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An Entropy Regularization Method Applied to the Wave Distribution Function Identification

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We present a new technique based on entropy regularization to compute the electromagnetic wave energy density from field measurements. It is based on the concept of the wave distribution function (WDF) introduced in the 70's to study the propagation of electromagnetic waves in plasma and, in particular, to determine the directional distribution of the wave energy. The WDF determination is by nature an ill-posed inverse problem: an infinite number of solutions may be found. The entropy regularization turns out to be a good way to determine a unique and stable solution which only contains the information required by the data. An algorithm has been developped for this task. To assess its suitability and efficiency, the algorithm is applied to experimental data recorded in the magnetosphere. The results are compared with solutions obtained by other inversion techniques, namely the maximum entropy and the gaussian peak methods. Statistical tests are performed to verify and quantify the solution stability. The ability of the method to detect plane waves is also investigated. All this goes to show that the entropy regularization algorithm is a powerful tool to analyze wave characteristics in space plasmas. It does not need any assumptions, for example, about the shape of the WDF and no specific parameters have to be anticipated. It is therefore suitable for statistical analysis.