

Non-linear heating of the upper thermosphere due to auroral electric field

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The electric field in the auroral zone and in the polar cap accelerates the movement of the upper thermosphere. The motion is associated with the movements of the constituent medium particles where electrons are highly affected by the driving force rather than heavy neutral and charged particles, and mainly responsible for the movement of thermosphere.

The thermospheric region above altitudes of about 160 km is characterized by different non-linear phenomena due to variation of the velocity distribution of the thermospheric constituents, medium temperature, ionizing frequency, effective collision frequency and recombination co-efficient of electrons and ions.

The penetration, diffusion and precipitation of auroral electrons into the medium introduce heating which is further enhanced by the level of geomagnetic activities, multiple scattering and Coulomb interactions with atomic nucleus and orbital electrons of atmospheric constituents. Energy distribution also depends on the variation of the atmospheric density with altitude. Analyses and interpretation of precipitation patterns, latitudinal distribution of energy and dynamics of the incoming particles have been modeled by various earlier workers.

Auroral electric currents and charged particle precipitation produce Joule heating, gravity waves and travelling ionospheric disturbances which initiate temperature enhancement and temperature fluctuations. The presence of fluctuating electric field initiates Joule heating along with viscous heating. Magnetosphere-Ionosphere coupling mechanism also provides informations about Joule heating rate along with various other electrodynamic parameters. These heating make the largest contribution to the total energy budget in the medium. Both of these would give rise to detectable pressure fields beyond the boundaries at which the auroral currents remain confined.

In this presentation, magnetohydrodynamic formalism has been used to derive an analytical expression of the velocity of the upper thermosphere in the auroral region. The effects of ionization and recombination processes, density and temperature fluctuation of the thermospheric medium along with the influence of gravity and viscosity are taken into account in the analyses. The spatial distribution of the velocity and its altitude dependence within the auroral zone has been explored. The expressions of Joule heating and viscous heating are derived. Numerical analyses are carried out to estimate their magnitudes as well as the rate of their variations with time. For different characteristic times, the variations of velocity with altitude are studied. The results have been presented graphically.

The numerical results of the present analysis support the observations made by DE-2 satellite. The results may be considered to reflect the enhanced influence of geomagnetic activities.