The University of Manchester
Jodrell Bank Observatory

Extending the analysis of dust heating in nearby galaxies with Herschel

George J. Bendo
(with the Herschel Reference Survey and Herschel Virgo Cluster Survey)

Overview

- Sample of nearby face-on galaxies from three surveys:
  - Herschel Reference Survey
  - Herschel Virgo Cluster Survey
  - KINGFISH
- Additional data used from three surveys:
  - Spitzer Infrared Nearby Galaxies Survey
  - Spitzer Local Volume Legacy Survey
  - Spitzer Survey of Stellar Structure in Galaxies
- Compare 160/250 and 250/350 μm surface brightness ratios (which trace dust heating) to heating sources
  - Use 3.6 μm to trace heating by total stellar population
  - Use 24 μm to trace heating by star formation
- Two different analyses used:
  - Qualitative (comparing colour temperature maps to 3.6 and 24 μm maps at same resolution)
  - Quantitative (comparing 160/250 and 250/350 μm ratios to 3.6 and 24 μm emission in binned data)

Results

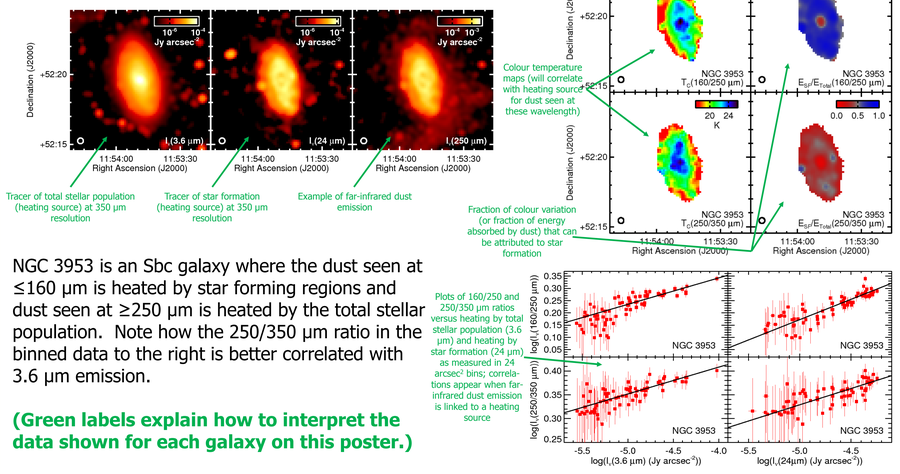
- Three dust heating scenarios seen:
  - Total stellar population dominates heating of dust seen at ≥250 μm (and sometimes dust seen at 160 μm)
  - Star forming regions and total stellar population contribute roughly equally to dust seen in 160-350 μm range
  - Star forming regions dominate dust heating up to 350 μm
- Tendency for bulge stars to dominate dust heating in early-type spiral galaxies
- Some Virgo Cluster galaxies are extreme cases where dust is heated solely by star forming regions

Implications and Future Work

- Relation of 160-350 μm emission to star formation is complicated
  - In some galaxies, dust seen at 160-350 μm is heated by star forming regions
  - In other galaxies, dust seen at 160-350 μm is not heated by star forming regions but related to star formation through the Kennicutt-Schmidt law
- Modelling dust emission is more complicated than appears from global spectral energy distributions (SEDs)
  - Accurate models will have different dust heating sources for different galaxies (even galaxies with the same Hubble type)
  - Number of thermal components (either modified blackbodies or more complex models) fit to SEDs will vary from galaxy to galaxy
  - Analysis of 160/250 and 250/350 μm ratios can be used to guide SED fitting and produce more physically accurate results
- Use of star formation tracer affects results
  - Hα emission trace 160/250 and 250/350 μm ratios better than 24 μm emission in some galaxies
  - Result may be indicative of nature of heating of large dust grains
  - Additional analysis needed to confirm this result

NGC 3953

Dust seen at ≥250 μm heated by evolved stars

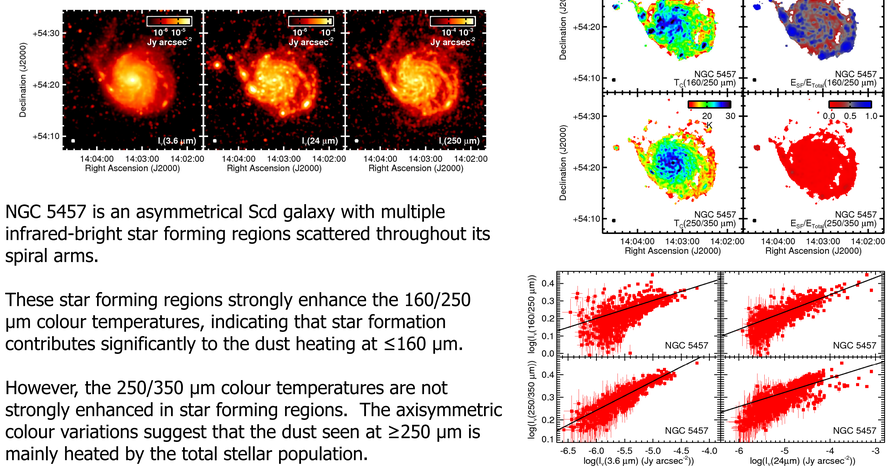


NGC 3953 is an Sbc galaxy where the dust seen at ≤160 μm is heated by star forming regions and dust seen at ≥250 μm is heated by the total stellar population. Note how the 250/350 μm ratio in the binned data to the right is better correlated with 3.6 μm emission.

