Impact of the dust properties on the photoelectric heating efficiency of the gas, using Spitzer, Herschel and SOFIA observations of the LMC

L. Belloir[1], F. Galliano[1] , S. Madden[1] , V. Lebouteiller[1], and the LMC+ collaboration

[1] Université Paris-Saclay, Université de Paris, CEA, CNRS, AIM Paris-Saclay, 91191 Gif-sur-Yvette, France

The Large Magellanic Cloud (LMC) provides a unique laboratory to understand the interaction between the interstellar medium (ISM) and massive star formation, in a galaxy with a low metallicity. The LMC's proximity to our Galaxy permits observation of its dusty and gaseous infrared emission at a parsec-scale resolution, thereby enabling study of interstellar properties at the scale of a molecular cloud. The SOFIA Legacy Program (LMC+; supported by PCMI) [1] has observed the [CII] λ 158 µm and [OIII] λ88 µm lines in the southern molecular ridge at a resolution of 2.5 pc. These new observations provide access to the dominant cooling lines in the neutral and ionised ISM, enabling investigation of the major heating and cooling mechanisms in the three massive star-forming regions, N158, N159 and N160. In neutral regions, the main mechanism responsible for the gas heating is the photoelectric effect. This process consists in the ejection of an electron from a dust grain after the absorption of a UV photon.

The objective of this work is to combine data acquired by the SAGE [2] survey with Spitzer (3.6 to 70 microns), the HERITAGE [3] survey with Herschel (100 to 250 microns), and new data from SOFIA, with the aim of creating maps of dust properties and constraining the efficiency of the photoelectric heating of the gas in this region. To that end, we have homogenized our multi-wavelength maps to an optimal, common resolution and pixel grid. We took particular care in the estimate of the non-Gaussianity of our uncertainties and their correlations. The spatially-resolved spectral energy distribution of each pixel was then fitted with the hierarchical Bayesian code, HerBIE [4], using the THEMIS dust model [5,6]. Two original aspects are presented in our work. The first one is that the modeling we perform allows us to compare the efficiency of the photoelectric heating to the actual mass of its carriers, and not only to their luminosity. The second one, is that, using ancillary data, we provide a phase decomposition of the [CII] luminosity. Doing so, the efficiency we estimate is less biased by the [CII] linked to other heating mechanism. Our results confirm that the photoelectric heating is dominated by the smallest grains. In addition, the overall efficiency of the heating appears reduced, because of the lower abundance of these grains, relative to the gas, in the LMC.

References

[1] Fischer et al, A&A, 702 (2025)
[2] Meixner et al, ApJ, 132 (2006)
[3] Meixner et al, ApJ, 146 (2013)
[4] Galliano, MNRAS, 476 (2018)
[5] Jones et al, A&A, 558 (2013)
[6] Jones et al, A&A, 602 (2017)