Extracting Plasma Frequency Profiles from Arecibo Spectral Data Sets

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High resolution measurements of the photo-electron enhanced plasma line using the coded long pulse technique have been carried out at Arecibo for more than a decade and a half. As data storage and computational capabilities have increased, the applicability of this demanding technique has broadened, so that it will soon be the standard for measuring electron densities, and other plasma parameters at Arecibo when the photo-electrons are present. Thus, we have developed a new technique for determining the range profiles of the plasma frequency from the data set consisting of at least 2,000 spectra of 4096 or more points measured about every ten seconds. Since recent applications use the difference between the up- and down- shifted measurements, very accurate profiles with small statistical errors are necessary.

The technique is applicable in the F region of the ionosphere where the plasma frequency profiles are smooth, meaning that the variation over a number of range gates can be described by a significantly smaller number of parameters. In this regime, the variation of the plasma frequency over a suitable range is typically much larger than the width of the spectra at the individual ranges, and so simple range averaging techniques are not useful. The new technique involves summing spectra along a curve that establishes their centers in frequency and range. Cubic spline interpolation determines the shape of the curve, and the parameters are varied in a systematic way in order to maximize the spectral sum.

At Arecibo, the plasma line spectrum generally has a signal to noise ratio that is greater than unity in most of the F region when measured with a one or two μ second (150 or 300 meter) resolution. In this region the technique enables very accurate determination of the frequency differences between the up- and down-shifted plasma lines. At higher altitudes where the signal becomes weaker, the technique is capable of measuring the plasma frequency profile even when the individual spectra are not distinguishable from the noise and clutter.