(Green labels explain how to interpret the data shown for each galaxy on this poster.)

NGC 5457

Dust seen at ≥250 μm heated by evolved stars



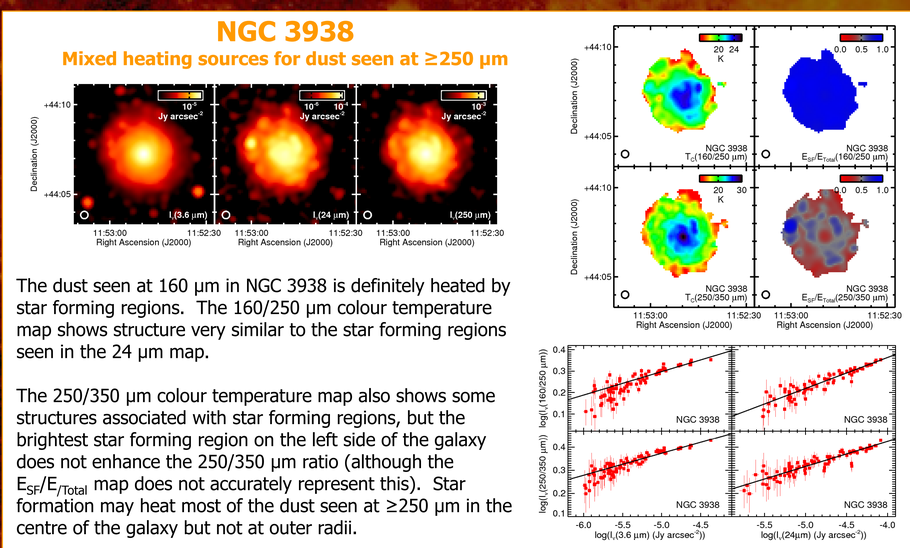
NGC 5457 is an asymmetrical Scd galaxy with multiple infrared-bright star forming regions scattered throughout its spiral arms.

These star forming regions strongly enhance the 160/250 μm colour temperatures, indicating that star formation contributes significantly to the dust heating at ≤160 μm.

However, the 250/350 μm colour temperatures are not strongly enhanced in star forming regions. The axisymmetric colour variations suggest that the dust seen at ≥250 μm is mainly heated by the total stellar population.

NGC 3938

Mixed heating sources for dust seen at ≥250 μm

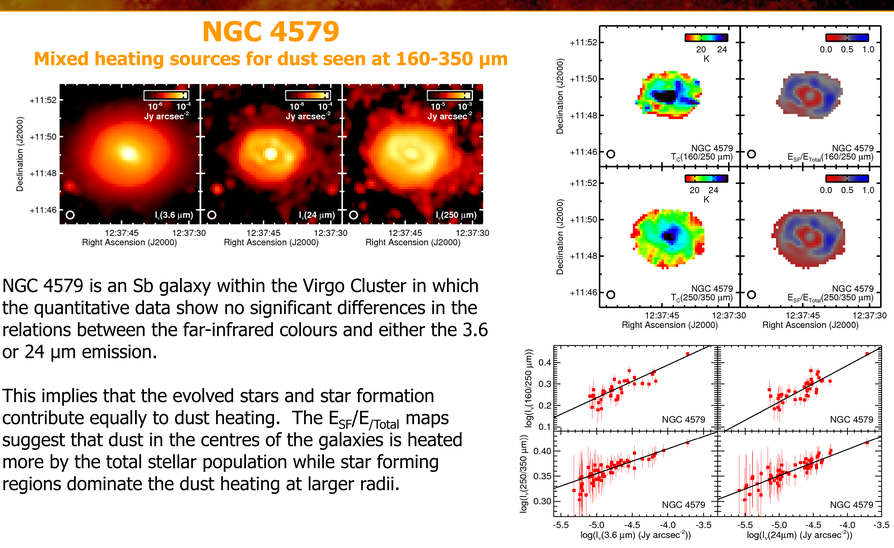


The dust seen at 160 μm in NGC 3938 is definitely heated by star forming regions. The 160/250 μm colour temperature map shows structure very similar to the star forming regions seen in the 24 μm map.

The 250/350 μm colour temperature map also shows some structures associated with star forming regions, but the brightest star forming region on the left side of the galaxy does not enhance the 250/350 μm ratio (although the E_{SF}/E_{Total} map does not accurately represent this). Star formation may heat most of the dust seen at ≥250 μm in the centre of the galaxy but not at outer radii.

