The Linear Plasma Theory of Meteor Trails and Implications for Radar Measurements

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Radars probing the atmosphere between 75 and 130 km frequently receive echoes from plasma trails left by ablating micron-sized meteors. These echoes have proven useful in characterizing meteors and in estimating wind velocities and temperatures. Two distinct types of radar echoes return from meteor trails. First, strong "specular" echoes occur when the radar pointing direction lies perpendicular to the meteoroid's trajectory. Second, weaker "non-specular" echoes are measured by large-aperture, high-gain, radars when not pointing perpendicular to the trail's orientation but when the radar points perpendicular to the geomagnetic field. Figure 1 shows an example of a head echo (the line at the left of the image) followed by a non-specular trail.

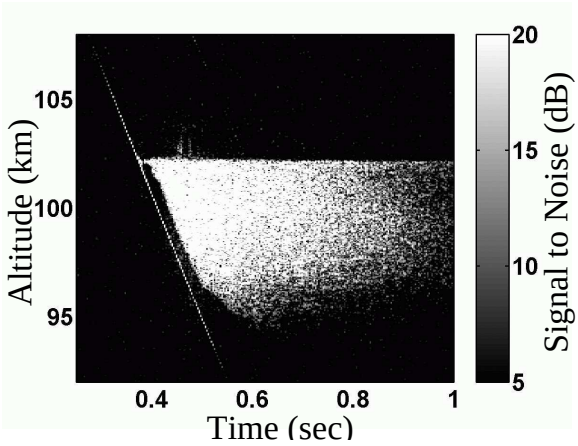

Figure 1: Example of a trail echo recorded by the VHF ALTAIR radar at the Kwajalein missile range as a function of altitude and time.

This paper further develops the plasma physics of meteor trail irregularities and compares the results of theory, simulations and observational data. This study helps us use radar data to better understand the composition of meteor trails and their interactions with the surrounding atmosphere. In particular, we can evaluate: (1) the criterion for the onset of the instability as a function of altitude, atmospheric temperature, and meteor trail composition and density; (2) the nature of the instability and the resulting waves as measured by radars; (3) anomalous cross-field diffusion will occur only within this limited altitude range with consequences for calculating diffusion rates and temperatures with both specular and non–specular radars. This analysis should enable us to better use meteor radar data to characterize meteors and the upper atmosphere.

Commission: G/H Meteor physics - invited talk

New knowledge contributed: Developing models of meteor trail turbulence allows a more accurate analysis of radar measurements of meteors.

Relationship to previous work: This research builds on previous work, particularaly in using non-specular trail characteristics to evaluate meteoroid characteristics.