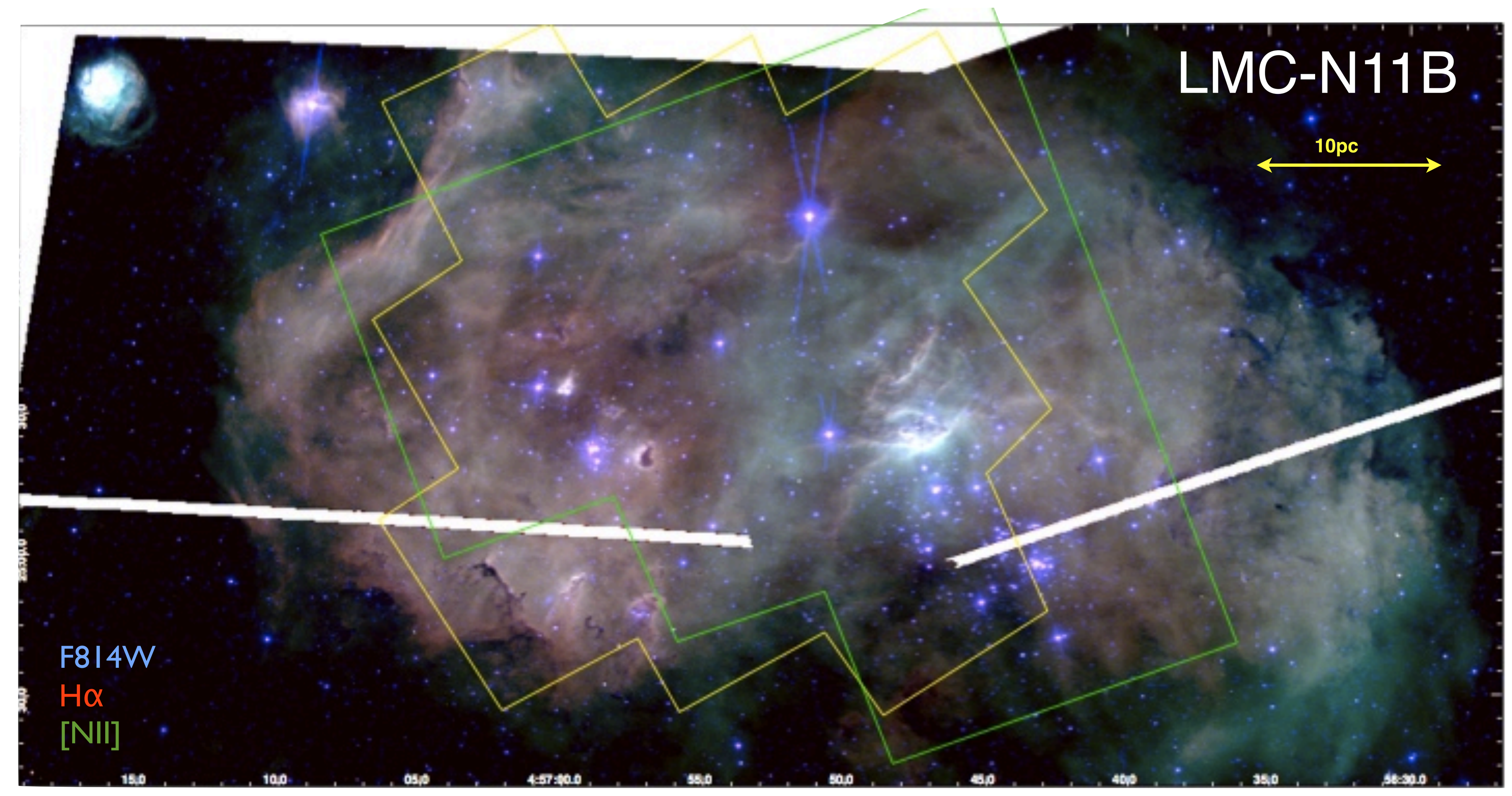
About N11B

N11B is part of the N11 complex, which is a starburst shell reaching 120pc in diameter around the stellar cluster LH9. N11B is a secondary peripheral star-forming region and the brightest in N11. A third stellar generation is being formed which is triggered by the local stellar association LH10.

This region is thus a case of sequential star-formation in low-metallicity environment (~half-solar). Several photodissociation regions (PDRs) are observed on the west that are influenced by the southern cluster of LH10. On the east side, a smaller cluster impacts several surrounding dense regions. Massive stars as early as O3 III were identified throughout the N11B nebula.







