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Diffusion and Anisotropy of Cosmic Rays in the Galaxy: Beyond the Dipole

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The transport of Galactic cosmic rays in both turbulent and regular magnetic fields can be described in terms of diffusion and drift motions. These produce gradients of cosmic-ray densities. The anisotropy resulting from these gradients for an observer located anywhere in the Galaxy is commonly described in terms of a pure dipole moment, the amplitude of which is proportional to the gradient at the observer point normalised by the density at the same observer point. By calculating the angular distribution on the sphere of the observer in the specific case of cosmic rays propagating diffusively from a single source, we show that this recipe to estimate the dipole moment is only an approximation, and that higher order moments are actually also expected. Since a dipole moment is by essence a vector, it is conceivable to build configurations of sources where the global vector cancels even with a non-vanishing gradient of cosmic-ray density. In this case, the non- vanishing gradient would show up at higher order moments that do not add linearly, such as the moment describing a symmetric quadrupole. Although the dipole moment is expected to remain dominant for an observer located on Earth and for sources distributed in the Galactic disk, the description given in this paper of the anisotropy expected within a pure diffusion model could contribute to some extent to explain the observed anisotropies of low-energy cosmic rays beyond the dipole.

Collaboration

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