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A First-Principle Kinetic Theory of Meteor Plasma Formation[1]
YAKOV DIMANT, MEERS OPPENHEIM, Boston University — Every second millions of tiny meteoroids hit the Earth from space, vast majority too small to observe visually. However, radars detect the plasma they generate and use the collected data to characterize the incoming meteoroids and the atmosphere in which they disintegrate. This diagnostics requires a detailed quantitative understanding of formation of the meteor plasma. Fast-descending meteoroids become detectable to radars after they heat due to collisions with atmospheric molecules sufficiently and start ablating. The ablated material then collides into atmospheric molecules and forms plasma around the meteoroid. Reflection of radar pulses from this plasma produces a localized signal called a head echo. Using first principles, we have developed a consistent collisional kinetic theory of the near-meteoroid plasma. This theory shows that the meteoroid plasma develops over a length-scale close to the ion mean free path with a non-Maxwellian velocity distribution. The spatial distribution of the plasma density shows significant deviations from a Gaussian law usually employed in head-echo modeling. This analytical model will serve as a basis for more accurate quantitative interpretation of the head echo radar measurements.

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