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Andrea Giannetti - Methanol to the rescue: estimating volume density of molecular gas

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Estimates of volume densities (n_H2) are still very uncertain, despite being fundamental to determine the stability of molecular condensations on all scales, from clouds to cores, to protostellar- and protoplanetary disks, their energy balance, and their chemical evolution. While in principle it is easy to use molecular emission to infer the density of the emitting gas, in practice these estimates depend critically on the temperature and chemical stratification of the tracer, and on the calibration accuracy of the data. Therefore, another method has been designed as the default: the volume density is estimated from the column density of H2, derived from dust emission, using as the spatial extent along the line-of-sight the average size of the object projected on the plane of the sky. This method too is plagued by significant uncertainties. The results rest on simplistic assumptions about the geometry of the object (spherical, cylindrical, etc.), that do not even consider the observed aspect ratios on the plane of the sky, let alone the uncertainty of the gas-to-dust ratio. To overcome this impasse, we developed a new framework to estimate n_H2 from CH3OH line ratios, independently of geometry and of temperature distribution. CH3OH uniquely offers lines that are quasi-exclusively sensitive to the density and can be observed in a single tuning, removing calibration uncertainties. Methanol is also widespread, tracing both cold and hot gas, making this probe ideal to be used on most scales and stages of star- and planet- formation. Our framework will bring comparisons between models and observations to an entirely new level by mapping the density distribution (e.g. helping to determine the stability of molecular fragments, their mass independently of the temperature, and their chemical evolution), and will allow to reconstruct the 3D structure of molecular condensations, revealing the intimate details of the star-formation process.

Session Classification: Milky Way