Observations

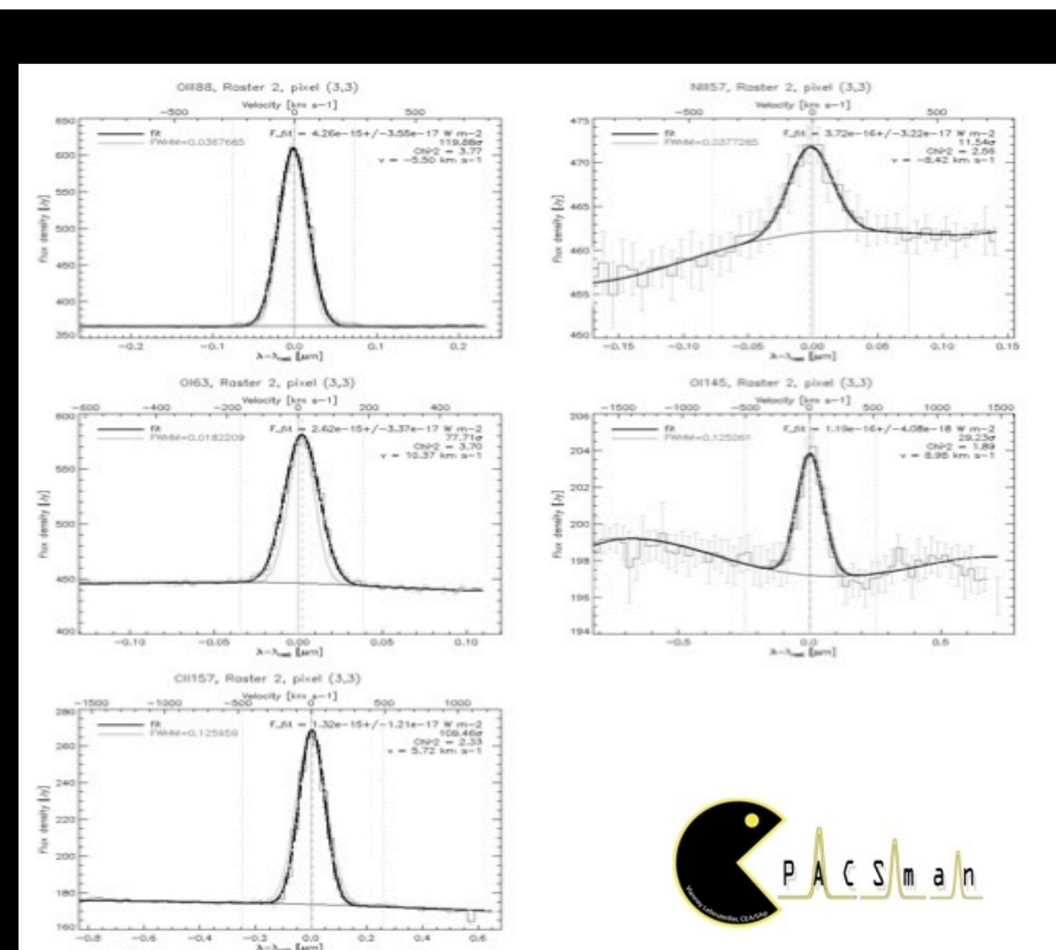
- Herschel/PACS spectroscopic map, 3x3 rasters in wavelength switching mode
- Each footprint: 47"x47" with 9.4" spaxel size
- Map coverage : ~2'x2' (yellow polygon)
- 3" = 0.7pc

