The theory and numerical modelling of non linear wave particle interactions in oblique whistlers

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Abstract

This research extends the excellent work of Bell and co-workers [3] who investigated in detail the complex equations of motion and trapping conditions of electrons resonant with whistlers propagating obliquely at an angle θ to the local magnetic field in the earth's magnetosphere. Cluster data points to oblique propagation and there are numerous satellite observations of chorus propagating at wide angles particularly at the Gendrin angle.

The developed MATLAB code is fully relativistic one dimensional and non selfconsistent in which the assumed wavefield is very flexible and has amplitude, propagation and frequency as arbitrary functions of z and t. In addition a detailed model of a chorus element based on the theory of Omura [1,2] may be employed. We have developed the novel concept of a generalised phase for resonance of order n, which enables huge savings of computation time and allows the code to operate at any resonance order n with a single command. Following Bell [3] we assume separability of all resonances. By backward trajectory integration and application of Liouville's theorem the distribution function about resonance may be calculated for any z,t, with any suitable choice of zero order df, e.g. bi-Maxwellian with loss cone. Further the non linear resonant particle current is computed and thus the localised non linear growth rate as well as 'reactive power'.

It is found that all resonances obey the trapping equation, though for example resonances n=-1 and n=2 require largish amplitudes and wide propagation angles for trapping. For example with wave amplitude of 80pT and θ=40 degrees for n=-1 strong trapping results. Using the chorus element wavefield model we found very strong trapping at n=1 resonance with a pronounced hole in the distribution function corresponding to the resonant particle trap. For the same wavefield the landau resonance n=0 was also non linear producing a 'hill' in distribution corresponding to the resonant trap.

By following resonant particle trajectories forwards in time the code is able to investigate both particle energisation and also particle precipitation. In the case of the chorus element wavefield model particle energisation from a one pass interaction up to 0.4keV was found for both n=1 and n=0 resonances.

References

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