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Weak Turbulence Effects in Space Plasmas[1]

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With the advent of multi-satellite missions such as Cluster and the Radiation Belt Storm Probes (RBSP) space plasmas have become a rich laboratory for the detailed and fundamental study of plasma turbulence. Space offers a diversity of plasma environments to directly test theory and simulation, from high-β plasmas in the solar-wind and the Earth's magnetotail, to low-β multi-species plasmas in the radiation belts and ionosphere. Recent theoretical work has demonstrated that by considering the effects of induced non-linear scattering (non-linear Landau damping, to be referred to as NL scattering) of electromagnetic waves leads to testable predictions in both storm-time radiation belt plasmas and the solar wind turbulent spectrum at scales below the ion gyroradius. In the radiation belts, VLF waves (with frequencies between the ion and electron gyrofrequencies) of sufficient amplitude may be nonlinearly scattered near the lower-hybrid surface inside the plasmasphere. Upon scattering a portion of these waves can return to the ionosphere where they may be reflected. This process can lead to the formation of a VLF wave cavity [1] that can efficiently resonate with the energetic (MeV) trapped electron population and quickly precipitate these particles into the ionosphere [2]. In the solar wind, the large-scale Alfvenic fluctuations can be shown to lead to a plateau in the electron distribution function that reduces the Landau damping of kinetic Alfven waves (KaWs). With the reduction of the linear damping the NL scattering of KAWs becomes important and leads to a non-local redistribution of energy in k-space and results in a steeper turbulent spectrum [3]. The edges of the plateaus are also unstable to electromagnetic left hand polarized ion cyclotron-Alfven waves as well as right hand polarized magnetosonic-whistler waves. These waves can pitch angle scatter the ion super-thermal velocity component to provide perpendicular ion heating [4].

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