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The Influence of Environmental Conditions on the CO-to-H_2 Ratio

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Abstract. A reliable estimate of the molecular gas content in galaxies plays a crucial role in determining their dynamical properties and star formation efficiency. However, H_2, the dominant molecular species, is difficult to observe directly, particularly in the regions where most molecular gas is thought to reside. Its mass is therefore commonly inferred by assuming a direct proportionality with the integrated intensity of the $CO(J = 1-0)$ emission line toward a source, since this line is readily observable and has been detected in many giant molecular clouds within the Milky Way and in galaxies out to redshifts of $z = 6$. The conversion factor is often referred to as the CO-to-H_2 ratio and a canonical value has been derived from observations of local molecular clouds. Although this value is used extensively, there is increasing evidence, both theoretical and observational, that the CO-to-H_2 ratio may vary by over an order of magnitude under conditions different from those of the local neighbourhood. In an effort to understand the influence of changing environmental conditions on the CO-to-H_2 ratio, we derive theoretical estimates of the ratio for a wide range of physical parameters using the UCL_PDR photon-dominated region (PDR) chemical model, benchmarking key results against those of the Meudon PDR code to ensure agreement. Based on these results, the dependence of the CO-to-H2 ratio on each physical parameter is interpreted in terms of the chemistry and physical processes within the cloud. We find that the time-dependence of the chemistry, often neglected in such models, is of considerable importance to the ratio.

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