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A perturbative approach to a nonlinear advection-diffusion equation of particle transport

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We explore analytical techniques for modeling the nonlinear cosmic ray transport in various astrophysical environments which is of significant current research interest. While nonlinearity is most often described by coupled equations for the dynamics of the
thermal plasma and the cosmic ray transport or for the transport of the plasma waves and the cosmic rays, we
study the case of a single but nonlinear advection-diffusion equation. The latter can be approximately solved analytically or semi-analytically, with the advantage that these solutions are easy to use and, thus, can facilitate a quantitative comparison to data. We present our previous work in a twofold manner.
First, instead of employing an integral method to the case of pure nonlinear diffusion, we apply an expansion technique to the advection-diffusion equation. We use the technique systematically to analyze the effect of nonlinear diffusion for the cases of constant and spatially varying advection
combined with time-varying source functions. Second, we extend the study from the one-dimensional, Cartesian
geometry to the radially symmetric case, which allows us to treat more accurately the nonlinear diffusion problems on larger scales
away from the source. The results are compared to numerical solutions, which are also extended to more complex situations.

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Collaboration

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Subcategory

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