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A long-wavelength instability involving the stress tensor

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(Submitted on 28 Jul 2011)

Cosmic ray acceleration through first-order Fermi acceleration in a collisionless plasma relies on efficient scattering off magnetic field fluctuations. Scattering is most efficient for magnetic field fluctuations with wavelengths on the order of the gyroradius of the particles. In order to determine the highest energy to which cosmic rays can be accelerated, it is important to understand the growth of the magnetic field on these large scales. We derive the growth rate of the long-wavelength fluctuations in the linear regime, using the kinetic equation coupled to Maxwell's equations for the background plasma. The instability, driven by the cosmic ray current, acts on large scales due to the stress tensor and efficient scattering on small scales, and operates for both left- and right circular polarisations. This long-wavelength instability is potentially important in determining the acceleration efficiency and maximum energy of cosmic rays around shock waves such as in supernova remnants.

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