The Emission by Dust and Stars of Nearby Galaxies in the Herschel KINGFISH Survey

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I. Abstract

Using new far-infrared imaging from the Herschel Space Observatory with ancillary data from ultraviolet (UV) to submillimeter (submm) wavelengths, we estimate the total emission from dust and stars of 62 nearby galaxies in the KINGFISH survey (Kennicutt et al., in prep.) in a way that is as empirical and model-independent as possible. We measure from the spectral energy distributions how much stellar radiation is intercepted and re-radiated by dust, and how this quantity varies with galaxy properties. By including SPIRE data, we are more sensitive to emission from cold dust grains than previous analyses at shorter wavelengths.

The dust/stellar flux ratio, which we measure by integrating the SEDs, has a range of nearly three decades. The inclusion of SPIRE data shows that estimates based on data not reaching these far-IR wavelengths are biased low. We find that the dust/stellar flux ratio varies with morphology and total IR luminosity. We also find a substantial metallicity-dependent scatter between dust/stellar flux and dust/stellar mass, indicating that the former is a poor proxy for the latter. Comparing the dust/stellar flux ratios and dust temperatures, we show that early-types tend to have slightly warmer temperatures than spiral galaxies, which may be due to more intense interstellar radiation fields, or to different dust grain compositions. Finally, we show that early-types and early-type spirals have a strong correlation between the dust/stellar flux ratio and specific star formation rate, which suggests that the relatively bright far-IR emission of some of these galaxies is due to ongoing star formation and the radiation field from older stars.

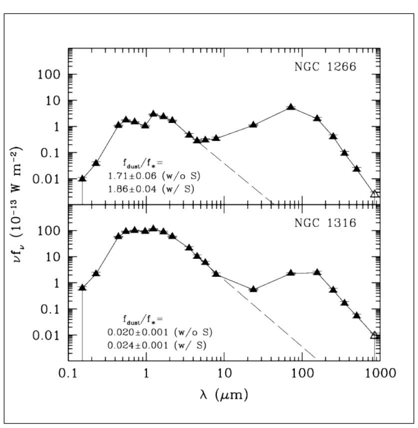
II. Data

Our sample consists of 61 nearby galaxies in the KINGFISH survey, plus M33. We use the global flux densities from Dale et al. (2007, 2009), which describes the UV to far-IR photometry of the SINGS and LVL surveys. To these we add SPIRE flux densities at 250, 350, and 500 μm. We also use visual morphology classifications (Kennicutt et al. 2003) and gas-phase metallicities (Moustakas et al. 2010).

III. Dust-to-Stellar Ratio

We measure the emission from stars and dust empirically from the SEDs, exploiting the diversity of data that have been taken for these galaxies. To estimate the stellar and dust emission, which we call f_* and f_{dust}, we integrate over the SED (while interpolating between the observed wavelengths) at $\lambda \leq 4.5\mu m$ and add the mid-IR stellar contribution for the former, and integrate the SED at $\lambda \geq 4.5\mu m$ and subtract the same contribution for the latter. (See Skibba et al. 2011 for details). The dust/stellar flux ratio is simply then defined as f_{dust}/f_*.

The figure shows two example SEDs, of NGC 1266 and NGC 1316:

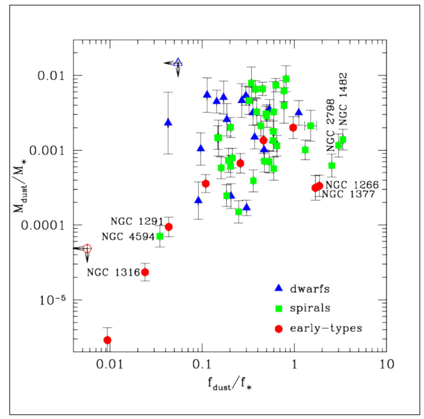


IV. Results

Dust/stellar *mass* ratio vs. dust/stellar *flux* ratio.

(See Gordon et al. 2010 and Zibetti et al. 2009 for a discussion of constraints on these masses.)

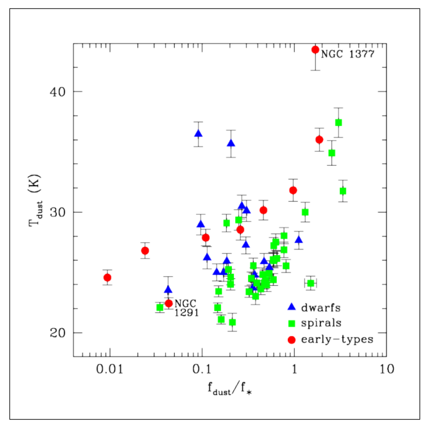
The correlation between the dust/stellar ratios is weak, with substantial scatter and many outliers, indicating that dust/stellar flux is a poor proxy for dust/stellar mass. The scatter depends on metallicity and dust temperature.



Dust temperature vs. dust/stellar flux ratio.

T_{dust} is estimated from a modified blackbody fit to the FIR SED.

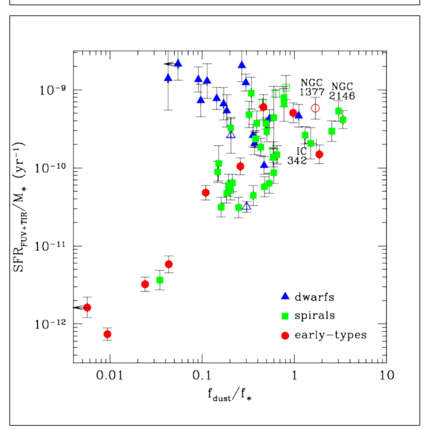
Spiral and early-type galaxies exhibit a strong correlation, implying that dust emission and dust heating are related. Interestingly, the early-types are warmer than the spirals (by ≈5 K), possibly due to more intense radiation fields in the bulge components.



Specific star formation rate vs. dust/stellar flux ratio.

SFRs estimated from TIR and FUV luminosities (Hao et al. 2011).

Spirals and early-types follow a tight correlation, indicating that the amount of star formation is related to the relative amount of emission reprocessed by dust grains. Note also that a few of the early-types in the sample have significant obscured star formation.



V. Summary

- Dust/stellar flux and dust/stellar mass ratios are only weakly correlated, with metallicity and dust temperature-dependent scatter.
- Spirals and early-types exhibit a correlation between dust/stellar flux and dust temperature. Early-types have warmer T_{dust} than spirals.
- Spirals and early-types also show a tight correlation between dust/stellar flux and specific star formation rate.
- Our results can also be compared to SED models, and can serve as a local benchmark for high-redshift studies.