The Impact of Dust Evolution on the Millimeter Emission of Nearby Galaxies

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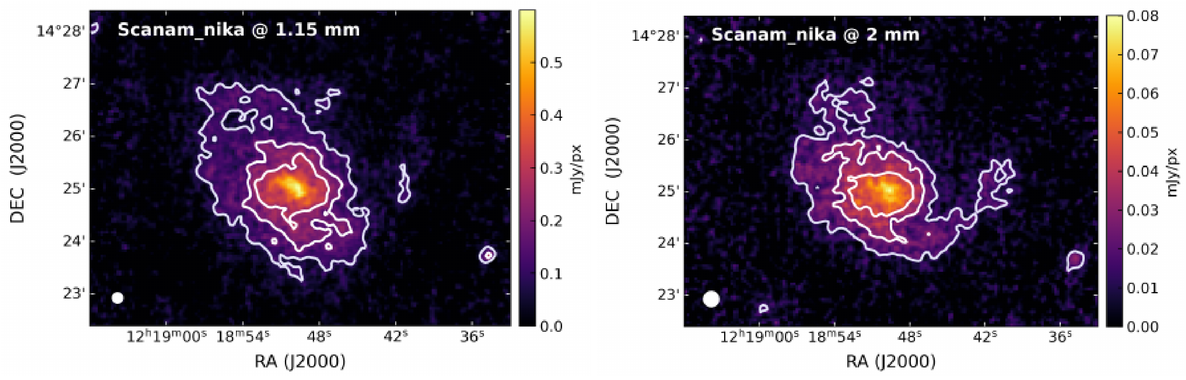
The IRAM-30m Millimeter Camera, NIKA2

NIKA2 – The *New IRAM KID Array 2* (NIKA2; Perotto et al., 2020) camera is installed on the IRAM 30m telescope (image on the left) at Pico Veleta (Spain).

Window – It has enabled continuum observations of galaxies at $\lambda = 1.15$ mm and 2 mm, with angular resolutions of $12''$ and $18''$ respectively, with an unprecedented sensitivity.

