Radio Science Issues Surrounding HF/VHF/UHF Radar Meteor Studies

J. D. Mathews
Communications and Space Sciences Laboratory, The Pennsylvania State University, University Park, PA 16802-2707 USA, JDMathews@psu.edu

Classical meteor radars depend on coherent (Fresnel) scattering from a meteor trail oriented perpendicular to the radar wave-vector at closest approach to the radar. Meteor trails viewed in this manner are described as “classical” radar meteors with under/over-dense trails. While meteor “head-echoes” are rarely seen with classical low-power, wide-beam HF meteor radars, they are essentially always seen by large aperture (narrow-beam), high-power VHF/UHF radars. We discuss the expected radar scattering cross-sections (RCSs) of head- versus trail-echoes and how equilibrium concepts such as plasma frequency are of limited use in describing the results. Particular attention is given to the frequency dependence of the RCS and how the frequency dependence may yield considerable new information regarding the plasma distribution in the “coma” surrounding the meteoroid. As the head-echo is directly associated with the meteoroid, instantaneous (single-pulse) Doppler observations are possible. In the case of classical trail-echoes, the time evolution of the RCS as a function of frequency may provide new information on the plasma diffusion rate and thus on atmospheric density and temperature. Information from the time evolution of the trail must however be considered in light of new results showing that the trail rapidly B-field-aligns in a manner apparently driven by plasma instabilities that develop in 10-100 msec after trail deposition. It is in the context of instability-driven B-field alignment of the trails that we discuss anomalous trail-echoes. The anomalous trail-echo is a range-spread chaotic (non-classical) trail-echo derived from a meteor that travels at an arbitrary angle relative to the radar wave-vector. We present numerical simulations illustrating these concepts.