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CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

DustPedia

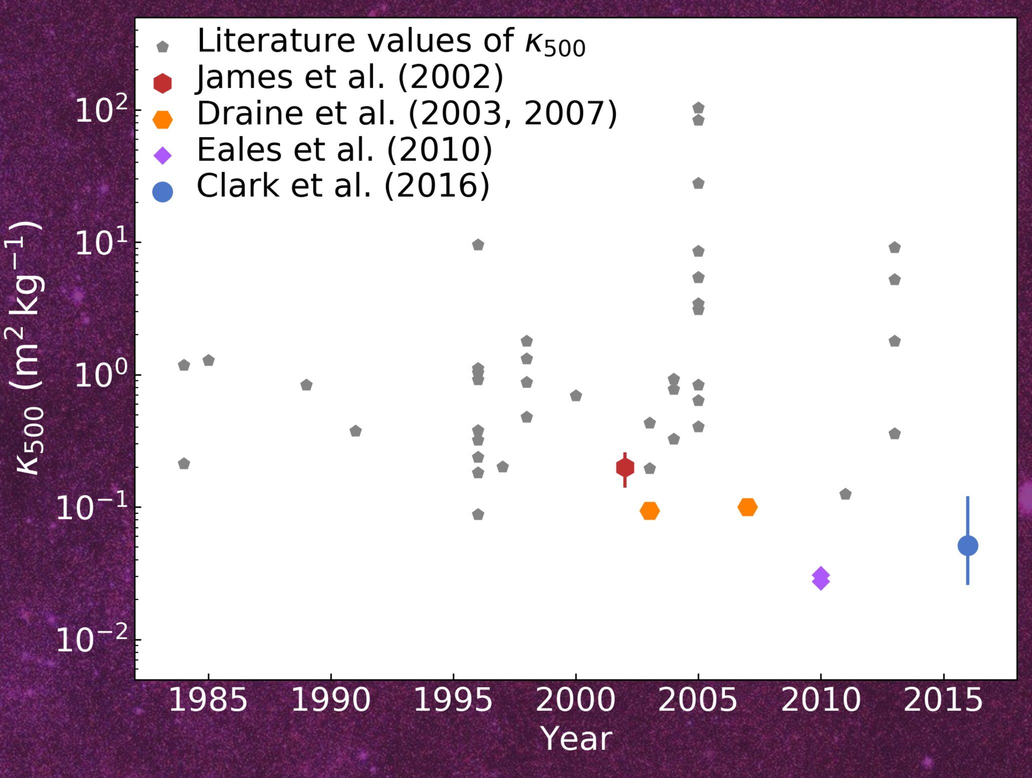
SEVENTH FRAMEWORK PROGRAMME

DustPedia: The First Map of K_d - the Dust Mass Absorption Coefficient - in a Nearby Galaxy

The dust mass absorption coefficient, K_d, is the conversion factor we rely upon to infer physical dust masses from observations of dust emission. However, it is notoriously poorly constrained, with estimated values spanning over an order of magnitude. Moreover, it is totally unknown how it varies between or within galaxies. Here we present preliminary results, using the DustPedia data for M83 to create the first ever map of K_d in a galaxy. We do this using an empirical method that assumes a constant ISM dust-to-metals ratio; by comparing gas & metallicity data to dust emission, we calculate K_d pixel-by-pixel. We find that $K_{500\,\mu m}$ varies radially in M83 by a factor of 4, from **0.081 m² kg⁻¹** in the centre, to **0.36 m² kg⁻²** in the outskirts. Even when considering possible systematic effects, these results still indicate a radial variation of K_d in M83 of at least a factor of 2.

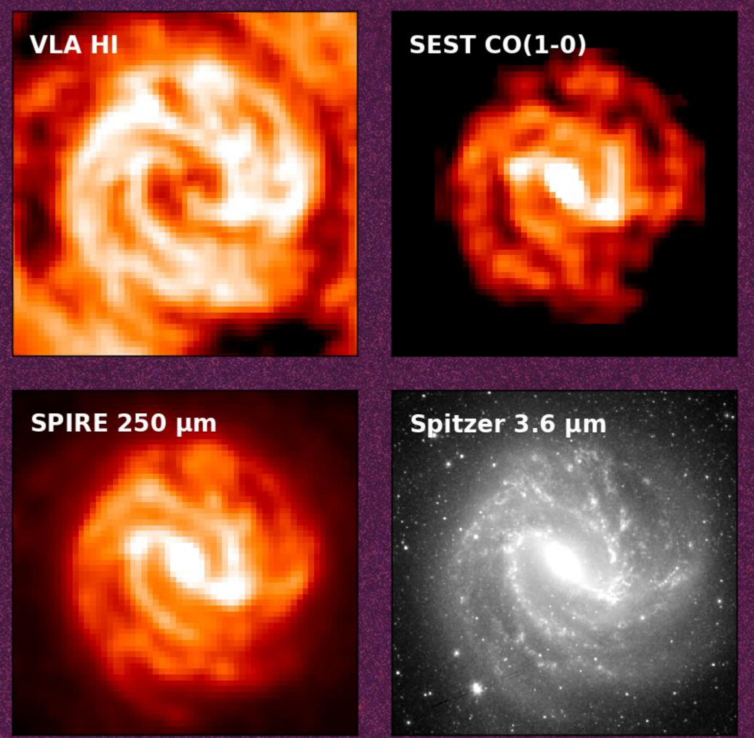
Motivation: Interstellar dust is an indispensable way to study galaxy evolution, as it can be observed in enormous numbers of galaxies very rapidly, out to high redshift. Dust is now a standard proxy for studying star-formation, gas mass, and chemical evolution – which are otherwise difficult and time-consuming to observe.

