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THERMAL ION HEATING IN THE VICINITY OF THE PLASMAPAUSE -- A DYNAMICS EXPLORER GUEST INVESTIGATION

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by

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This investigation of thermal ion heating near the plasmapause is progressing on several fronts. Some of the initial results have been unexpected in their details, although in keeping with the general maxim in geophysical problems that what is happening is seldom as straightforward as we would hope. Our general objectives are to identify the response of ion thermal structure to geomagnetic activity and to determine how this may be related to thermal plasma density structure. A particular focus is to determine what role the ring current may play in this process, in those cases where it is appropriate. Primary emphasis to date has been placed on the more general problem, as is discussed below.

With regard to magnetic activity effects, we have initially tried to focus on periods of very high and very low activity. For long periods periods of very low activity, when they exist, this is fairly straightforward; but for active periods, it turns out to be more complicated. Aside from the usual difficulty of having available the right data for the time of interest, a major problem is in knowing what the appopriate time of interest is. That is, given a geomagnetic disturbance, how soon and where does it begin to affect the thermal ions? This is intimately related to the problem we are studying and must be addressed early in the investigation in order to compare data properly. This aspect of the study will be discussed in context below.

Since different aspects of the investigation are proceeding somewhat independently, these are discussed separately below.

Response of Plasmaspheric Thermal Structure to Geomagnetic Activity

One of the more surprising results of initial comparisons of quiet and disturbed plasmaspheric ion temperature profiles was finding that ion temperatures inside the high altitude plasmapause appear to be depressed during disturbed times relative to quiet times. This is found to occur for both morning and afternoon regions of the outer plasmasphere. It appears more likely to be associated with a decreased heating of the outer plasmasphere than with a cooling mechanism. Although supported by several examples, this phenomenon needs to be examined more systematically as our data base of analyzed data is increased. A point of particular interest will be the timing of this effect relative to the onset of geomagnetic disturbance, as noted above. The initial results were reported at the Fall AGU Meeting (Comfort et al., 1984) and were described more fully in a paper on DE-1/RIMS temperature observations (Comfort et al., 1985).

Response of the Plasmapause Temperature Gradient to Geomagnetic Activity

Work in this area has been affected to a significant degree by the need to know more about the timing of the effects of geomagnetic disturbance on thermal ions. In an effort to see how best to proceed, several sets of data for very quiet and very active times were compared. The magnitudes of the enhanced temperature gradients near the plasmapause were examined with respect to variation with magnetic activity (both immediate and when that location was in the post-midnight sector) and were also compared with density gradient magnitudes; little direct correlation was found in either case. It is possible that the temperature gradient is not correlated with either of these factors. However, given the substantial variations which are observed, it appears likely that they are related in some manner to either the density or magnetic activity (or both). The apparent lack of correlation may be the result of a limited data set; or it may be because the temperature gradient evolves much more rapidly than the density gradient, together with uncertainties about how to relate the observations to magnetic activity history. This preliminary finding was reported to the DE Science Team at its March,1985 meeting. This particular aspect will be examined more extensively with a larger data set, and with a more refined approach to the timing of the response. At some point, numerical modelling will probably be needed to help sort out some of the different possible mechanisms involved in establishing the observed thermal ion temperature gradients.

Another approach taken in this direction was to examine where (L shell) the enhanced temperature gradient began (identified as a significant slope increase in the ion temperature profile), as a function of magnetic activity. Results in this case were more indicative. It was found that this location moves to lower L shells with increasing magnetic activity, similar to the behavior of the plasmapause. However, this change in the temperature gradient is not found to be located uniquely with respect to any particular feature of the plasmapause density gradient. With regard to magnetic activity history, the variation in this location was correlated with immediate activity, with activity when that location was in the post-midnight sector, and with the highest magnetic activity in the previous 24 hour period, using both Kp and Dst geomagnetic indices. The best correlations were achieved in the last case for both Kp and Dst. Interestingly, the correlations were slightly higher for Kp in local morning and Dst in local afternoon. If this difference holds for a substantially larger data set, it may indicate different mechanisms at work in changing plasmapause ion temperatures in these different local time regions. These initial results were reported to the Spring AGU Meeting (Comfort et al., 1985b). In addition to pursuing this question with a larger data set, we may gain additional insight into the way magnetic activity history affects what we observe through time series correlations.

Correspondence between Ionospheric Electron Temperatures and Plasmaspheric Ion Temperatures

To see how plasmaspheric ion thermal structure relates to features in the ionosphere, we have participated in a study comparing electron temperatures and densities measured by LANG on DE-2 with ion temperatures, densities and composition from RIMS on DE-1 when they were along approximately the same field lines near the same time. One interesting feature that is commonly seen is a local peak in the electron temperature profile (plotted versus invariant latitude) near the invariant latitudes of the plasmapause density gradient; this is sometimes a rather large enhancement. In some cases the variation of ionospheric electron temperatures with invariant latitude roughly parallels that of the plasmapheric ions, particularly in the region of enhanced gradients (near the plasmapause). However, this is not universally true, and in other cases the ionospheric electron thermal structure appears to be more closely related to plasmaspheric ion density or composition features. So it appears that several processes are operating simultaneously, each predominating under different circumstances. Preliminary results were presented to the Fall AGU Meeting (Horwitz et al., 1984) and a paper is being prepared presenting more detailed comparisons (Horwitz et al., 1985a).

Structure of the Plasmapause Density Gradient

One of the particular mechanisms which we are testing for ion heating at the plasmapause is the interaction of ring current particles with thermal plasma and the dependence of this heating on the density of the thermal plasma. As a part of this aspect of the investigation, we are participating in a study which classifies plasmapause density gradients in terms of their steepness or other structural features. Then a statistical examination is being made to determine the dependence of the occurrence of these different types of structure on local time and magnetic activity, both current and past, A similar data base will be used to relate the ion thermal structure to the density structure. The initial phase of this study is almost complete, and analysis of the occurrence frequencies is about to begin. A paper on this study will be prepared shortly (Horwitz et al.,1985b.). With input from this study, the ring current part of the investigation will be carried out.

Heating near the Equatorial Plasmapause.

Previous satellites have found the equatorial region to be a location of unusual and interesting phenomena, and DE-1 observations confirm this. We have participated in a study of these features and found several to be of significance to this investigation. Equatorially trapped thermal plasmas seem to occur in the plasmapause region, where densities are about 20 cm^{-3} to 200 cm^{-3}. These trapped plasmas consist primarily of H^+; and most of the plasma is heated, with no preferential heating of the heavy ions. Although there is an enhanced flux near the equator, this is due not to enhanced densities, but to enhanced temperatures. In fact, there may be a density minimum at the equator, associated with an apparent positve plasma potential. This latter point may limit interhemispheric interchange of cold plasma, a point of interest for plasmasphere modellers. A paper describing details of these observations is almost ready for submission (Olsen et al., 1985).

Further Work

In this investigation to date we have explored in a number of directions, all showing the plasmapause to be a region of exciting, if sometimes bewildering, geophysics. In subsequent work, the emphasis will be on refining the approaches and consolidating the results already obtained. An enlarged data base of analyzed plasma parameters will be employed to cover a greater variety of conditions. Timing of the thermal ion response to geomagnetic disturbance will be the objective of more intensive study. And with the initial work on plasmapause structure developed, more attention will be directed toward the possible role of the ring current in causing the thermal ion heating heating observed near the plasmapause.

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