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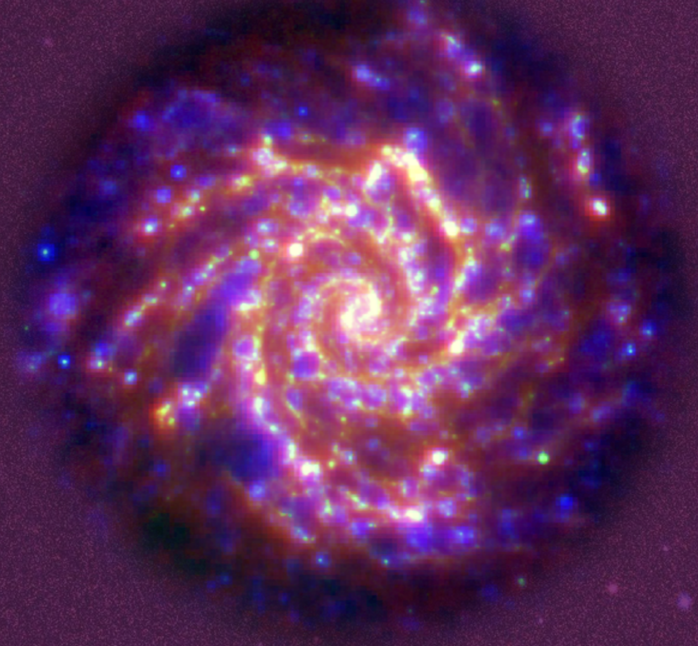
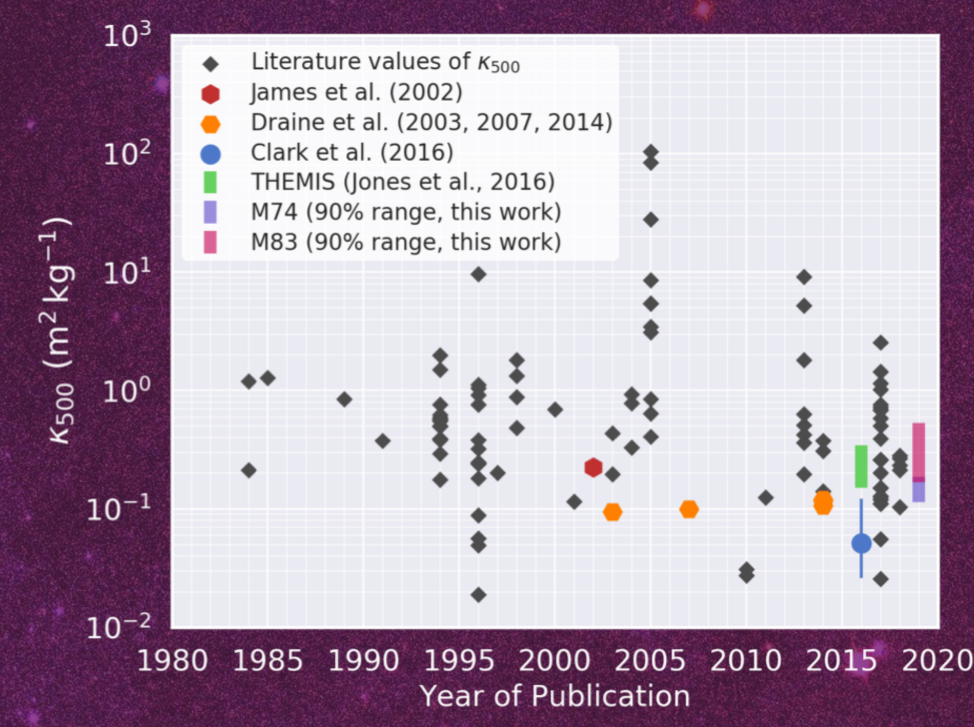
DustPedia: The First Maps of κ_d - the Dust Mass Absorption Coefficient - in Nearby Galaxies



