# Extracting Plasma Frequencies from High Resolution Arecibo Plasma Line Data: Developing the Model and Fitting Techniques

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Extracting plasma frequencies from a set of high resolution plasma line spectra with reasonable accuracy is easy when the signal to noise ratio is good, but this task is much harder when the best possible accuracy is required under less than optimum conditions, that is, at the altitude extremes, when the height gradient in plasma frequency is very large, or some combination of the two. This paper describes a fitting technique that allows essentially all the information to be used in the resulting plasma frequency profiles. It does not apply when strong thin layers are present in the E region.

The radar technique uses random codes (coded long pulse technique) to measure plasma line spectra in the E and (primarily) F regions of the ionosphere with either 150 or 300 meter resolution. Although such high resolution is not necessary to follow the profile variations in the F region, it is necessary in order to make use of the information potentially available from the scatter because it allows the measurement of many independent spectra that are quite narrow when the height gradient is small. When the gradient is large a similar total power is spread over a wider frequency range, and the signal to noise ratio can become small, especially at high altitudes where the scatter is weak or even at lower altitudes when the gradient is very large.

In such circumstances a fitting technique that uses the information in the entire profile (or a substantial portion of it) simultaneously is required. Except when the gradient is quite small, the width of the spectrum is determined nearly entirely by the gradient of the profile. That is, the profile of plasma frequencies determines the widths of the measured spectra. This is a constraint that must be used in the model if all the information is to be extracted, and it is a constraint very unlike that occurring in fitting the ion line of incoherent scatter. A model incorporating this functionality is non-linear and requires iteration to minimize the differences between the model and measurements, generally the LM algorithm. The profiles of frequency and amplitude are determined by cubic splines.

However, a set of spectra in which the widths can be as much as a thousand times smaller that the frequency range of the spectral centers is difficult to work with because the initial conditions for starting the iteration must be very accurate. A pre-filtering operation with a detection of maxima is necessary, one supporting different bandwidths in different parts of the range-frequency space. The techniques under investigation use linear least squares fitting and a set of basis functions, generated for example, by bi-cubic spline interpolation of a set of delta functions.