Time-dependent treatment of cosmic-ray spectral steepening due to turbulence driving

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Short summary for ICRC 2021

1 Introduction

Cosmic rays at shocks drive turbulence, which constitutes energy loss and may eventually soften the particle spectra. An earlier study based on steady-state consideration for Bell's mode suggested a significant effect. We present a temporally and spatially resolved analysis that can account for the limited time available for turbulence driving and nonlinear energy transfer in the cosmic-ray precursor.

2 Results

We find a weak spectral effect of turbulence driving.

- For large Alfvénic Mach number of the thermal sub-shock, the change in spectral index is $\Delta s \ll 1$.
- For small M_A the growth rate of the turbulence is small, and the spectral steepening is likewise weak.
- For $M_\mathrm{A} \lesssim 10$ the modification of the shock compression ratio by the magnetic field can be more important for the spectra than is turbulence driving.

To conclude, driving Bell's mode non-relativistic shocks can likely not explain the soft particle spectra observed in, e.g., supernova remnants.