A FURTHER INVESTIGATION OF THE ARIEL 4 AMBIENT
ELECTRON DENSITIES AT VERNAL EQUINOX

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Abstract. Ariel 4 satellite electron density data returned by the rf-capacitance probe on board are
further investigated in order to seek any possible signature of the magnetic cusp in two different
hemispheres during magnetically quiet periods at the 1972 vernal equinox. Ariel 4 electron density
data covering the middle and high invariant magnetic latitudes at around 550 km altitude, for 91 days
centered on the March 1972 equinox are employed. The data revealed a strong magnetic local time
(MLT) dependence. The cusp signature was clearly in the Northern Hemisphere.

1. Introduction

In the cusp-shaped regions, where the magnetic field of the earth is weak, the solar
wind and the geomagnetic field interact. Electrons in the solar wind have typical
energies of a few electron-volts (Isenberg, 1991). The cusp region is characterized
by intense electron fluxes with very low energy similar to those of the solar wind.
Therefore, the investigation of the structure, the location and variation of the cusp
area, especially at low altitudes, is important in understanding the solar wind entry
into the magnetosphere.

Pre-noon and pre-midnight maxima are also observed for the auroral primary
electrons (Hardy et al., 1989). But these can be separated from the electrons since
this precipitation has much higher energies compared to the soft cusp electrons.

Earlier data such as from the Ariel 4 satellite include the electron density values,
but a spectrum of electron energy values is not available. On the other hand, some
earlier satellites may have an advantage for the cusp studies; i.e., their orbits cover
the lower altitudes.

The cusp area has been investigated several times. Even a subdivision of the
region into smaller parts has been done (Yamauchi and Lundin, 1993). But still
there are uncertainties. Viking satellite which is at the intermediate altitudes (2,000–
13,500 km) provided data for recent statistical studies. In one study, the low-energy
electrons, called the “cusp proper”, extend from 1000 to 1330 MLT and from about
77° to 82° invariant latitude (INL). The center of this distribution is close to 1200
MLT and 79° INL (Kremser and Lundin, 1990). In the same study, the area called
the “cusp” extends from 800 to 1400 MLT and from 76° to 82° TNT.

In another recent detailed analysis, 1972 winter data of the Ariel 4 satellite have
been used for the investigation of electron densities. The largest density values
are reported to be at around 16 MLT during the winter solstice (Öke and Tulunay,
1990).

The objective of the present work is to analyse the temporal and the spatial variation of the hourly means of the electron densities for another period of investigation and only for higher latitudes (i.e. to investigate the cusp area).

2. Instrumentation

Carrying on board the Birmingham University rf-capacitance electron density probe (Isenberg, 1991), the Ariel 4 satellite was launched on December 11, 1971 by NASA into an almost circular orbit having an inclination of 83° with perigee at 471–472 km and apogee at 587–611 km. The orbital period was 95 minutes. This probe measured the local electric permittivity from the changes in capacitance of a parallel plate capacitor formed by two gridded sensors excited at a frequency of 29 MHz. The spatial resolution of a data point was about 2° (geographic latitude) and the time resolution was about 28 seconds. The successive orbits were spaced about 24° in geographic longitude and the same local time repeated at the equator every 94 days. The data, thus, is suitable for the analysis of seasonal, latitudinal or diurnal variations.

3. Results and Discussion

In this research, the results of an extended analysis of electron density variations are obtained at the March 1972 equinox at middle and high latitudes in both the Northern and the Southern Hemispheres. The data coverage is between 4 February and 5 May 1972. All electron densities, selected in this period, correspond to magnetically quiet days having the 3-h planetary magnetic activity index $K_p \leq 2^+$. The arithmetic means of the electron densities are obtained for four magnetic local time (MLT) intervals during which the cusp is assumed to be formed (i.e. 09:00–11:59, 12:00–14:59, 21:00–23:59, 24:00–2:59). For each group the data are studied between 60° and 90° invariant latitudes (INL) both in the North and in the South.

Table I summarises the results of the analysis. In this table the hourly means of electron densities are listed for five degrees of invariant magnetic latitude for four magnetic local time intervals.

Figure 1a is a polar plot of (MLT–INL) for the Northern Hemisphere results. As expected, around the cusp latitudes there are enhancements of electron densities between 12:00–14:59 MLT. The symmetrical enhancements in electron densities, on the other hand, are observed at post midnight sectors. This is probably due to auroral activities. However, these electron densities are smaller than those around the cusp by a factor of about 2. The results reveal a very similar pattern in the South (Figure 1b). Here, the mean electron densities are slightly smaller (by a factor of 0.9) than their counterpart in the Northern cusp latitudes between 12:00 and 14:59 MLT. Whereas, they are larger by a factor of 1.6 than the mean electron densities in the North between 24:00 and 2:59.