Modeling the multi-phase ISM shaped by star formation and feedback in the Large Magellanic Cloud

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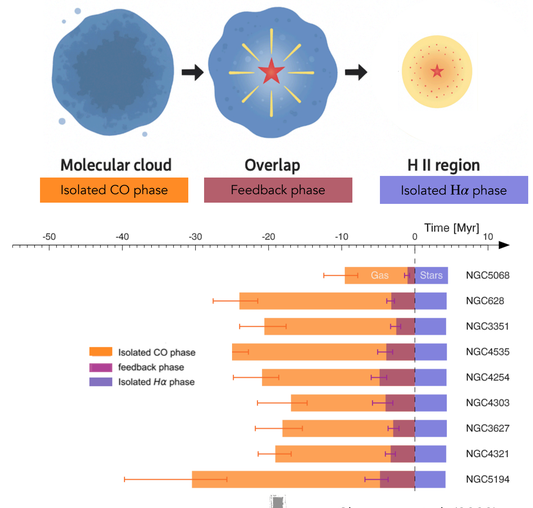
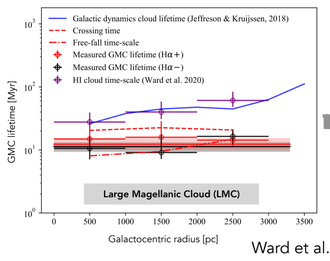
1. Introduction

The evolutionary path of giant molecular clouds (GMCs).



Chevance et al. (2020)

GMC lifetime varies across galaxies!

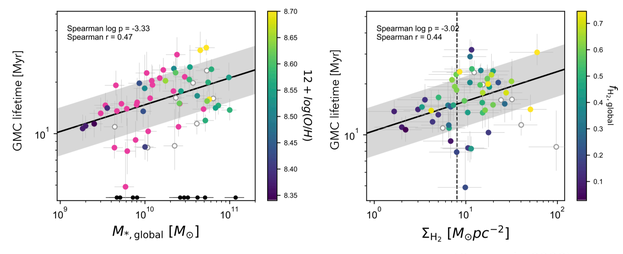


Ward et al. (2022)

GMC lifetime also varies *within* galaxies (see e.g., Kruijssen et al. 2019, Chevance et al. 2020)**!**

What governs the GMC lifetime?

Global environmental properties vs. the GMC lifetime

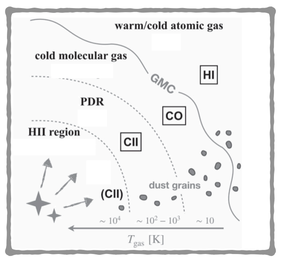


Kim et al. (2022)

Global galactic properties have been found to correlate with the duration of the GMC lifetime (see e.g. Kim et al. 2022 and figure above).

What is the role of the local environmental properties on the GMC evolution?

Multi-phase interstellar medium (ISM)!



Sun et al. (2019)

2. Method

SCAN ME

MULTIGRIS (Lebouteiller & Ramambason 2022), a multi-component probabilistic grid search

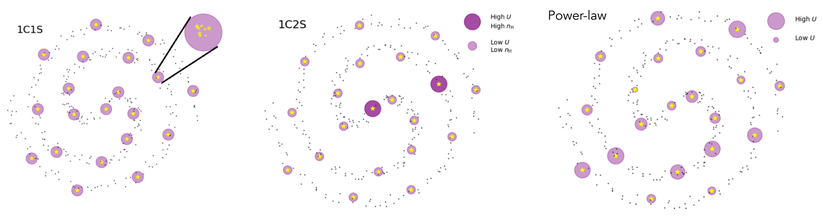
- Goal: Constrain the properties of the multi-phase ISM
- How: Fit the emission-line observations using linear combinations of precomputed 1D Cloudy models from the SFGX grid. (Ferland et al. 2017, Ramambason et al. 2022).
- Results: Probability density functions of ISM properties for multiple ISM components

Input

- Emission line fluxes and errors
- Configuration (see figure below):
  - 1 star cluster with 1 ISM component (1C1S)
  - 1 star cluster with 2 ISM components (1C2S)
  - power-law distribution of one or several parameters

Output

- Posterior probability density distributions of
  - primary parameters: density (n), ionization parameters (U), depth into the cloud (cut)…
  - secondary parameters: mass, escape fractions of ionizing photons…



Lebouteiller et al. (2025)

1C1S

$\{n_1, U_1, cut_1, \dots\}$

1C2S

$\left\{ \begin{matrix} n_1, U_1, cut_1, \dots \\ n_2, U_2, cut_2, \dots \end{matrix} \right\}$

Power-law model

(see also Ramambason et al. 2024)

$\phi_n \propto n^{\alpha_n}; \quad [n_{\min}, n_{\max}]$
$\phi_U \propto U^{\alpha_U}; \quad [U_{\min}, U_{\max}]$

$\phi_{\text{cut}} \propto \text{cut}^{\alpha_{\text{cut},1}}; \quad [\text{cut}_{\min}, \text{cut}_{\text{IF}}]$
$\phi_{\text{cut}} \propto \text{cut}^{\alpha_{\text{cut},2}}; \quad [\text{cut}_{\text{IF}}, \text{cut}_{\max}]$

