METEOR TRAILS IN THE E-REGION IONOSPHERE: DIFFUSION AND ELECTRIC FIELDS

Y. S. Dimant[1], M. M. Oppenheim[1], L. Dyrud[1], G. M. Milikh[2]
[1]Boston University
[2]University of Maryland, College Park

Abstract Submission Form

2006 National Radio Science Meeting

Abstract: dimant1176

Date Received: September 17, 2005

Meteoroids penetrating the Earth's atmosphere frequently leave behind trails of dense plasma in the region between 130km and 75km. Low-power, small-aperture radars detect many of these trails as specular echoes when the trail lies perpendicular to the radar line-of-sight. Upper atmospheric scientists use these radars to monitor winds between 85 and 105 km altitude and solar system scientists use them to estimate the population of small particles in the solar system. High-power, large-aperture (HPLA) radars observe short duration signals, traveling with the ablating meteoroids, called head echoes and long duration signals, persisting for a relatively long time in a broad altitude range, called non-specular echoes. We have argued that non-specular echoes result from radar signals scattered from turbulent electron density irregularities generated by plasma instabilities, which in turn are driven by strong electric fields developing during the trail ambipolar diffusion. Obtaining accurate quantitative predictions for the diffusive evolution and fields generated by these trails within the magnetized ionosphere has proven difficult. In this talk, we will present a refined quantitative model of the fields and density evolution which accounts for both the geomagnetic field and the background plasma. Combining our theory with radar observations of specular and non-specular echoes should yield useful information about meteor trails and the surrounding atmosphere.

Using both simulations and 2-D analytical theory, we can accurately model trail evolution for trails at a broad range of altitudes and initial plasma densities. Both simulations and theory show that at altitudes above 94km, meteor trails initially become highly anisotropic due to the different diffusion rates for electrons and ions. With time, however, the trail diffusion becomes nearly isotropic due to its interaction with the background plasma. The transition from anisotropic to isotropic diffusion takes place when the plasma trail density remains much larger than the background plasma. This may help explain unexpected results of some radar observations of specular echoes.

Ambipolar diffusion of trails leads gives rise to polarization electric fields, which may drive plasma instabilities and generate electron density irregularities visible to radars as non-specular echoes. During the trail evolution, when the trail diffusion becomes more isotropic, the electric field may drop below the level necessary to drive instabilities. This is of importance for interpretation of non-specular trails.

At the equatorial and high-latitude E-region electrojets, a strong external DC electric field perpendicular to the magnetic field frequently occurs. This field polarizes a highly conducting meteor trail resulting in substantial spatial redistribution of the electric potential around the trail. A simplified 3D analytical theory shows that the total electric field in the near-trail region may be drastically amplified, which may help explain long-lived non-specular echoes.

1. (a) Yakov Dimant
Center for Space Physics
Boston University
725 Commonwealth Avenue
Boston, MA
02215 USA
dimant@bu.edu
(b) 1-617-353-7411
(c) 1-617-353-6463

2. G - Ionospheric Radio and Propagation
3. (a) G/H2
4. C - Contributed Paper
5. No special instructions