However, our ability to exploit dust in this way requires that we can reliably infer dust masses from observations of dust emission. But the conversion factor, K_d (the dust mass absorption coefficient), is uncertain to an *order of magnitude at best!* The huge range in published K_d estimates is shown in the figure below (with a number of prominent values highlighted); note the *logarithmic* y-axis.



This uncertainty forces us to treat K_d as constant – both within, and between, galaxies. But this of course cannot be true in reality. Pinning down K_d, and how it varies, is therefore vital. Clark+ (2016) developed an empirical method for estimating K_d, that works by assuming a constant value for the ISM dust-to-metals ratio (50%). Thus, once we know the metallicity of a galaxy's ISM, and its total gas mass, we can infer its dust mass; comparing this to the observed dust emission calibrates K_d; The Clark+ (2016) value is plotted as a blue circle in the figure above.

The poster border depicts all 875 DustPedia galaxies, as seen in FIR (red), NIR (green) and UV (blue). Visit dustpedia.com for all of our data!

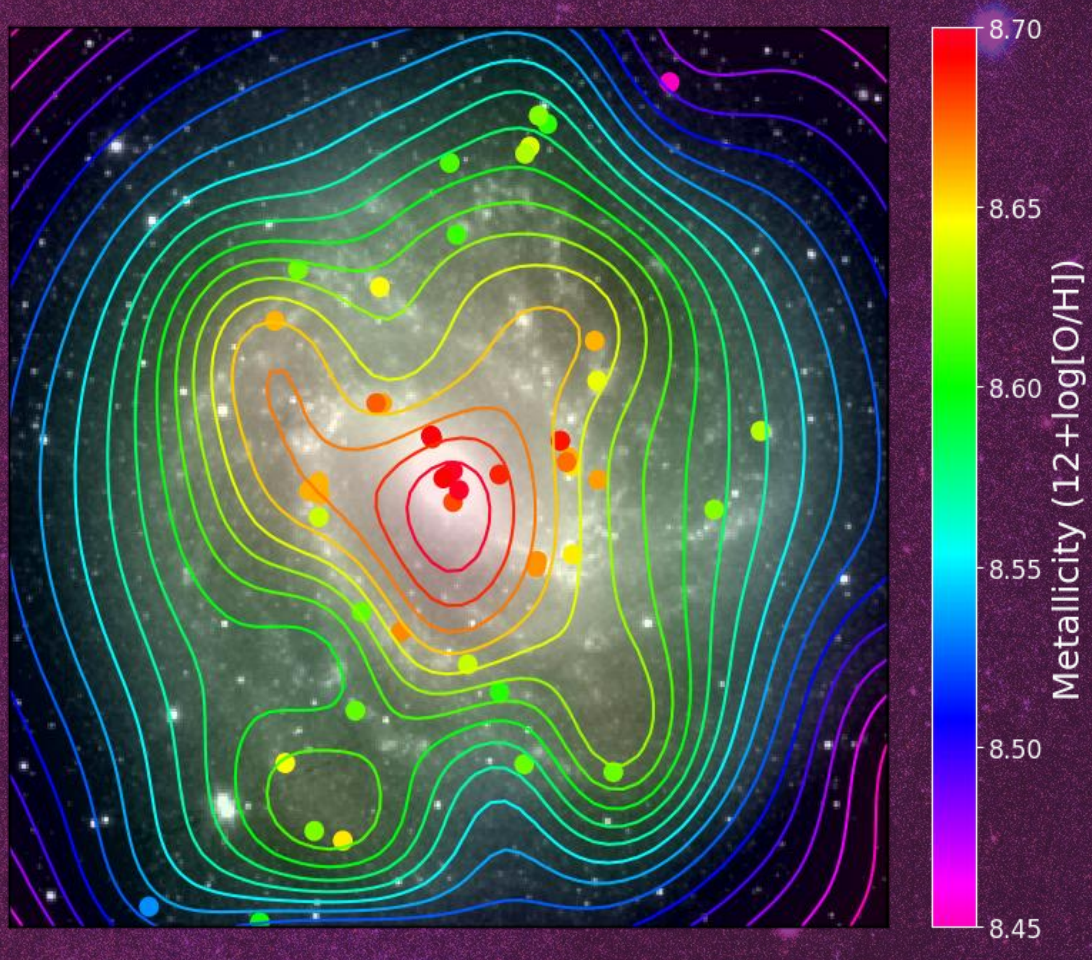


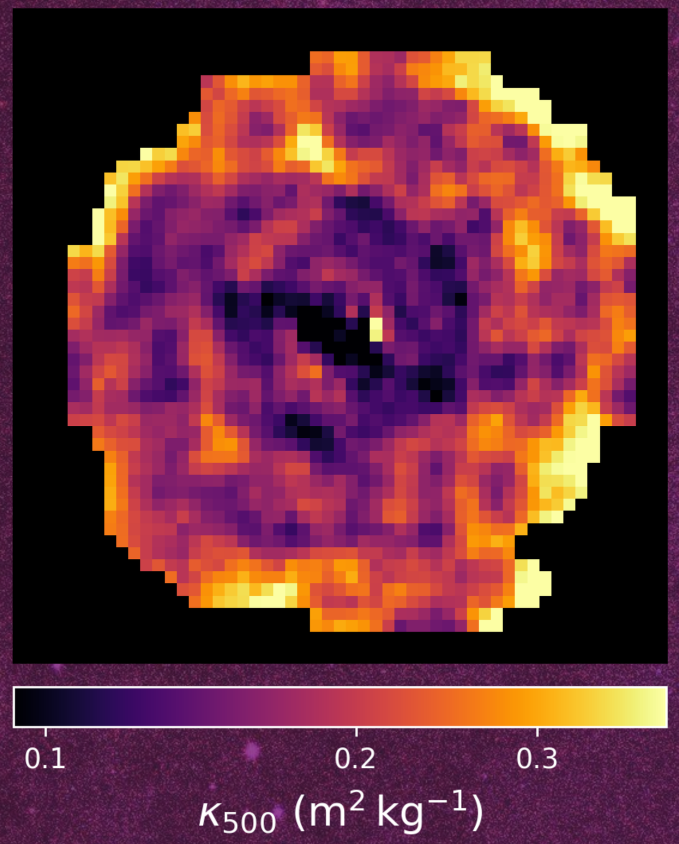
Data & Target: The DustPedia project (Davies+ 2016) has assembled an extensive multiwavelength database covering 875 nearby galaxies observed by *Herschel*, spanning 40 UV–mm photometric bands (Clark+ 2018). The database also includes available atomic & molecular gas data (Casasola+ 2017); plus >10000 standardised metallicity measurements from IFU, slit, and fibre spectra (De Vis+ *in prep.*).

