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CR diffusion in a dwarf galaxy and the γ-ray-FIR relation

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Cosmic-ray feedback is suspected to affect star formation in molecular clouds by providing pressure support comparable to the thermal and magnetic ones. Thanks to numerical simulations, this extra support is known to drive galactic winds and thicken the galactic disc. The feedback efficiency, however, depends on CR transport properties which locally vary with interstellar turbulence, gas ionisation, and magnetic field line tangling, so we need to find observational clues about actual CR propagation properties in the different interstellar phases.
As a first step toward searching for new observational diagnostics, we have simulated the evolution of a gas-rich dwarf galaxy ($\sim 10^{11}$ $M_\odot$ in total mass) with the adaptive mesh refinement code RAMSES, with 9 pc resolution. These simulations include cosmic rays that are advected by the gas and that diffuse either isotropically or along the magnetic field with uniform diffusion coefficients ranging from 3×10^{27} to 10^{29} cm^2 s^{-1}, to bracket the value inferred for the Milky Way. The simulation models the multiphasic structure of the interstellar medium. Unlike in other simulations, we find that the global γ-ray luminosities and star-formation rates of the simulated galaxies compare well with the observed γ-ray-FIR relation for anisotropic $10^{27.5-29}$ cm^2 s^{-1} diffusion and for isotropic diffusion slower than about 3×10^{28}cm^2 s^{-1}. Our results, therefore, do not confirm claims of very fast diffusion 10^{29-31} cm^2 s^{-1} to match the Fermi LAT observations. We also observe positive feedback of CR rays on the amplification of the magnetic field in the inner halves of the galaxies, except for fast isotropic diffusion. Whereas the global mass in the different gas phases is marginally altered when changing CR transport, the magnetic amplification can suppress star formation by a factor of three to four.

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