

The Relationship Between Dense Star Forming Gas, Bulk Molecular Gas, and Total Infrared Luminosity Along Spiral Arms in M51

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Abstract

We investigate the relationships between the dense molecular gas tracers, HCN ($J=1-0$) and HCO+ ($J=1-0$), bulk molecular gas, ^{12}CO ($J=1-0$), and total infrared luminosity in the nearby grand-design spiral galaxy, M51. Previous work has shown a near linear correlation between the total infrared luminosity and dense gas tracers luminosities between Galactic dense clumps and spirals and starburst galaxies. There is a relationship spanning nine-order of magnitude between the galactic and extragalactic measurements, however there is a three orders of magnitude gap separating the groups of measurements. Our aim is to study the relation between dense gas and star formation, including this relationship, by measuring HCN and HCO+ luminosities on and below kpc-scales filling in this gap. We find that both tracers do correlate with the infrared luminosity and the bulk molecular gas. In addition, we study the dense gas ratio by comparing the line ratios between HCN and HCO+ with CO in both the nucleus and along spiral arms. The HCN and HCO+ emission was mapped using interferometric observations from the Owens Valley Radio Observatory and Combined Array for Research in Millimeter Astronomy. Total infrared maps are made from Spitzer MIPS $24\mu\text{m}$ and Herschel PACS $70\mu\text{m}$ and $160\mu\text{m}$ maps. The ^{12}CO map is from the CANON survey.