EFFECTS OF THE BACKGROUND TURBULENCE ON THE RELAXATION OF ION CYCLOTRON AND FIREHOSE INSTABILITIES AND ITS ROLE ON TEMPERATURE ANISOTROPY PRODUCTION IN THE SOLAR WIND

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Abstract:

Turbulence in space plasmas usually exhibits two regimes separated by a spectral break that divides the so called inertial and kinetic ranges. Large scale magnetic fluctuations are dominated by non-linear MHD wave-wave interactions following a −5/3 or −2 slope power-law spectrum. After the break, at scales in which kinetic effects take place, the magnetic spectrum follows a steeper power-law $k{-}\alpha$ shape given by a spectral index $\alpha > 5/3$. Despite its ubiquitousness, the possible effects of a turbulent background spectrum in the quasilinear relaxation of solar wind temperatures are usually not considered. In this work, a quasilinear kinetic theory is used to study the evolution of the proton temperatures in an initially turbulent collisionless plasma composed by cold electrons and bi-Maxwellian protons, in which electromagnetic waves propagate along a background magnetic field [1]. Considering Ion-Cyclotron waves, we show that a sufficient turbulent magnetic power can drive stable protons to transverse heating, resulting in an increase in the temperature anisotropy and the reduction of the parallel proton beta. Similarly, considering fast magnetosonic waves, our results show that, depending on the value of beta, a turbulent spectrum of magnetosonic modes leads an initially thermally isotropic plasma to develop anisotropic states in which $T_{\perp} < T_{||}$, which in turn may excite firehose instabilities that regulate the anisotropy production. Thus, in either case stable proton velocity distribution can evolve in such a way as to develop kinetic instabilities. This may explain why the constituents of the solar wind can be observed far from thermodynamic equilibrium and near the instability thresholds.

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References:

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