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Semi-annual Report for NASA grant NAGW-998, titled "Wave Generation and Particle Transport in the Plasma Sheet and Boundary Layer"

The one and two ion beam instability was considered as a possible explanation for the observations of broadband electrostatic noise in the plasma sheet region of the geomagnetic tail (Dusenbery and Lyons, JGR, 90, 2915, 1985; Dusenbery, JGR, 91, 12,005, 1986). When only hot streaming plasma sheet boundary layer ions were present, no broadband waves were excited. Cold, streaming ionospheric ions can generate electrostatic broadband waves propagating in the slow beam-acoustic mode, but the growth rates of the waves were significantly enhanced when warm boundary layer ions were present. (Both the slow and fast beam-acoustic modes can be excited, depending on the relative ion drift.) This model predicted that the wave intensity of the broadband noise should peak in the plasma sheet boundary layer (PSBL). Observations of less intense electrostatic waves in the lobes and plasma sheet were likely a result of the absence of warm ion beams or large ion temperatures, respectively, which resulted in smaller growth rates.

The model dependence of the ion beam instability has also been studied (Dusenbery and Lyons, Chapman Conference Proceedings, 1986). For cold and warm ions streaming in the same direction, we found wave growth peaked for wave normal angles $\theta = 0°$ and wave frequencies ~0.1 x the electron plasma frequency. However, for anti-parallel streaming cold and warm ions, wave growth peaks near $\theta = 90°$ and wave frequencies were an order of magnitude smaller. Including counterstreaming warm ions in addition to a cold ion

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stream resulted in wave growth that was a superposition of that for the above two cases.

Convective growth of slow and fast beam acoustic waves in the PSBL was investigated (Dusenbery, JGR, 92, 2560, 1987). It has been shown previously that a cold ion population must be present in order to excite beam-acoustic waves in the PSBL. However, growth rates were significantly enhanced when warm PSBL ions were present. Net wave growth along a ray path is determined by convective growth. This quantity was calculated for particle distribution models consistent with the PSBL where the intensity of broadband turbulence is observed to peak. Total number density dependence on beam acoustic convective growth was evaluated and it was found that even for low density condition $\sim 0.01 cm^{-3}$, a measurable level of broadband turbulence was expected. Relative drift effects between cold and warm ion populations were also considered. In particular, it was found that slow mode convective growth can be enhanced when slowly streaming cold ions are present compared to fast ion streams.

Besides understanding the characteristics of this turbulence such as frequency range excited, growth rates, and convective growth, it is important to determine the interactions such waves have on the PSBL particle distributions present. For normal PSBL conditions, it is unlikely that ion beam-acoustic waves will affect warm PSBL electrons much. However, significant diffusion of warm PSBL ions in velocity space may occur. Interactions between beam-acoustic waves and boundary layer ions may offer a possible explanation for heating the boundary layer ions to form the hot ion component of the central plasma sheet as has been inferred to occur from observations.

The wave-particle interactions and resulting diffusion of PSBL ions with beam-acoustic waves are a hybrid between the case where there is no magnetic field and where the magnetic field dominates. In a study with Larry Lyons (at The Aerospace Corporation), we refer to such diffusion as unmagnetized diffusion. It essentially results from a Landau resonance but affects oblique as well as parallel degrees of freedom.

Besides studying the diffusion times, we also plan to investigate the temporal evolution of a warm boundary layer ion distribution. We feel that understanding the dynamics of the PSBL is an important study and therefore it is important to understand what effects are caused by the interactions which can occur between broadband turbulence and PSBL ions.

Work is continuing on the properties of the beam acoustic mode under both plasma sheet and auroral conditions. In addition to the linear and quasi-linear properties of the instability, the nonlinear evolution and saturation of the excited wave fields are presently being investigated by simulation experiments (Dusenbery and Nishikawa, JGR, submitted, 1987).