Project 5: The Spatially-Resolved Dust Properties of Nearby Galaxies

Davide Belfiori · Lucie Correia · Luis Garduno · Niklas Moszczynski · Andrea Romanelli · Martin Shanobe · Suphakorn Suphapolthaworn · Stefan van der Giessen

Supervisors: Frédéric GALLIANO & Lara PANTONI
Outline

★ Scientific goals
★ Data: NGC1140, NGC3938 (DustPedia)
★ Method: MCMC Error propagation
★ Results
Scientific goals

1. Learn to homogenize multi-wavelength images of galaxies

2. Perform SED modeling in order to infer maps of the dust properties

Useful to:

❖ Estimate dust-to-gas mass ratio distributions
❖ Have a better understanding of the heating sources
❖ Study dust evolution
Data sample: 2 nearby galaxies

**NGC3938**
- Spiral, unbarred
- Distance: ~15 Mpc
- (Angular) diameter: ~5’

**NGC1140**
- Irregular, starburst
- Distance: ~19 Mpc
- (Angular) diameter: ~1.7’
DustPedia

- UV-to-mm photometry

- Images of 800 nearby galaxies with ancillary data
  → Use of IRAC, SPIRE, MIPS, PACS, WISE

http://dustpedia.astro.noa.gr/Data

**The Data**

The DustPedia Data archive contains multiwavelength imagery for 875 nearby galaxies (every extended galaxy within 3000 km s\(^{-1}\) that was observed by the Herschel Space Observatory). The data hosted in the archive are all the available maps for the DustPedia sample coming from the GALEX, SDSS, DSS, 2MASS, WISE, Spitzer, Herschel, and Planck surveys. In the left-hand side of each entry some basic galaxy properties are provided, as well as, photometry cutouts (in png format) for each galaxy with the exact aperture used for the photometry, per band, and the annuli used to calculate the background.

The user can retrieve all the available maps (and in some cases its associated error map) in the database in fits format. All maps are in units of Jy pixel\(^{-1}\) except for DSS (left as photographic densities). The user can search with Galaxy Name, Hubble Stage (T), Velocity (in km s\(^{-1}\)), Inclination Angle (in degrees), and size (D\(_{25}\) in arcmin). In each search parameter the user can define the range desired but also have the option to define only the lower or the higher limit. A "show all results in a single page" button allows the user to print all results on a single page.

Homogenizing multiwavelength data

- Different size maps, spatial resolution, pixel size, orientation, units

- HIP pipeline: Homogenization of IMEGIN Photometry (Pantoni et al. in prep.)
  - Foreground large scale emission subtraction
  - Unresolved background sources
  - Mask bright foreground stars
  - Convolution to SPIRE 500 resolution
  - Regridding and reprojecting to same frame
Monte Carlo error propagation

Monte Carlo method (frequentist approach) relies on random perturbations that are added to the data map for a number $N$ of iterations. It accounts for e.g. correlations between pixels.

1. The random perturbation is a random normal distribution centered on zero with standard deviation equal to the original uncertainty on the data map.

$$F^{(i)}_\nu(x, y, \lambda) = F_\nu(x, y, \lambda) + \delta^{(i)}(x, y, \lambda) \times \sigma_\nu(x, y, \lambda)$$
Monte Carlo error propagation

3) After N iterations, we have N perturbed data map that have been processed in the same way.

4) The px-by-px standard deviation of the N data maps gives the final statistical uncertainty map.

N random realization of the processed data map
NGC 3938 (before homogenization)
NGC 3938 (cropped / background subtracted)
NGC 3938 (convolved)

Pixel size = original px size

Convolve all to SPIRE 500 μm
NGC 3938 (after homogenization)

Pixel size = SPIRE 500 μm px size

then mask out pixels with S/N < 3

Reproject all to SPIRE 500 μm
NGC 1140 (before homogenization)
NGC 1140 (after homogenization)
Check flux calibration between overlapping bands

NGC 3938
NGC 3938
Signal-Noise comparison

NGC 1140
Signal-Noise comparison

NGC 1140
SED fitting with HerBIE (Galliano 2018)

A pixel in the disk

NGC 3938
SPIRE 500 μm
Physical properties

- Radiation field decreases with radius
Physical properties

- Radiation field decreases with radius
- Dust mass decreases with radius
Physical properties

- Radiation field decreases with radius
- Dust mass decreases with radius
- PAH fraction varies with dust mass
Thank you!
NGC 3938 (background map)

Mask stars / galaxy

Interpolate bkg emission behind the galaxy