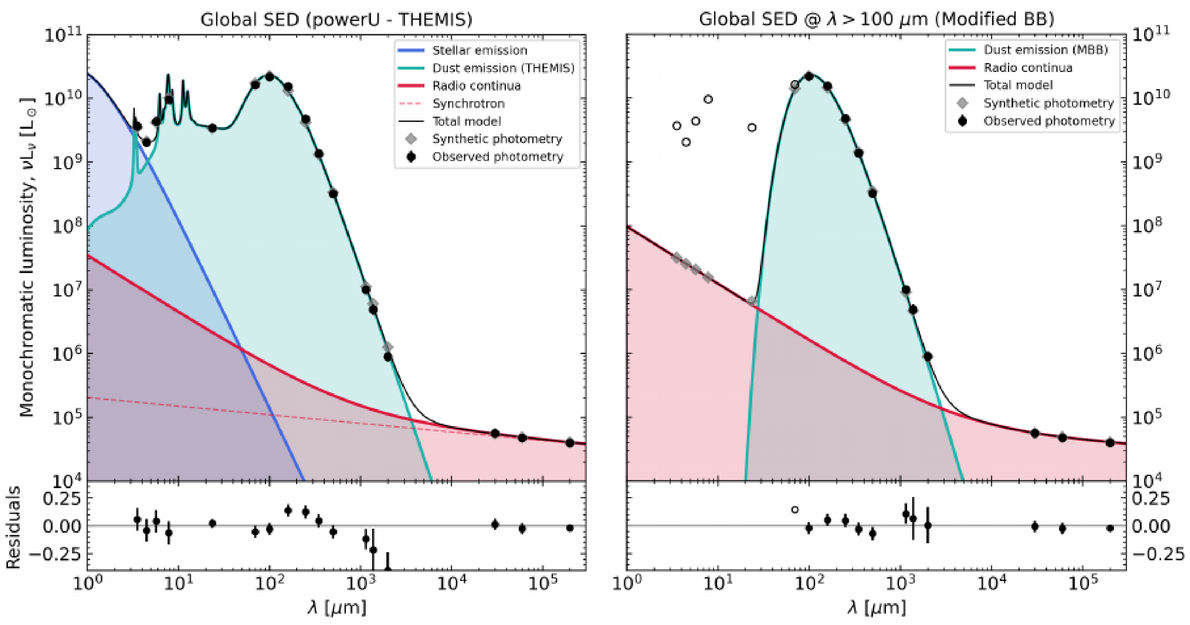
M 99 & the IMEGIN Program

M 99 – well-studied face-on spiral galaxy, located at $d = 14.4$ Mpc and with an apparent size $\simeq 5'$ (image below; Pantoni et al., *submitted*). It has a roughly Solar metallicity ($Z \simeq Z_\odot$).



IMEGIN – *Interpreting the Millimeter Emission from Galaxies with IRAM NIKA2* (IMEGIN; P.I. Madden) is a guaranteed-time large program targeting 22 nearby galaxies with NIKA2. This program was allocated 200 hours. All the data has been acquired and is progressively published (Katsioli et al., 2023; Ejlali et al., 2025).

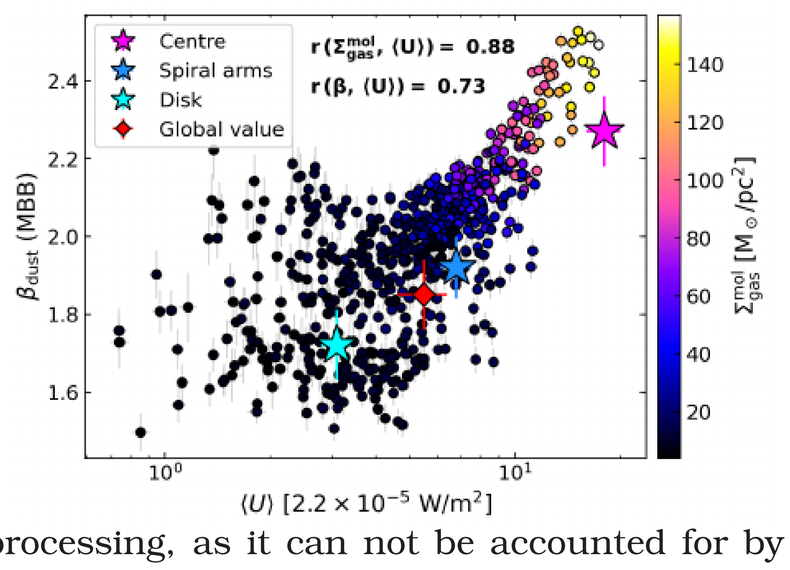
The Global SED of M 99



A steeper slope – We have fitted the global SED of M 99 using the THEMIS dust model (Jones et al., 2017, left panel), within the hierarchical Bayesian code HerBIE (Galliano, 2018). This model has a fixed *emissivity index*, $\beta = 1.79$, fine-tuned to the diffuse ISM of Solar-metallicity galaxies. The fit present systematic residuals in the millimeter. In comparison, leaving β free, helps reduce the residuals right panel, giving $\beta \simeq 2$ (Pantoni et al., *submitted*).

