Galaxies in 3D across the Universe
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Dust as a tracer of gas in galaxies

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Abstract. We use a sample of 36 galaxies to study empirical relations between Herschel infrared (IR) luminosities and the total mass of the interstellar gas (H_2 + HI). Such a comparison provides a simple empirical relationship without introducing the uncertainty of dust model fitting. We find tight correlations, and provide fits to these relations, between Herschel luminosities and the total gas mass integrated over entire galaxies, with the tightest, almost linear, correlation found for the longest wavelength data (SPIRE500). However, we find that accounting for the gas-phase metallicity (affecting the dust-to-gas ratio) is crucial when applying these relations to low-mass, and presumably high-redshift, galaxies. When examining these relations as a function of galactocentric radius, we find the same correlations, albeit with a larger scatter, up to radius of $r \sim 0.7 r_{25}$ (containing most of a galaxy's baryonic mass). The tight relations found for the bulk of the galaxy's baryonic content suggest that total gas masses of disk-like (non-merging/ULIRG) galaxies can be inferred from far-infrared continuum measurements in situations where only the latter are available. This work is to appear in Groves *et al.* (2014).

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1. Summary

The evolution of the gas mass density over cosmic time plays a direct role in the evolution of galaxies through its link to the star formation rate. As dust and gas are intimately associated, the dust infrared continuum may provide a more feasible way to determine the total gas mass of galaxies at high redshift. To demonstrate the use of the IR continuum as a gas tracer we have compared the total gas mass and IR luminosity of a well-studied sample of 36 nearby galaxies (average distance 10 Mpc) observed with the KINGFISH (IR), THINGS (HI), and HERACLES ($CO_{(2-1)}$) surveys. These galaxies sample the peak of the mass function, with stellar masses from $\sim 10^{6.5}$ to $\sim 10^{10.5} M_\odot$, and, unlike the local merger-induced ULIRGs, these galaxies have disk-like morphologies that are likely more representative of the main-sequence galaxies at high redshift observed in current and future deep sub-mm surveys.

We find a strong correlation between the total gas mass and IR luminosity in all Herschel bands, with the strongest and tightest correlation found for the longest wavelength (SPIRE 500μm). The gas to luminosity ratio, M_{gas}/L_{500}, is found to increase with decreasing sub-mm luminosity, which can be ascribed to the declining metallicity associated with the lower galaxy masses of the low luminosity galaxies. This declining metallicity will lead to a lower dust to gas ratio, and therefore higher gas to dust luminosity ratio. . To minimize the effects of metallicity, we also fit only galaxies with stellar masses greater than $10^9 M_\odot$ in our sample, which also results in a significantly reduced dispersion. For the SPIRE 500 band we find that a linear relation is a reasonable approximation, and find that $\log(M_{gas}/L_{500}) = 28.5[M_\odot/L_\odot]$, with a dispersion of only 0.118 dex.

Reference

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