Generation of magnetospheric whistler-mode waves by kappa electron distributions

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Kappa particle distributions are ubiquitous in space plasmas and characterize distributions with a high-energy power-law tail. Here we assume that whistler-mode waves are generated by a small,hot anisotropic electron population in the presence of a cold background plasma with neutralizing ions. The hot electrons are modeled by a bi-kappa momentum distribution with spectral index kappa.The waves are assumed to be field-aligned and satisfy the cold plasma dispersion relation. Typical parameter values for the Earth's inner magnetosphere are assumed. The influence of the spectral index on the linear wave growth rate is found to be subtle. Specfically,we find that the growth rate corresponding to the bi-kappa distributiion dominates that for the bi-Maxwellian distribution for electron anisotropy A values less than a critical value. For electron anisotropy values greater than the critical value,the reverse is true. We find that the influence of the spectral index on the threshold wave amplitude for nonlinear wave growth likewise depends importantly on the electron anisotropy A as well as the wave frequency. We plot model nonlinear chorus-wave elements and find that the chorus frequency sweep (chirp) rates typically increase as the spectral index kappa is increased. Further,we examine the influence of the spectral index on the chorus wave generation region in (A,n)-space where n is the hot electron number density. We find that whether or not the extent of the chorus generation region corresponding to the bi-kappa distribution is greater than that for the bi-Maxwellian distribution depends for instance on the value of the parallel thermal momentum parameter for the hot electron population. Overall, we find that a suprathermal hot electron population may strongly enhance or suppress whistler-mode wave instability dependent on the values of the system parameters.

Keywords: whistler-mode waves, kappa distributions, chorus wave generation

