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Study on direction finding method based on sparsity

OTA, Mamoru[1*] ; KASAHARA, Yoshiya[1] ; GOTO, Yoshitaka[1]

[1]Kanazawa University

Investigating characteristics of plasma waves observed by scientific satellites in the Earth's magnetosphere is the effective key to understand not only generation mechanisms of the waves but also a plasma environment which influences its generation and propagation conditions. In particular, direction finding of the waves is important for understanding the propagation characteristics of VLF waves. In order to find the directions, the wave distribution function (WDF) method was proposed. This method can estimate direction of arrival for multiple waves included in electromagnetic waves observed by the satellite, and the estimated direction is represented as wave energy density distribution (WDF). For the estimation of WDFs, this method uses dispersion relation for the plasma surrounding the satellite. However, this estimation is an ill-posed problem and cannot determine a unique solution. In order to obtain a unique solution, therefore, we need to give some prior information. In previous work, some models were proposed as the prior information, and its performance was evaluated by using computer-generated data.

In the present study, we propose a new method using a sparsity assumption of the WDF. This assumption expresses that the effective direction of arrival to explain the data is a smaller number, therefore, it can be expected that the reconstructed WDF by the new method is more precise than conventional methods. In conventional evaluations, the spectral matrix which is used as the input data of the estimation was assumed precisely calculable. However, in the case of the actual observation data, there is a problem about how to calculate precise spectral matrix. We examined the problem that arises in the case that the WDF method is applied for the actual observation data.

Keywords: Waves in plasma, Ill-posed problem, Wave distribution function, Sparsity