

High-J CO as a Probe of Warm Molecular Gas in Galaxies: Herschel Evidence for Feedback and the Need for Future Far-Infrared Spectroscopy

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Abstract: High-J CO observations with the Herschel Space Observatory have revealed a luminous, warm component of molecular gas in luminous infrared galaxies. Generally, $\sim 90\%$ of the molecular gas appears in a cool, low-pressure component, which is responsible for 10% of the CO luminosity, and 10% of the mass is in a warm, high-pressure component that is responsible for 90% of the CO luminosity. Mechanical heating (shocks and turbulence) is an important source of heating of the high-pressure component, with contributions from photodissociation regions, X-ray dissociation regions, and cosmic rays, while the low-pressure component appears to be heated also. Characterizing the feedback from star formation and active galactic nuclei into the molecular interstellar medium and understanding the consequences for star formation and galaxy evolution will require sensitive future far-infrared observations with multiple probes of atomic and molecular gas. Sufficient angular resolution to separate physical conditions in nuclei, disks, and merger components will require a large aperture or interferometry.