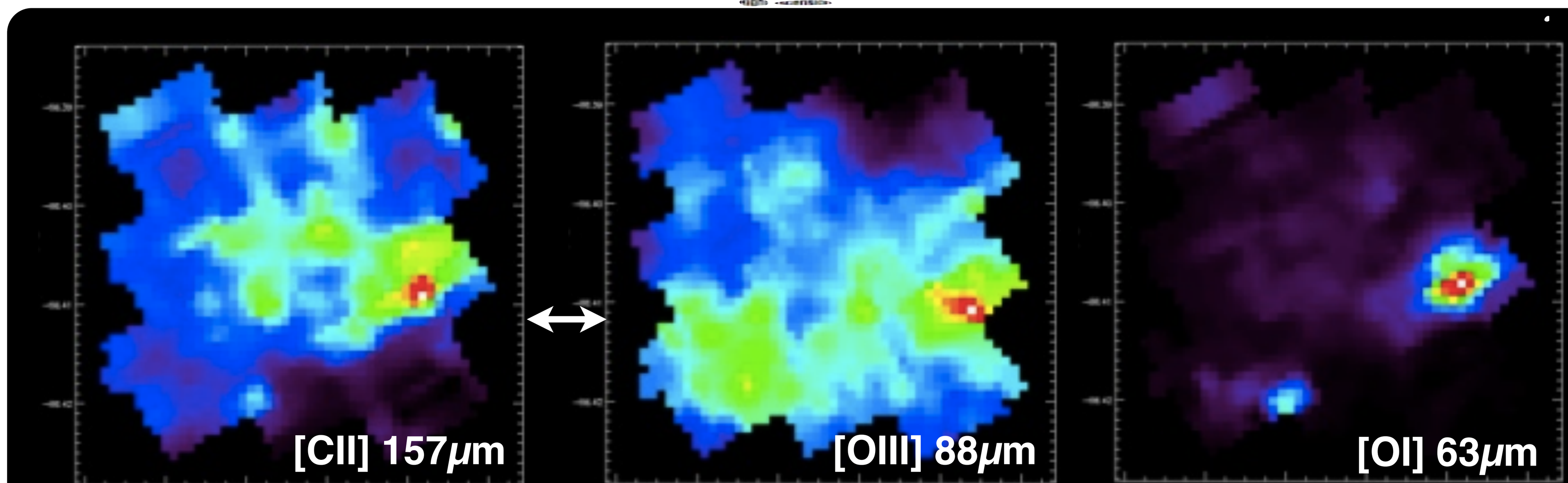
Lines

- PDR tracers: [CII] 157μm, [OI] 63μm, 145μm
- Ionized gas tracers: [OIII] 88μm, [NIII] 57μm
- and [NII] 122μm, 205μm

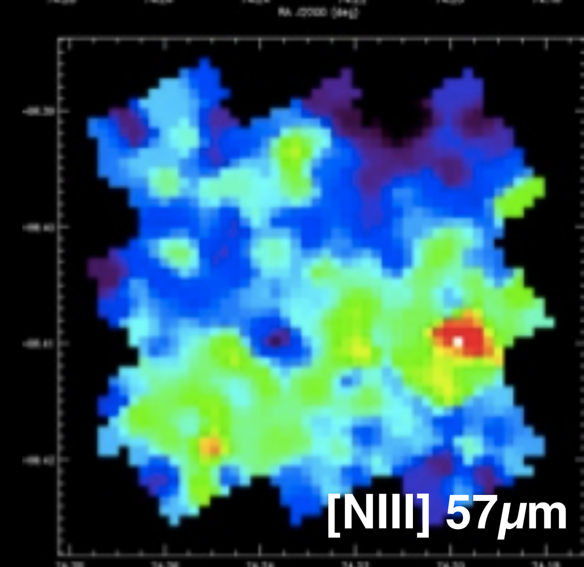
Data analysis

Analysis performed with the PACSman tool, including:
- constrained line fitting
- map projection on a sub-pixel grid (3" pixels)
- aperture photometry on individual regions





- All lines are the brightest toward the main PDRs on the west side
- [OI] shows very little diffuse emission
- [CII] shows some level of diffuse emission as well as several compact clumps
- [OIII] is widespread, varying by only a factor 7 across the map



Quick facts

- [OIII] is brighter than [CII] ! Large filling factor due to the overall low-density of the medium and maybe by clumpy PDRs
- [CII] and [OIII] show complementary spatial distributions

