Cooler and smoother – the impact of cosmic rays on the phase structure of galactic outflows

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Abstract

Cosmic rays are an important energy component in the interstellar medium with energy densities comparable to the thermal and magnetic one but with different transport and cooling processes compared to the thermal gas. CRs diffuse relative to the gas and thus transport a significant fraction of the energy away from their production sites throughout the interstellar medium and into the halo. Using three-dimensional magneto-hydrodynamical simulations including CRs as a relativistic interacting fluid, we investigate their dynamical and chemical impact on the interstellar medium and molecular clouds. We find that only 5-10 percent of the CR energy injected by SNe is lost via hadronic interactions. The remaining CRs can thicken the galactic disk and delay the formation of molecular clouds. They drive strong and smooth outflows with mass loading factors or order unity. The outflows mainly consist of warm atomic gas. In addition, we extend the classical advection-diffusion approximation for CRs with a spectral method in order to cover the large energy range and the accurate energy dependent interactions. Our novel, non-dissipative implementation allows us to span the regime from MeV to TeV and accurately account for CR losses, pressure and diffusion in every computational cell.

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