Comment on 'The effect of strong velocity shears on incoherent scatter spectra: a new interpretation of unusual high latitude spectra'

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COMMENT ON "THE EFFECT OF STRONG VELOCITY SHEARS ON INCOHERENT SCATTER SPECTRA: A NEW INTERPRETATION OF UNUSUAL HIGH LATITUDE SPECTRA"

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The authors discuss in their article (Swartz et al., 1988) the distortion of incoherent scatter spectra due to high-velocity shears in the scattering volume. This is a well-known effect (see, for example, the discussion of one aspect of this problem in Kofman et al., 1984). It is our opinion that the demonstration and analysis of one single event of such a distortion is not very conclusive. A better justification of such a paper would have been a systematic modelling of this effect, giving the experimenter some tool at hand to estimate the shear from the distortion in a more quantitative way.

With their paper the authors cast some doubts on the interpretation of incoherent scatter data in terms of unusual high ion temperatures (Kofman and Lathuillere, 1987), non-Maxwellian ion velocity distributions (Moorcroft and Schlegel,1988; Lockwood et al., 1987) and anisotropic ion velocity distributions (Lovhaug and Fla, 1986; Perraut et al., 1984). We would like to state the following in this context :

1. The authors term these effects as "exotic", but these phenomena are at least as common as high-velocity shears. Indeed, Farmer et al. (1988) have employed a coupled ionosphere-thermosphere model to show how the supersonic flows required to produce non-Maxwellian plasma arise in certain locations at even very low magnetic activity.

2. The work cited above was performed with EISCAT which generally uses much smaller scattering volumes than those of 300 km length described by Swartz et al. (1988). Usually the effective range resolution is 54 km or, in the case of tristatic measurements, of the order of only a few km. This reduces the probability of having strong velocity shears in a single scattering volume.

3. The EISCAT measurements yielding high ion temperatures were made while the antenna pointing was along the magnetic field line. We do not expect to have large velocity shears in this direction.

4. The fact that the effects described in the above cited papers generally appeared in several consecutive range gates rather than in one single gate reduces the probability further that velocity shear would have caused the unusual spectra. The EISCAT observations using the Polar and Common Programme 4 experiments show non-Maxwellian spectra in all range gates along both beam directions employed. Hence, as discussed by Lockwood et al. (1988b), interpretation in terms of velocity shears requires two such shears, each one well-aligned with an antenna azimuth. Furthermore, these shears must always give mean line-of-sight velocities such that the beam-swinging technique gives large ion drift: the EISCAT observations only show the non-Maxwellian spectral form when the derived ion drift is large.

5. Swartz et al. (1988) state that the asymmetry of the spectra affected by velocity shears is not in agreement with the spectral shape predicted by non-Maxwellian velocity distributions or in observed cases of hot spots. In fact, in the EISCAT investigations cited above the measured spectra were mostly symmetric (the generally sufficient signal-to-noise ratio allows this statement) which again speaks against an interpretation in terms of velocity shears. Shears can produce symmetric spectra, similar to those for non-Maxwellian plasma, only under very special circumstances: the power received from the two halves of the scattering volume separated by the shear must be almost exactly equal (or the spectrum will be asymmetric) and the velocity difference across the shear must give Doppler shifts which always differ by very close to twice the ion acoustic frequency (otherwise four spectral peaks will be resolved).

6. Winser et al. (1987) have shown that the aspect angle dependence of spectra observed by the EISCAT Common Programme 3 is clearly reproduced using theoretical expressions for the ion velocity distribution function which are based on the generalized relaxation model (Raman et al. 1981). Furthermore, Lockwood and Winser (1988) have shown that the ion velocity distribution function derived by two methods of non-Maxwellian analysis is quantitatively very similar to that predicted by Monte-Carlo simulations of non-Maxwellian plasma (Barakat et al.1983; Kikuchi et al., 1988). This would require a series of wind shears which would be even more contrived than that discussed in 4. if the alternative view were to be considered.

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We were always well aware of the effect of velocity shears on the spectra and most of the papers cited above refer to this possibility. For example, Farmer et al. (1988) state: "...spectral shape alone is not enough to identify non-Maxwellian plasma. This is because sampling noise, velocity shears and other effects can mimic the spectral shape expected for non-Maxwellian plasma". Other papers (e.g. Lockwood et al., 1987; 1988a) show that the changes in scattered power during the onset of non-Maxwellian plasma is inconsistent with velocity shears. One must also always remember that we are talking about supersonic flows of ion gas through a neutral gas with which it frequently collides: the premise that it will remain Maxwellian is fundamentally unreasonable. We were and are still fully confident that the effect of velocity shears can be ruled out in the above cited investigations.

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