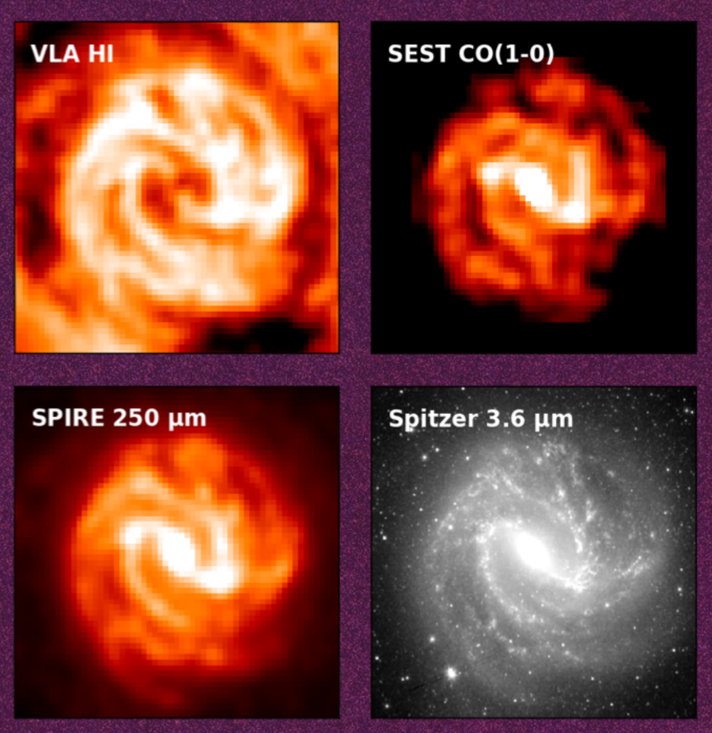
The dust mass absorption coefficient, κ_d, is the conversion factor we rely upon to infer physical dust masses from observations of dust emission. However, it is notoriously poorly constrained, and it is totally unknown how it varies between or within galaxies. Here we use create the first maps of κ_d within galaxies, for M74 & M83. We do this using an empirical method that assumes a fixed value for the ISM dust-to-metals ratio; by comparing gas & metallicity to dust emission, we calculate κ_d pixel-by-pixel. We find values of $\kappa_{d\ (500\mu m)}$ spanning 0.11– 0.25 m^2kg^{-1} in M74, and 0.15– 0.80 m^2kg^{-1} in M83. Surprisingly, we find that larger values of κ_d are associated with regions of *lower* ISM density, the opposite of what is predicted by most models. If we assume that the dust-to-metals ratio isn't fixed but instead varies with radius or ISM density, then this inverse trend becomes even more pronounced.

Motivation: Interstellar dust can be observed in vast numbers of galaxies very rapidly, out to high z. This has made it a standard proxy for studying star-formation, gas mass, and chemical evolution – which are very time-consuming to observe directly.

Exploiting dust observations generally requires us to infer dust masses from observations of dust emission. But the conversion factor, κ_d (the mass absorption coefficient), is highly uncertain; see the wide range of published estimates plotted below.



Clark+ (2016) developed an empirical method for estimating κ_d, that works by assuming a value for the ISM dust-to-metals. Thus, once we know the gas mass of a target's ISM, and the metallicity of that gas, we can infer its dust mass; comparing this to the observed dust emission calibrates κ_d.

