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Complex molecules in diffuse clouds observed at radiofrequencies

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Abstract. Complex molecules are commonly studied in dense interstellar gas *via* their cm and mm-wave rotational emission spectra but mm-wave absorption spectra from the Plateau de Bure Interferometer reveal a complex polyatomic chemistry even in regions of surprisingly low extinction and pressure, *i.e* in typical "diffuse clouds". In these regions, C^+ is the dominant form of carbon and CO has 0.1%–3% of the expected amount of gas-phase carbon (Liszt & Lucas 1998). Molecular absorption lines from CO, HCO^+, C_2H, *etc.* appear even when CO emission is undetectable, indicating that the polyatomic chemistry accompanies the turn-on of molecular hydrogen itself in regions of low density and pressure which nonetheless are non-negligibly molecular. At radio wavelengths, HCO^+ absorption (not CO emission) is the avatar of the molecular component of diffuse gas (Lucas & Liszt 1996), although the observed amounts of CO follow directly from the recombination of the observed amounts of HCO^+ (Liszt & Lucas 2000).

Strong linear relationships are found among the abundances of species in related chemical families, as for CN, HCN, and HNC (Liszt & Lucas 2001); OH and HCO^+(Lucas & Liszt 1996; Liszt & Lucas 1996); C_2H and C_3H_2(Cox et al. 1988; Lucas & Liszt 2000); or CS and H_2S (Lucas & Liszt 2002). Abundances of CS and HCN are also well linearly correlated, as are those of H_2CO and NH_3 when both are seen ((Nash 1990)). Overall, relative abundances with respect to HCO^+ are in many cases surprisingly like those quoted for TMC-1. Somehow, the molecules manage to exist in relatively unshielded, partially-molecular regions of moderate number density and comparatively high electron and proton abundance. Unlike H_3^+ whose relatively high abundance in diffuse gas (McCall et al. 2002) can be explained solely by increasing the assumed cosmic-ray ionization rate by an order of magnitude (Liszt 2003), no such comprehensive explanation exists for the overabundances of HCO^+, HCN, CS, H_2S, NH_3 *etc.*; discrepancies between observation and quiescent gas-phase chemical models of low-density regions (**???**) range from one to many orders of magnitude, bracketing (and greatly extending and generalizing) the famous, long-unsolved "CH^+ problem."

Although CO emission significantly underrepresents the full extent of molecular conversion in the diffuse neutral gas, it has a significant influence on the CO sky. CO emission from individual features can be surprisingly intense, typically 3 K. Furthermore, ^{13}C is fractionated into CO (Liszt & Lucas 1998) so that the $N(^{12}CO)/N(^{13}CO)$ ratio is substantially smaller than the carbon isotope ratio (60-65; (Lucas & Liszt 1998)), in turn causing the $^{12}CO/^{13}CO$ emission brightness ratio to be $<< 60$, thereby mimicking the appearance of optically thick CO emission. We find that some low latitude lines of sight having quite high total extinction and large integrated CO intensity harbor no dense gas, but rather are comprised of high atomic gas column densities and multiple, kinematically distinct diffuse clouds with larger H_2 fractions.

Keywords. ISM, Molecules

References

Cox, P., Güsten, R., & Henkel, C. 1988, A&A, 206, 108
Liszt, H. 2003, A&A, 398, 621
Liszt, H. & Lucas, R. 2001, A&A, 370, 576
Liszt, H. S. & Lucas, R. 1996, A&A, 314, 917
—. 1998, A&A, 339, 561
—. 2000, A&A, 355, 333
Lucas, R. & Liszt, H. 1998, A&A, 337, 246
Lucas, R. & Liszt, H. S. 1996, A&A, 307, 237
—. 2000, A&A, 358, 1069
—. 2002, A&A, 384, 1054
McCall, B. J., Hinkle, K. H., Geballe, T. R., Moriarty-Schieven, G. H., Evans, N. J., Kawaguchi, K., Takano, S., Smith, V. V., & Oka, T. 2002, ApJ, 567, 391
Nash, A. G. 1990, Astrophys. J., Suppl. Ser., 72, 303