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Effective Shielding of $\lesssim$ 10 GeV Cosmic Rays from Dense Molecular Clumps

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The density of cosmic rays (CRs) inside molecular clouds determines the ionization rate in the dense cores where stars form. It is also one of the drivers of astrochemistry leading to the creation of complex molecules. Through *Fermi*-LAT observations of nearby giant molecular clouds (GMCs), we observed deficits (holes) in the gamma-ray residual map when modeling with the expected gamma-ray diffuse emission from uniform CRs interacting with the molecular content. We propose the deficit is due to the lack of penetration of the low energy (sub-GeV to GeV) CRs into denser regions or clumps. This differs from the prevailing view of fast CRs transport in GMCs where the magnetic turbulence is suppressed by neutral-ion damping, as our results require a slow diffusion inside dense molecular clumps. Through modelling, we find that while the shielding is negligible on the cloud scale it becomes important in the denser, pc-sized regions where the gravitational collapse is already at play, changing the initial condition of star formation and astrochemistry.

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