Split–beam Studies of the Effect of Electron Collisions on ISR Spectra Near k ⊥ B

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Sulzer and Gonzales [October 1999 JGR] first pointed out that electron collisions will affect the spectrum and auto–correlation function (ACF) of incoherent scatter echoes when the beam is pointed very nearly perpendicular to the magnetic field, and that furthermore this effect, if neglected, will cause the Te/Ti ratio to be underestimated. There are various theoretical models of this effect, in particular the relatively simple BGK and Fokker–Planck models and the much more complicated numerical simulations of Sulzer and Gonzales. The Sulzer and Gonzales simulations predict larger effects than do the simpler models.

In an effort to test these models, we divided the Jicamarca radar into two beams, each with half the power and half the antenna of the full system, and ran the standard double pulse Faraday/ACF mode that gives ACFs in the F region. With split beams each beam has only one quarter of the signal–to–noise ratio of the full system, but it allows us to measure at two different aspect angles simultaneously. We have made comparisons between three pointing directions, which at an altitude of 400 km differ from normal to **B** by 4.8°, 3.4°, and 2.0°. (We compared 4.8 with 3.4 degrees and then with 2.0 degrees.) These angles all vary slightly with altitude and are significantly smaller than they were when Jicamarca was built because of the slow change in the geomagnetic field. (These beam positions once were called the 6, 4.5, and 3 degree (on axis) positions.)

The goals of the experiment were to determine (1) which collisional model (if any) best matched the data, (2) what collisional corrections, if any, are needed at the 3.4° position (the "standard" pointing direction for many ISR observations now), and (3) what corrections we might apply in a reanalysis of old ACF data taken at Jicamarca. These temperature and density data extend back more than a solar cycle into the middle 1980s and were mostly taken with the beam in the on–axis position (which was then at more like 3°).

Since we are close to solar maximum, the electron densities are now high at Jicamarca, which should enhance the effect of collisions. However, perhaps surprisingly, the high densities make it difficult to obtain high quality ACF data in the F region using the standard double–pulse technique except in a relatively limited range of altitudes. Electrojet clutter is serious at low F region altitudes and Faraday dispersion is a problem above 400 km or so in the daytime, and the situation is not much better at night. Nevertheless we obtained some usable data a few days before the abstract deadline.

We also operated for one afternoon using the alternating code mode, also with a split beam (comparing 4.8 and 2.0 degrees). In this experiment we alternated between the two beams every 15 minutes, using the full 50 MHz transmitter for one circular polarization on one beam only, and so the sensitivity of the measurement was reduced by only a factor of 2 instead of 4.

The relatively crude analysis of the data that we have been able to do so far shows no clear evidence of any collisional effects at either 3.4° or 2.0°, even during midday with electron densities somewhat above $10^{12}\,m^{-3}$ and electron temperatures between 1000 and 1500K. More specifically, our preliminary analysis has not shown any electron temperature differences between the 4.8° data and the 2.0° data that are larger than the scatter in the temperature values. However, these statements are very tentative at the time of writing. It is a bit surprising that we have seen no clear evidence of collisions even at the 2.0° position. We need to do a more thorough analysis in order to reach solid conclusions regarding the collisions. We hope to be able to report the results of this analysis at the Symposium.