# Including the diffuse dust in nearby galaxies

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Dust evolution is studied at a high level of detail in different environments within our Milky-Way. Yet external galaxies (especially nearby ones) offer the opportunity of an external view, a full inventory of the different ISM phases and a wider variety of environments (metallicity, star formation rate, ...). Studies of dust in nearby galaxies has been pursued in the last two decades with Spitzer, Herschel as well as with ground-based sub-millimeter and millimeter facilites. Yet, observations of dust emission in nearby galaxies are affected by the limited sensitivity and/or spatial filtering so that the observed dust emission has often been biased toward star forming and dense regions, missing extended diffuse emission.

Combining low resolution Planck data with Herschel higher resolution maps, Clark et al. (2022,2023) studied dust emission with respect to the gas properties in 4 of the nearest and well resolved galaxies: the Magellanic Clouds, M31 and M33. We showed that up to 20% of the dust emission was missed in the Herschel observations, especially at shorter wavelengths. The restored colors are hence bluer and the dust is warmer on a galaxy wide scale than what had been deduced before. The corresponding dust-to-gas ratios obtained in the Magellanic Clouds are 2.4 and 2 times greater than previous estimates and are more consistent with UV depletion measurements. Restoring the diffuse extended emission in these four nearby galaxies also allowed us to probe dust emission in very diffuse regions with hydrogen densities sometimes lower than $1 M_{\odot} pc^{-2}$. Studying the dust emission over the wide range of densities (more than 2 orders of magnitude in gas surface density), we find a significant increase in the dust-to-gas ratio with density. Within each galaxy, the dust-to-gas ratio varies by up to a factor 22.4 as density changes. Our favored explanation for this dust-to-gas ratio evolution with density involves dust grain growth in denser regions of the ISM. These studies underline the importance of including diffuse extended emission in the study of dust emission in galaxies and highlights the need for facilities that will be able to observe or recover extended emission. In the sub-millimeter to millimeter range in particular, interferometric observations suffer from spatial filtering and projects like AtLAST will be instrumental to observe the extended emission of galaxies and allow us to get an accurate view of dust properties in galaxies that will be missing otherwise.