Tracing the Flow in Massive Molecular Clumps: New Results from CHaMP

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We present a newly-calibrated CO mass conversion law from the CHaMP project, $N_{12CO} = (4.0 \pm 0.3) \times 10^{19}$ molec.m^{-2} $(I_{12CO}/\mathrm{K.km.s}^{-1})^{(1.27 \pm 0.02)}$ for 12CO integrated intensities, based on radiative transfer analysis of CO-isotopologue data for ∼300 massive molecular clumps in the Milky Way. For velocity-resolved data, the exponent in this law is even higher, 1.92±0.05 when averaged over all clumps, but ranging from 1.5 to 2.2 in different clouds. These non-linear relations confirm an overall 2-3× higher total molecular mass for Milky Way clouds, compared to the standard X factor. We use these laws to compare the kinematics of clump interiors with their foreground 12CO envelopes, and show that most clumps are not dynamically uniform: irregular portions are either slowly accreting onto the interiors, or dispersing from them, at relative speeds ∼0.1-0.2 km/s. We compute the spatially-resolved mass accretion / dispersal rate across all clumps, and map the local flow timescale. While these flows are not clearly correlated with clump structures, the accretion rate is a statistically strong function of the local mass surface density, implying near-exponential growth or loss of mass over timescales ∼10-100 Myr. At high enough surface density, accretion dominates, suggesting gravity plays an important role in both processes. This sedimentation picture supports arguments for long clump lifetimes mediated by pressure confinement, with a terminal crescendo of star formation, suggesting a resolution to the 40-yr-old puzzle of the dynamical state of molecular clouds and their low star formation efficiency.

Molecular Clouds