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The role of unresolved sources on the gamma-ray spectra of molecular clouds

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Galactic diffuse emission in the MeV-GeV energy band is mostly contributed by the interaction of cosmic-ray (CR) nuclei with the dense interstellar medium (ISM). Observations of this radiation bring priceless information regarding the spatial and spectral distribution of CRs in the Galaxy far from the Solar System. Fermi-LAT observations of large-scale emission and of molecular clouds unveiled that in some locations, towards the inner Galaxy, the spectrum is harder than what was measured at Earth. In order to correctly interpret the data, however, one needs to differentiate the contribution of the "truly" diffuse emission, namely the one contributed by the bulk of CRs interacting with the ISM, from the contribution of unresolved sources. The latter constitute a non-negligible component that adds up to the large-scale gamma-ray flux. Previous studies constrained this contribution to be less than 20% at GeV energies, but they disregarded the contribution of pulsar wind nebulae (PWNe) in this band, as PWNe are mostly detected at higher energies. Newly developed theoretical models account for this source population and showed that their cumulative flux significantly shapes the spectrum of the diffusion emission, therefore challenging the conclusions about a spectral hardening of the CR flux towards the center of the Galaxy. In light of the newest theoretical results, we discuss here the contribution that this unresolved source population provides to the observed spectra of the diffuse emission with a particular focus on molecular clouds. Being this contribution subject to the observed angular size, we expect it to be less important when observing smaller regions. We discuss the influence of unresolved sources on clouds of different sizes and locations and give a prescription on how to choose the regions to target in order to have an unbiased determination of the "truly" diffuse emission.

Summary

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