ISO: a Novel Look at the Photodissociated Surfaces of Molecular Clouds

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Abstract

Photodissociation regions (PDRs) form at molecular cloud boundaries wherever the far-UV radiation strikes the cloud surface. They are transition layers between the dense, cold molecular gas and the tenuous, warm, ionized gas. The UV radiation here governs the chemical structure by dissociating H_2, CO, and other molecules, by ionizing carbon, silicon, or iron, e.g., and by heating the gas, mostly via photoelectric emission, to temperatures of order $10^2 - 10^3$ K.
PDRs are responsible for reprocessing much of the energy output from massive stars, reemitting this energy at other wavelengths, including a rich mixture of infrared lines. Especially through many lines not observable from the ground, ISO provides a window into the star formation environment, revealing the properties of the molecular gas near newly-formed massive stars, and clarifying important features in the overall spectrum of galaxies with significant star formation, particularly starburst galaxies.

ISO now yields beautiful spectra from various PDRs (S140, M17, NGC 7023, IC 1396, RCW 103, Orion ...) of H_2 rotational and rotation-vibrational transition lines and of fine structure lines such as the major coolants [OI]63,146μm, and [CII]158μm. These observations, in conjunction with ground-based imaging and theoretical modeling, now enable us to address outstanding problems such as the

- density structure and degree of clumpiness of gas in molecular clouds,
- temperature structure in PDRs, now indicating that the temperature in the H/H_2 transition region is higher (> 500K) than previously thought,
- abundances of elements such as oxygen, carbon, silicon, iron,
- effects of advection of gas through the PDR,
- H_2 formation rate coefficient at $T > 100$ K,
- level distribution of newly formed H_2,
- heating yield of photoelectron emission off dust grains,
- ortho-H_2 to para-H_2 abundance ratio,
- H-H_2 collisional excitation rate coefficients,
- nature of the extended warm molecular gas component.

Observations of a PDR near the supernova remnant RCW 103 may illuminate how molecular gas is excited and dissociated by X-rays, which is of great importance in starbursts and AGN.