

# 30 Years of Photodissociation Regions:

A symposium to honor David Hollenbach's lifetime in science  
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## Molecular gas in luminous galaxies

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We have investigated the minimum line information needed to determine molecular gas properties in galaxy centers, by collecting line fluxes (one <sup>13</sup>CO, two [CI], three CO transitions) in 76 galaxies. We find that a useful analysis of the simplest cases requires a minimum of five of these lines. The CO lines do not provide much information on the ISM in the parent galaxies, nor do the [CI] lines by themselves. Their luminosities poorly predict H<sub>2</sub> mass in any particular galaxy. However, taken together, they can be used to classify the parent galaxies in terms of ISM gas pressure, and the (U)LIRGs with the highest pressure are well described by single-gas-phase models. They are dominated by dense ( $10^4$ - $10^5$  cm<sup>-3</sup>) and warm gas (35 K) with low [<sup>13</sup>CO]/[<sup>12</sup>CO] and [C]/[CO] abundances. This analysis can also be used to determine molecular gas temperature, density, and mass in high-redshift galaxies and we have identified six redshift ranges for which all five lines required fall in atmospheric windows. In the more numerous, less luminous galaxies, lower-density gas is more important and a multiple-gas-phase analysis is needed, requiring better coverage of at least the <sup>12</sup>CO and <sup>13</sup>CO ladders, and preferably also the HCN, HNC, HCO<sup>+</sup> etc ladders for a more sophisticated treatment of the gas heating process (UV photons, X-ray photons, CRs, shocks etc) as pure-PDR models are no longer sufficient.