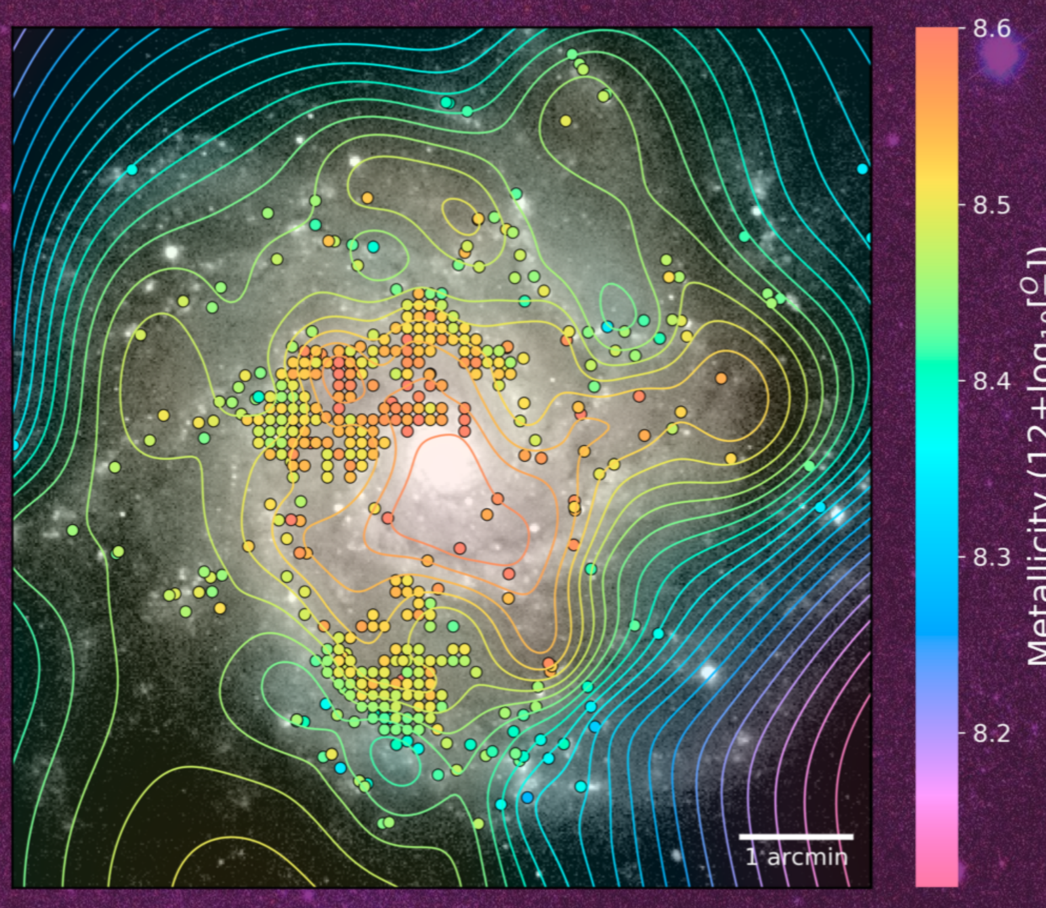


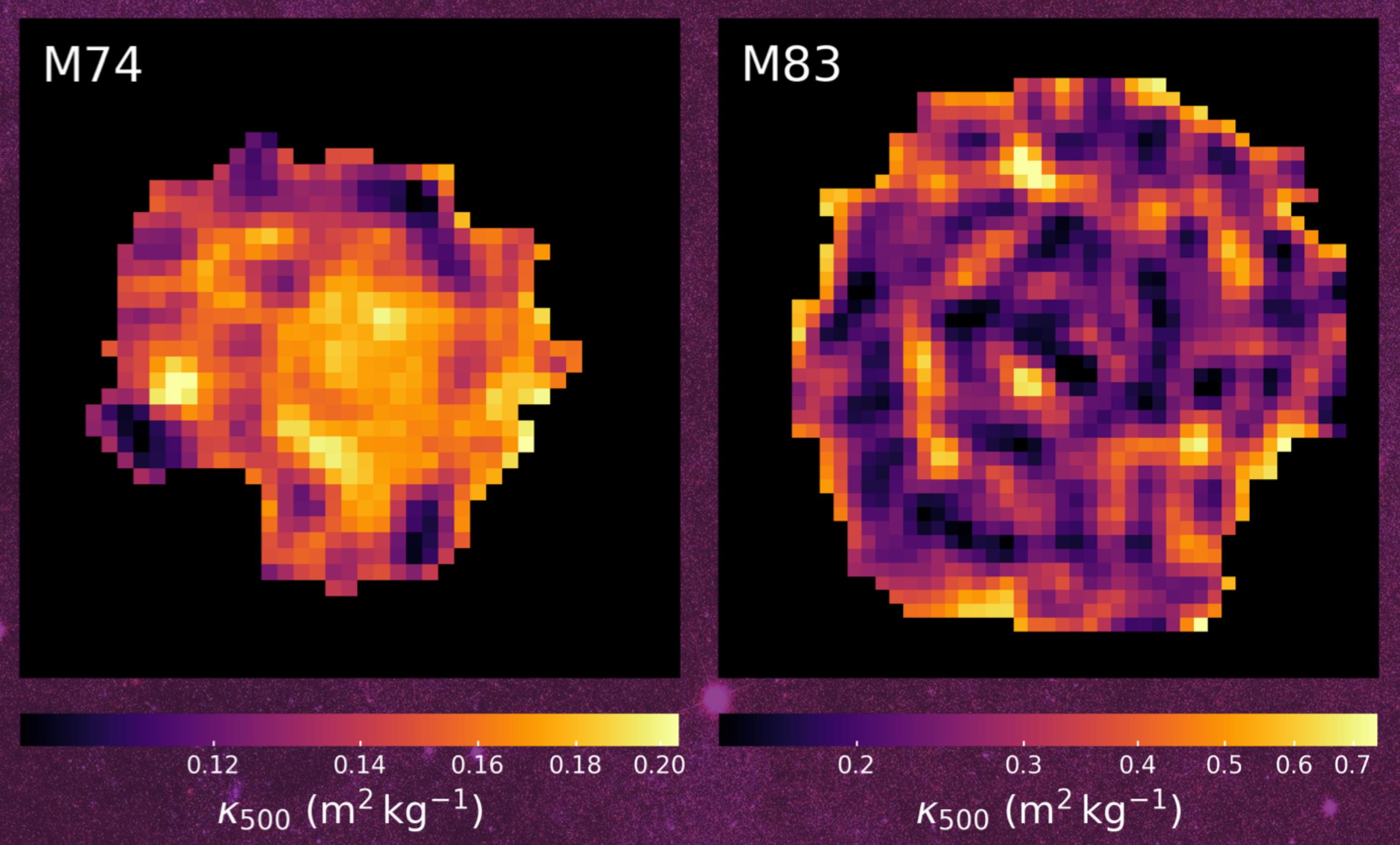
Data & Targets: The DustPedia project (Davies+ 2016) has assembled a multiwavelength database covering 875 nearby galaxies observed by *Herschel*, spanning 40 UV–mm photometric bands (Clark+ 2018), plus atomic & molecular gas data (Casasola+ *in prep*), and >10000 standardised spectroscopic metallicity measurements (De Vis+ 2019).

