CO depletion in ATLASGAL-selected high-mass clumps

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In the low-mass regime, it is found that the abundances of C-bearing molecules rapidly decrease with radius in starless cores, where the density is very high and the temperature is very low. Here the molecules tend to stick to the grains, forming ice mantles.

We observed low-J transitions of several CO isotopologues in 870 μm-bright clumps of the ATLASGAL survey, to investigate the depletion of carbon monoxide in regions of (potential) massive star formation, where not so much is known about this key parameter and its evolution with time.

The sample is selected to include the brightest sources in the sub-mm in different evolutionary stages, from IR-bright to 24 μm-dark sources. We find that, just like for low-mass cores, depletion of CO is relevant in massive sources during their early life, and varies with time. Older clumps with mid-IR emission show values of the depletion factor f_D about $3-10$ times lower than in younger IR-dark objects, whose f_D may be as large as ~ 20. The larger depletion found in IR-dark clumps was confirmed with one-dimensional models made with RATRAN, to take into account possible non-LTE effects. Therefore, also in high-mass objects carbon monoxide is frozen onto grains in the earliest stages, before the feedback from star formation evaporates the molecules back into the gas phase. The column- and volume densities are also found to correlate with the depletion factor: denser sources have a larger f_D, on average.

Alternatively, the observations can be reproduced by models with a central drop in CO abundance, rather than a constant one. This model, as well as the comparison of typical lifetimes with the timescale for depletion as a function of radius suggest that the radius of the central depletion hole is roughly in the range $\sim 0.02-0.1$ pc.