This dataset is ideal for creating a pixel-by-pixel map of K_d *within* a galaxy using the Clark+ 2016 method. For our proof-of-concept example, we have used the DustPedia data for face-on spiral M83. The HI, CO(1-0), and submm data for M83 is shown to the left (along with a NIR reference image).

Resolved Metallicity: Galaxies extended enough to have well-resolved global gas & dust data, like M83, are often *too* extended to have their metallicity fully mapped by integral field spectroscopy. But, they often have many metallicity points from large numbers of individual HII region spectra.

We developed a way to use these HII region metallicity points to infer the underlying metallicity distribution, by using Gaussian Process Regression – a type of Bayesian non-parametric interpolation. The resulting metallicity map is shown to the right. The background image is M83 in the NIR. Coloured dots show HII regions. Contours trace the mapped metallicity distribution.





Map of K_d: With resolved gas, dust, and metallicity data, all at common scales, we produced the first ever pixel-by-pixel map of K_d. The resulting map is shown to the left. It shows variations in $K_{500\,\mu m}$, from 0.081 m² kg⁻¹ in the core, to 0.36 m² kg⁻¹ in the outskirts. The bar and spiral structures are apparent.

Our assumption of a constant dust-to-metals ratio must break down at some point; so some of this variation in K_d may be artificial. However, evidence from observations (Wiseman+ 2016), simulations (McKinnon+2016, Popping+ 2017), and theory (Jones+ *in prep.*), all indicate that the dust-to-metals ratio varies by a factor of <2 at high metallicity. This suggests that, of the factor of 4.4 variation in K_d we find, that at least a factor of 2.2 cannot be attributed to this possible systematic. This is the first observational measurement of variation in K_d.