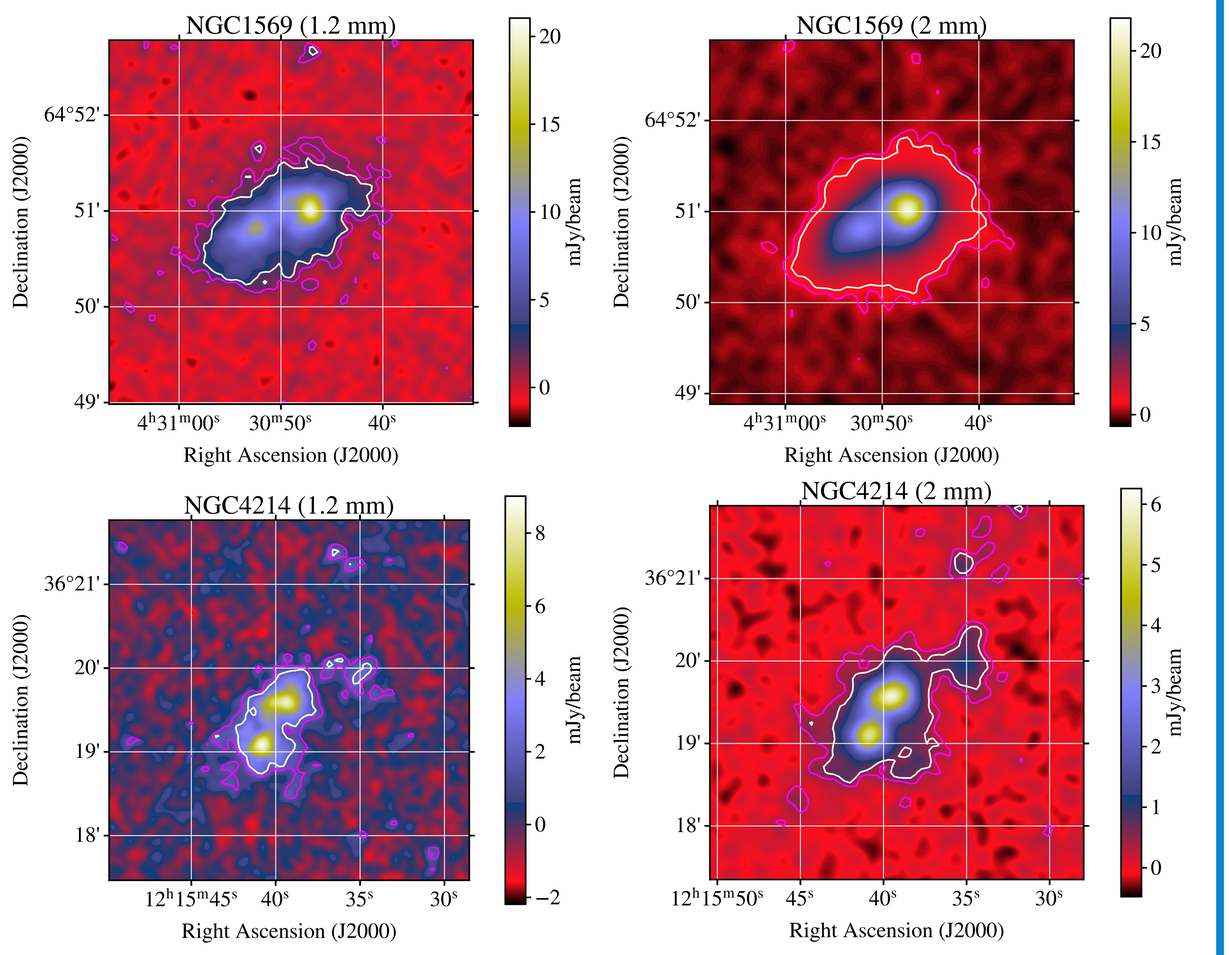
The Millimeter Slope Variation Within M 99

We performed a pixel-by-pixel SED fit of M 99 using HerBIE. It shows a clear correlation between β, the UV field and the column density (right figure; Pantoni et al., *submitted*).



