R05a Probing physical conditions of molecular gas in nearby galaxies with CO multi-line excitation analyses

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We investigate the radial variation in physical conditions (H_2 volume density, n_{H_2}; kinetic temperature, T_k; and $\left[^{12}\mathrm{CO}\right]$ / $\left[^{13}\mathrm{CO}\right]$ abundance, X_{13}) in nearby galaxies using CO multi-line excitation analyses, and explore correlations with other physical parameters in nearby galaxies. Using $^{12}\mathrm{CO}\,(J = 1 - 0)$, $^{13}\mathrm{CO}\,(J = 1 - 0)$, and $^{12}\mathrm{CO}\,(J = 2 - 1)$ archival data from COMING and HERACLES surveys, two intensity ratios R_{21} and $R_{13/12}$ are computed and fitted with models calculated with RADEX. Out of 20 galaxies in our sample, $R_{13/12}$ of 12 galaxies increases with galactocentric radius. We have found that n_{H_2} can be well-constrained and a decreasing trend with the galactocentric radius can be seen in most galaxies. Moreover, a positive correlation between $R_{13/12}$ and the derived n_{H_2} is seen when single value of X_{13} is fixed for the entire galaxy. However, when its value is set as a free parameter, the correlation between $R_{13/12}$ and n_{H_2} disappear. In some galaxies a positive correlation between n_{H_2} and star formation efficiency, which has been found previously in NGC 2903 and NGC 4303, can be seen regardless of the adopted value of X_{13}. Furthermore, when considering only emissions from ^{13}CO-detected regions which picks up only emissions from cloud-phase gas, the derived n_{H_2} is higher in many regions, since ^{13}CO emission comes from denser gas components. The dependency of the derived values on ^{13}CO emission suggests that to perform similar analysis, the existence of cloud-phase gas must be carefully considered.