INVERTING ARECIBO PLASMA RESONANCE MEASUREMENTS TO RECOVER ELECTRON TEMPERATURE AND DENSITY

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Most measurements of the plasma resonance frequency using the Arecibo 430 MHz radar use a spectral technique with high range resolution but low enough sensitivity so that these measurements are useful only when the line is so narrow, that is, sufficiently high electron density and low electron temperature. Thus the frequency information is limited to the center frequency, rather than spectral shape, or in the case of measurements of both the up and down shifted plasma lines, the small differences between the two as well.

When the pair of measurements is available, it is possible to derive the electron temperature, although possibly not without some ambiguity, and the electron density with very high accuracy. This inversion process is not as straight forward as it might seem because the simple familiar Langmuir dispersion relationship is not sufficiently accurate over much of the parameter range in the ionosphere. Thus it is necessary to construct a model using the theory of incoherent scatter. This paper describes a technique for performing the inversion.

The forward theory is used to predict the two plasma resonance values from the electron density, temperature, and other parameters. The inverse process must find the temperature and density corresponding to a pair of frequency measurements, expressed as average and difference. Suppose one used the theory to compute a vast number of corresponding pairs. Then, it is only necessary to search through the frequency pairs resulting from the calculations to find one that very closely matches the result of a measurement, and then take the the temperature and density pair used in its calculation. This is not practical.

However, it is practical to compute and search through a sufficient quantity in order to allow accurate interpolation. Two dimensional quadratic interpolation is used for both unknowns. The six nearest pairs are chosen, using a definition of distance that weights the two coordinates equally. The question of how to distribute the calculated pairs in density and temperature space arises, so that a reasonable distribution in frequency pair space results. It turns out that a random distribution over the necessary density/temperature area works out very well. Only a few thousand computed points are necessary, giving fast execution.

The process has been verified by generating simulated data. Many assumed temperature/density pairs are used to calculate the frequency pairs which are then run through the inversion process. An analysis of the resulting deviations from the initially assumed values shows that they are randomly distributed with sigmas hundreds of times lower than those resulting from the random errors in the actual measurements, and so the statistical nature of the inversion is unimportant.