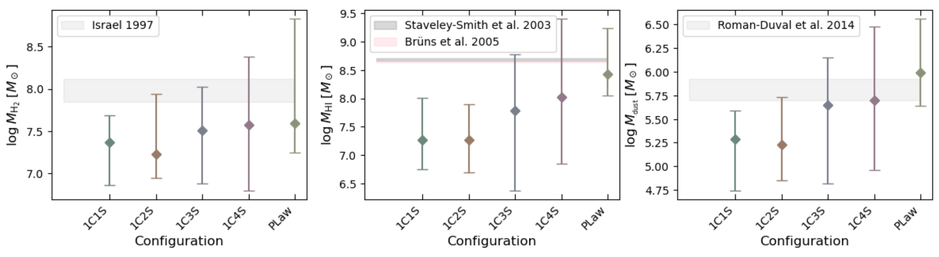
3. Model selection

A. Metrics comparison

	1C1S	1C2S	1C3S	1C4S	Power-law
Log Marginal likelihood	-44.8	-43.7	-45.8	-46.9	-47.2
Percentage of posterior draws within 3σ	79.43%	79.50%	74.94%	75.72%	80.63%
The fraction of well fitted lines (2.5<*ppp*<97.5)	0.91	0.91	0.91	0.82	0.82

All the potential models perform well across different statistical metrics!

B. Comparison with literature data

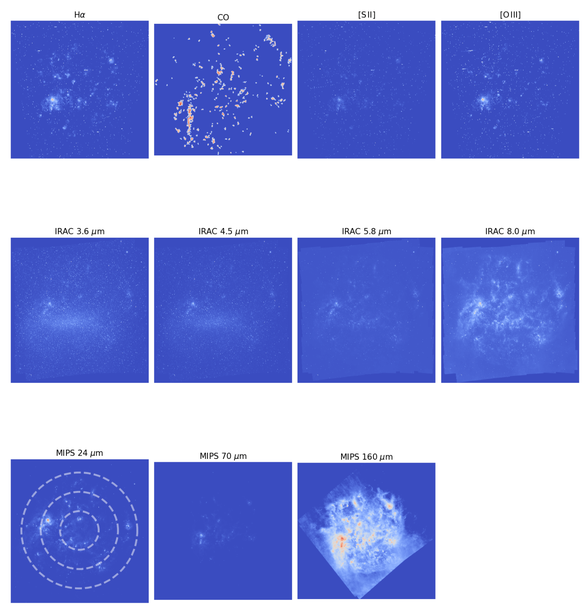


Power-law model is chosen!

4. Observational data

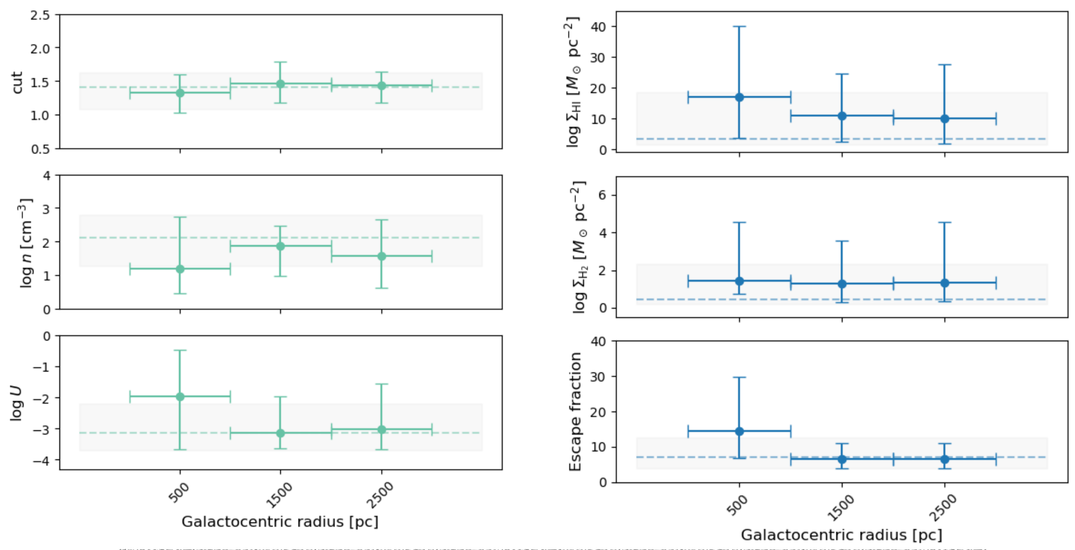
LMC

- **Molecular gas : CO(1-0)** (From MAGMA, Wong et al. 2011)
- **HII region: $\mathrm{H}\alpha$, [SII], [OIII]** (From MCELS, Smith & MCELS Team 1998)
- **Dust: 3.6μm; 4.5μm; 5.8μm; 8μm; 24μm;70μm; 160μm** (From SAGE, Meixner et al. 2006)



5. Results

We use the above multi-wavelength observations of the LMC to constrain the physical properties of the ISM, assuming a power-law configuration with MULTIGRIS, in three galactocentric radial bins. The figure below illustrates the radial profiles of the chosen model parameters (left) and constrained ISM properties (right).



Other ISM properties, such as the surface density of dust and HII, remain to be explored!

6. Conclusions and future work

- For the average model parameters and ISM properties, we *do not find a significant dependence on galactocentric radius*; however, their dispersions still need to be explored.
- By analyzing the radial profiles of the constrained ISM properties, we found that *there are more density-bounded regions in the inner part of the LMC*, as the escape fraction increases toward the center.
- We compare the radial profiles before and after *masking 30 Doradus* and found *no significant differences* between them.

Next steps:

- Compare the radial distribution of the constrained parameters and their dispersion with the GMC evolution timeline (from Ward et al. 2022).
- Filter the diffuse emission.
- Include more multi-wavelength observations from APEX (CO(3-2)) and the Local Volume Mapper (LVM: $\mathrm{H}\alpha$, [OII], [OI], [NII]…).

7. References

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