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Electron temperature anisotropies measured by CHAMP

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CHAMP (CHAllenging Minisatellite Payload), a low Earth orbit minisatellite launched by the German Space Agency (DLR), was operated between July 2000 and September 2010. Its primary mission was to provide high accuracy measurements of Earth gravity and magnetic fields, but it was also equipped with other instruments to monitor its near ionospheric environment, including a large area planar Langmuir probe (PLP) used to measure local electron density and temperature. Over the ten years of operation of the satellite, it was observed that, at given latitudes, there were a small but systematic difference between electron temperatures obtained when the satellite was Southbound compared to those when it was Northbound [1]. The largest relative differences of order 10%, were observed at mid latitudes in both hemispheres. In this work we show that a possible explanation for these differences can be attributed to the geometry of the planar Langmuir probe, and the varying "magnetic connection"between the probe and the boom of the satellite. With the boom and the attached magnetometer in the upstream direction, and under normal CHAMP flying attitude, magnetic field lines passing through the PLP will intersect the boom when the satellite is Northbound in the southern hemisphere, or when it is Southbound in the Northern hemisphere. Otherwise, magnetic field field lines passing trough the LPL do not intersect the boom or any other satellite structure. Given thermal electron gyroradii of order 2 cm at CHAMP altitude, the fact that electrons essentially trapped in magnetic flux tubes of radius of order of a gyroradius, and the dimensions of the boom and LPL, it follows that when the probe is "magnetically connected"to the boom, the latter effectively obstructs the flow of electrons to the probe and hence the number and velocity distribution of collected electrons. This hypothesis is tested with Particle in Cell (PIC) simulations of the CHAMP PLP characteristics measured under representative ionospheric plasma parameters assuming a simplified satellite geometry. Characteristics obtained from computed collected currents as a function of probe bias voltage are then fitted using the probe response function derived by Rother, et al. and shown to be consistent qualitatively and quantitatively with observation. In particular, it is found that, using the same plasma density and temperatures in the simulations, the electron temperature is lower by approximately 10% when magnetic lines at the PLP intersect the boom, than when they don't.

[1] Rother, et al., Radio Science, Vol. 45, RS6020, doi:10.1029/2010RS004445, 2010

Author: MARCHAND, Richard (University of Alberta)

Presenter: MARCHAND, Richard (University of Alberta)

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