Meteor Trails in the Ionosphere: Latest Results from Observations and Theory

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Extended Abstract

A meteoroid penetrating the Earth's atmosphere leaves behind a trail of dense plasma embedded in the E-region ionosphere. As the trail diffuses into the background plasma, a large ambipolar electric field develops. A recent theory of meteor trail plasma diffusion made the novel prediction that meteor trails diffuse much faster during daylight hours than at night[1,2,3]. This occurs because the plasma density of the background ionosphere increases by up to a factor of 100 with sunrise. The interaction between the meteor plasma and the background plays an important role in enabling plasma turbulence to develop which, in turn, enables radars to detect the trails as non-specular echoes. This talk presents evidence of a dramatic day to night difference in the occurrence rates and durations of non-specular meteor trails. It will also examine how meteor trail diffusion changes as a function of altitude and how radar observations depend on the aspect angle[4].

Observations used in this study were made by the high-power, large-aperture, (HPLA) 50MHz radar at the Jicamarca Radio Observatory (JRO) in Peru. In one 20-minute period starting 95 minutes before sunrise, this radar detected 1241 head echoes and 340 trails while a similar time after dawn, it measured 1287 head echoes but only 50 trails. Also, the duration of the nighttime trails greatly exceeded the daytime ones. A second experiment in July 2007 confirmed this pattern was by measuring an even greater day to night variation. This data provides strong observational evidence that one needs to account for the effect of the ionospheric plasma density to explain the plasma physics of meteors.

There are many consequences of the ambipolar field generated by a meteor trail. Since this field is strongest perpendicular to the Earth's geomagnetic field $\boldsymbol{B_0}$ and generally extends many kilometers along $\boldsymbol{B_0}$ before gradually diminishing in amplitude, it can have a dramatic impact on the background plasma. This field will cause ionospheric plasma to collect into a long ridge extending along $\boldsymbol{B_0}$, perhaps for many kilometers, enhancing the density by as much as a factor of 2. The field will also dig out density depressions on each side of the ridge, removing up to 90% of the plasma. We predict that meteor-induced, large-amplitude, density perturbations may fill as much as 20% of the ionosphere between 95 and 120 km altitude[5].

Both the theoretical work and the observational provide strong evidence that one needs to account for the effect of the ionospheric plasma density to explain the physics and observations of meteors.

References

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