ARECIBO RADAR METEOR STUDIES: RADIO SCIENCE, AERONOMIC, AND INTERPLANETARY ENVIRONMENT IMPLICATIONS AND RESULTS.

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ABSTRACT

The 2 MW 430 MHz radar system at Arecibo Observatory has now been used to study radar meteors for a decade—significant results have emerged. While the radio science of the head-echo scattering mechanism remains in dispute, we propose a solution that is consistent with our results. The head-echo—a scattering signature from the immediate region of the meteoroid and moving at the speed of the meteoroid—contrasts with the Fresnel-scattered trail-echoes seen by "classical" HF meteor radars. At Arecibo, the radar scattering mechanism most consistent with the observations appears to be coherent scattering from the ensemble of electrons within about one-quarter wavelength of the meteoroid. In this scenario Arecibo detects as few as ~10^8 electrons associated with the lowest SNR head-echoes detectable. We additionally report detection of zero-Doppler signatures associated with many of the head-echo events and presumed to indicate trail formation, thus further illuminating meteoroid-atmosphere interaction processes and supporting optically-thin, coherent scattering mechanisms.

Recently an automated data-processing routine has been utilized to find large numbers (~10^5 thus far) of radar micrometeor events and accurately determine parameters such as Doppler speed and deceleration thus allowing a mass inference assuming a canonical mass density (3 gm/cc), spherical shape, and a model atmosphere. Top-of-atmosphere speeds and orbits are determined for a large fraction of these events. We report that the speed distribution typically peaks near 50 km/sec with only a small fraction of events at or above 72 km/sec. About 3% of the events are found to exceed the hyperbolic limit indicating a small flux of extra-solar particles—this flux has been show to be dynamically related to the interstellar particle flux observed by Galileo and Cassini at 3-5 AU. The altitude distribution of head-echo meteor events peaks near 105 km and extends over 80-120 km.

We give a synopsis of the automated meteor search process and introduce a new interferometer system that locates the meteor within the narrow Arecibo beam. We also discuss the size distribution—ranging over about 0.1-100 microns radius or 10^{-8}-10 micrograms—of the AO-observed micrometeoroids as well as the diurnal flux of these particles in the radar beam. From this information, the mass flux of these particles into the upper atmosphere can be estimated as can the consequence to E-region processes. In addition to the classical view of continuously ablating particles, we observe about 20% of all particles undergoing "terminal" events where the particles abruptly disappear while generating excess plasma suggesting explosive disintegration that may generate "smoke" rather than atom-level dispersion. We briefly allude to meteor observations conducted at ALTAIR, Jicamarca, EISCAT, and other larger-aperture, high-power radars.