This dataset is ideal for creating pixel-by-pixel maps of κ_d *within* galaxies using the Clark+ (2016) method. For the proof-of-concept study we present here, we have used DustPedia data for face-on spirals M74 & M83. ISM data for M83 is shown to the left (plus NIR reference image).

Resolved Metallicity: Well-resolved nearby galaxies are some of the most useful astrophysical laboratories, but often have irregularly- or sparsely-sampled metallicity measurements.

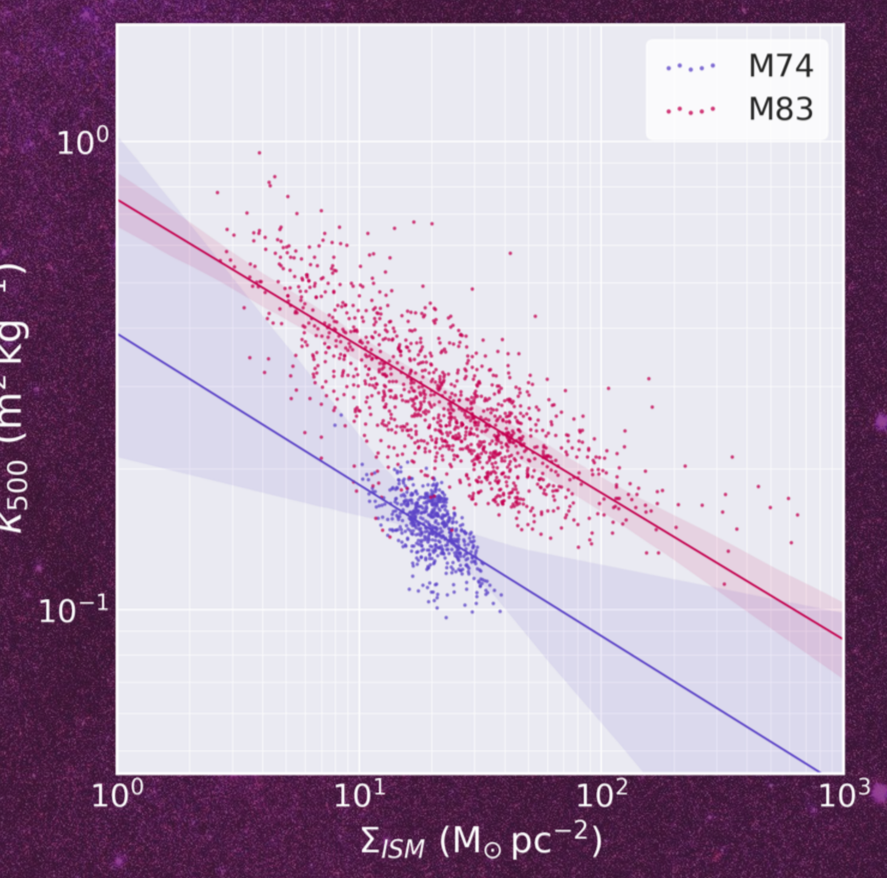
We used Gaussian Process Regression (a probabilistic interpolation) to infer the underlying metallicity distribution using these measurements. The resulting metallicity map for M74 is shown to the right. The background image is NIR. Coloured dots show individual metallicity measurements. Contours trace the inferred metallicity distribution.





Maps of κ_d: With gas, dust, and metallicity data, we produced our maps of κ_d, shown to the left. We find that larger values of κ_d are associated with *lower* density ISM (see plot to right) – the opposite of what is predicted by most models.

Our assumption of a constant dust-to-metals ratio must break down at some point. But if we instead assume that dust-to-metals increases with radius, or ISM density, then the inverse trend with ISM density becomes even more pronounced.



The poster border depicts all 875 DustPedia galaxies, as seen in FIR (red), NIR (green) and UV (blue) observations, arranged in order of RA. Visit dustpedia.com to explore our public data!