NGC 4579

Mixed heating sources for dust seen at 160-350 μm

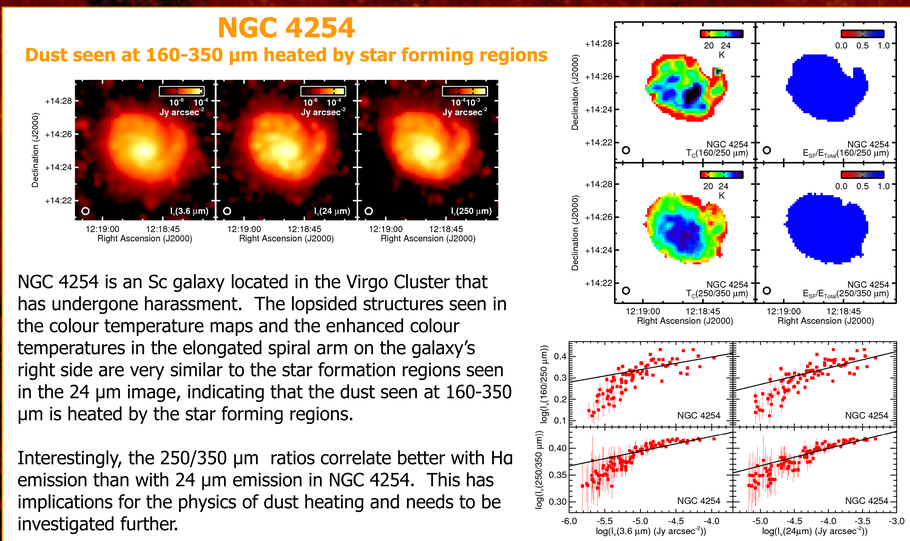


NGC 4579 is an Sb galaxy within the Virgo Cluster in which the quantitative data show no significant differences in the relations between the far-infrared colours and either the 3.6 or 24 μm emission.

This implies that the evolved stars and star formation contribute equally to dust heating. The E_{SF}/E_{Total} maps suggest that dust in the centres of the galaxies is heated more by the total stellar population while star forming regions dominate the dust heating at larger radii.

NGC 4254

Dust seen at 160-350 μm heated by star forming regions

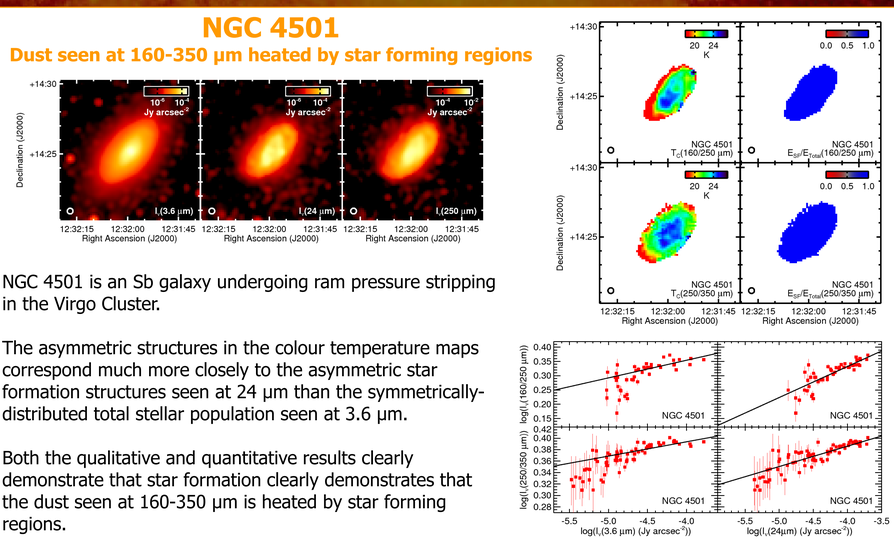


NGC 4254 is an Sc galaxy located in the Virgo Cluster that has undergone harassment. The lopsided structures seen in the colour temperature maps and the enhanced colour temperatures in the elongated spiral arm on the galaxy's right side are very similar to the star formation regions seen in the 24 μm image, indicating that the dust seen at 160-350 μm is heated by the star forming regions.

Interestingly, the 250/350 μm ratios correlate better with Hα emission than with 24 μm emission in NGC 4254. This has implications for the physics of dust heating and needs to be investigated further.

NGC 4501

Dust seen at 160-350 μm heated by star forming regions



NGC 4501 is an Sb galaxy undergoing ram pressure stripping in the Virgo Cluster.

The asymmetric structures in the colour temperature maps correspond much more closely to the asymmetric star formation structures seen at 24 μm than the symmetrically-distributed total stellar population seen at 3.6 μm.

Both the qualitative and quantitative results clearly demonstrate that star formation clearly demonstrates that the dust seen at 160-350 μm is heated by star forming regions.