Analysis of the ionized gas distribution

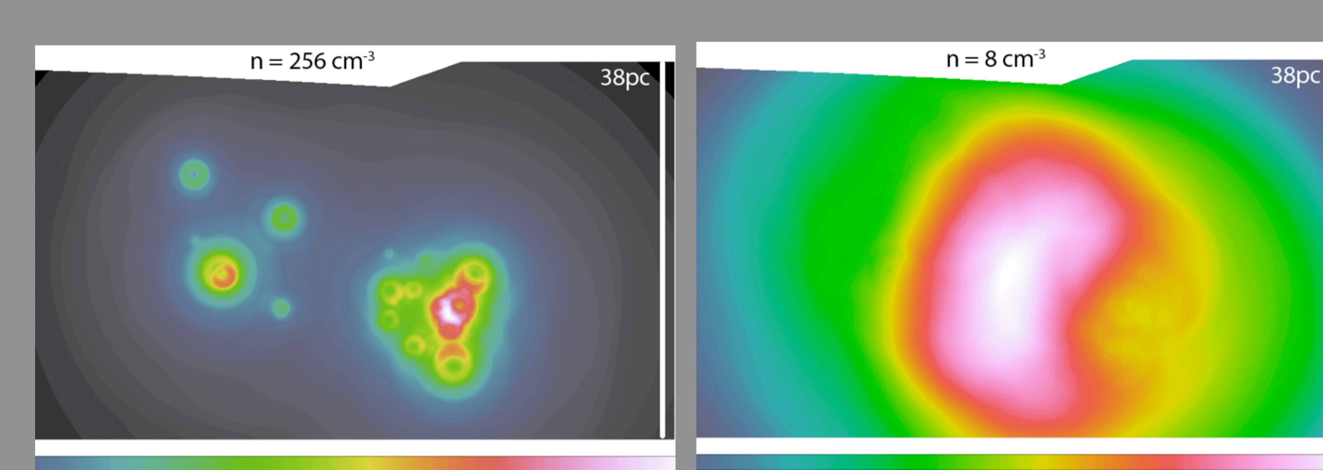
The FIR lines [OIII] and [NIII] are excellent tracer of the ionized gas, not being affected by dust extinction. They also allow constraining the gas density and temperature as well as dust extinction when compared to the optical lines.

Line	IP	n_{crit}
[NIII] 57μm	29.6eV	3000cm^{-3}
[OIII] 88μm	35.1eV	500cm^{-3}
[OIII] 5007A	35.1eV	8.6e4cm^{-3}

We computed CLOUDY models for solar metallicity (dotted lines) and half-solar metallicity (solid lines).
The ratios we investigated are [NIII]/[OIII] and [OIII] 88μm/5007A

Other results

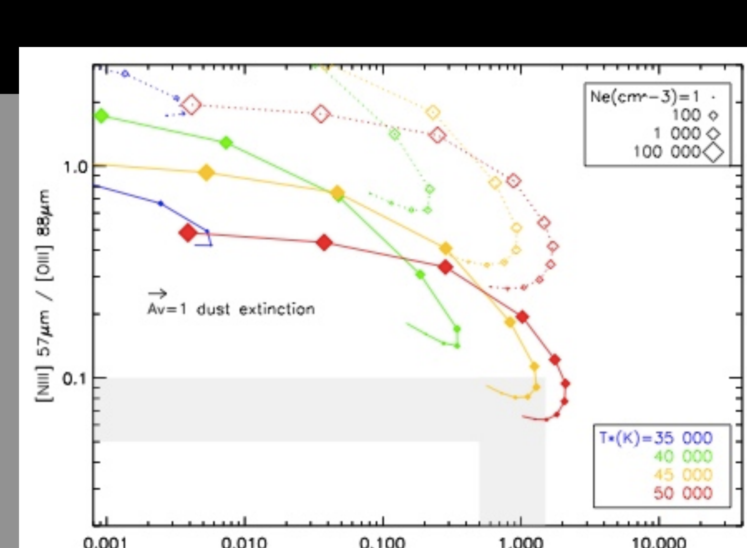
- The extent of [OIII] 88μm is consistent with a low-density medium about 10-20cm^{-3}. This implies some level of clumpiness in the ionized gas itself but also in the PDRs which allow FUV photons to permeate throughout the region.
- We were able to reproduce the observed [OIII] 88μm flux with low-density models, implying that most of the 88μm emission originates in low-density ionized gas.



The [NIII]/[OIII] ratio:

- sensitive to the low-density regime (<3000cm^{-3})
- strong function of the stellar temperature T*
- not affected by dust extinction

Our results (gray zones) are consistent with the observed N/O abundance ratio, a low-density medium (<200cm^{-3}) and high excitation (T*>45000K)



The [OIII] FIR/optical ratio:

- depends on the gas density and on metallicity
- informs us on the dust extinction
- [OIII] 5007 / Hα depends on T*

Our results (gray zones) are not consistent with an unobscured gas, a moderate extinction of A_V=1 is required. Consequence: 50% of the ionized gas is hidden in the optical!