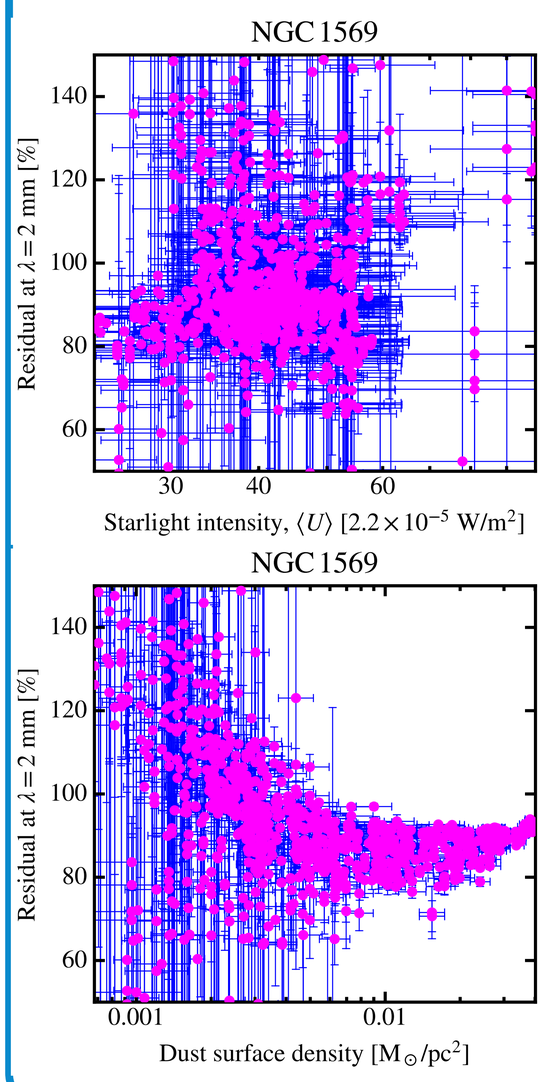
This is a sign of dust processing, as it can not be accounted for by temperature mixing along the sightline.

Spatially-Resolved Low-Z Millimeter Properties



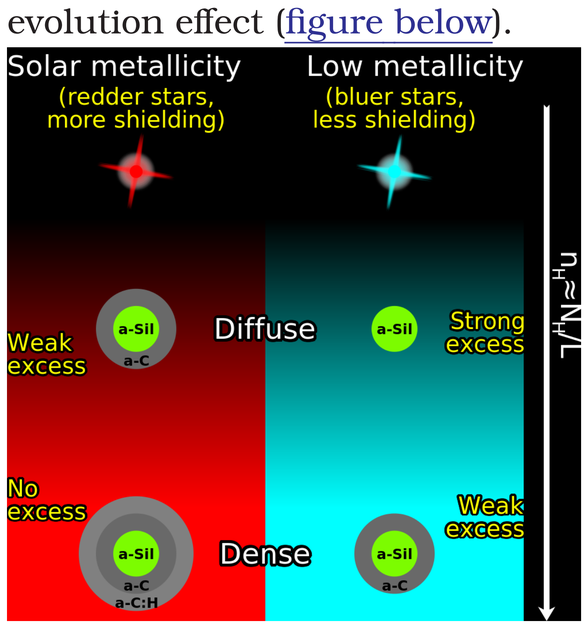
Submillimeter Excess In Nearby Fairly-Extended Low-metallicity Dwarfs (SEINFELD; 36 hours; P.I. Galliano): an open-time NIKA2 program.

An Environment-Dependent Millimeter Slope



The "*submm excess*" – Low-Z galaxies exhibit an unexplained excess (low β) in $500\ \mu\text{m} \lesssim \lambda \lesssim 3$ mm (Galliano et al., 2018).

Spatial variations – Our NIKA2 data shows that this excess is not related to the temperature of the grains (top left figure), but rather to the density of the ISM (bottom left figure). This could be a dust evolution effect (figure below).



Take-Away Points

- We now have ***good quality images*** of galaxies in the mm regime at $\simeq 18''$ resolution, thanks to NIKA2, down to $Z \gtrsim 1/5\ Z_\odot$.
- The ***slope of the grain emission*** in this regime exhibits ***large variations***, between individual galaxies, and within galaxies.
- Late-type, $Z \simeq Z_\odot$ galaxies, (*e.g.* M 99), have a steep mm SED ($\beta \gtrsim 2$). This is enhanced in dense, brightly illuminated regions.
- At low-metallicity, the SED is flatter ($\beta \simeq 1$). The mm slope correlates with the column density, but not with the grain temperature. This could be a consequence of the ***processing and disappearance of the grain mantles*** in these environments bathed by hard UV photons.

References

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