Ionospheric Irregularities Detected by the Meteor Radar at High Latitudes

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An important task of the meteor radar signal processing is finding echoes from meteor trails and rejecting other signals, like echoes from satellites and aircrafts, lightning, sporadic ionospheric layers, etc. However, meteor radar observations at high latitudes in Sodankylä Geophysical Observatory (SGO, 67° 22' N, 26° 38' E, Finland) show that certain ionospheric irregularities are interpreted as meteor trails.

First, echoes from active aurora are sometimes detected at low elevation on the northern horizon, typically during substorms. These echoes have a near-zero Doppler shift, relatively low power and oscillating amplitude at a frequency higher than 1.7 Hz. We suggest that such echoes are in fact ground backscatter of the radar waves which have been refracted in the ionosphere, passing through the ionosphere in the substorm region, where pulsating aurora occurs and causes quasi-periodic modulation of the wave propagation conditions, which leads to corresponding modulation of the amplitude of return. The meteor radar treats such oscillating signal as meteor trails.

Second, aerosol particles in the mesosphere may produce electron density irregularities, which phenomenon is known as polar mesosphere summer echo (PMSE). Similar, although much stronger effect was observed on 9 December 2009 when a 36.8 metric tons solid propellant ballistic rocket was self-destroyed at a distance about 500 km from SGO, at an altitude of 170-260 km. After 2-3 hours the meteor radar received unusual echoes, which indicated turbulence of ionospheric plasma (irregularities of electron density) with temporal scale of the order of 0.1 s and spatial scale of a few to tens meters. The turbulence occurred at a height of about 80 km and was localized in several areas of about 60 km in horizontal scale. Obviously, aerosol particles of the missile remains (presumably composed of aluminium oxide) played a key role in producing the electron density irregularities. We suggest that sedimented by gravity and, hence, moving with respect to the air, charged aerosol particles might produce meter scale irregularities (electrostatic waves) via dissipative instability, which mechanism is analogous to that of the resistive beam-plasma instability.