

Study on prior information suitable for wave distribution function method

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The plasma waves propagating in the Earth's magnetosphere are influenced by plasmas on the propagation path in the generation and propagation process. In order to deeply understand the space plasma environment, in situ plasma wave observations by scientific satellites are indispensable. Spectral matrices which consist of cross spectra of electromagnetic field components are generally used for polarization analysis and direction finding of plasma waves.

On the plasma wave experiment (PWE) aboard the ERG mission, power spectra and spectral matrices of VLF waves are generated onboard and transmitted continuously to the Earth. These data are used in order to decide downlink timings of the high-resolution waveform data which are transmitted intermittently.

Conventional methods of direction-finding of VLF waves using a spectral matrix are classified as follows. One is based on the plane-wave approximation such as Means method, and the other is the wave distribution function (WDF) method which regards observed signals as random waves. The WDF method estimates direction of arrival for multiple waves included in observed signals, and the number of the model parameters is generally more than the number of the input data components. We therefore cannot determine the solution uniquely, and we need some prior information (model) in order to obtain the unique solution. Until now, the many models have been proposed. However, the estimated images are sensitive to the models, and we must evaluate the validity of the solutions by confirming the results of all the models. There are two problems that the validity of the WDF method cannot insure and its confirmation process is difficult for the users of the WDF method. In the present study, we proposed a new WDF method without arbitrary assumption. This method is based on the boundedness of the solution set which is derived from the properties of the spectral matrices and the wave distribution function. Since the new method assumes a uniform distribution on the solution set and calculates statistic such as average and confidential intervals as estimated results, it doesn't need any models in order to obtain a unique solution. We also consider an evaluation method of the validity of models using some model selection references.

Keywords: Waves in plasma, Ill-posed Problem, Wave distribution function method, Model selection