METEOROID BULK DENSITY FROM HIGH POWER LARGE APERTURE RADAR HEAD ECHO OBSERVATIONS

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The bulk density of meteoroids is an important physical quantity from both an engineering and a planetary science point of view. The bulk density of meteoroids is a proxy measure for the porosity and density of their parent bodies, providing details of the physical structure of asteroids and comets at scales of order microns. Knowing the essential building blocks of these larger bodies can help distinguish between processing effects (such as thermal metamorphism) on evolved bodies from pristine material, such as dust from interstellar clouds incorporated into cometary nuclei. Meteoroids near the Earth can pose a threat to orbiting satellites. One critical parameter needed to understand the impact effects of meteoroids on spacecraft are their bulk density. Previously, the density of microgram mass meteoroids has been assumed or extrapolated from data gathered for larger bodies; direct measurements have been lacking. Changes in the assumed bulk density of impacting meteoroids will influence future satellite and spacecraft design. Here we use head echo observations of meteoroids to carefully measure their mass and deceleration simultaneously and independently to uniquely determine their instantaneous bulk density. Large aperture radar observations are well suited to this task as they are able to make very precise spatial and temporal measurements of meteoroids moving across the radar beam. Observations were made using the ARPA Long-Range Tracking and Instrumentation Radar (ALTAIR). ALTAIR is a high power large aperture radar which can operate simultaneously at 158 and 422 MHz. Data was collected on Aug. 12, 1998, Nov. 17, 1998 and Nov. 17, 1999 and consists of approximately 80 minutes of observation time. During the observation periods, the ALTAIR beam was pointed mainly at the north apex sporadic source of meteors, which is populated with high inclination meteoroids, believed to be associated with long-period comets. Thus our sampling is biased toward this source and cannot be taken as broadly representative of the entire meteoroid background. Meteoroid masses are obtained by applying a new full wave scattering theory to the observed radar cross section. The observed meteoroids are in the mass range of 10^{-10} to 10^{-6} kg. Meteoroid densities are calculated using the equations of the classical physical theory of meteors and are found to have a median value of approximately 1000 kg/m^3. This is somewhat lower than has previously been assumed for meteoroids in this size range and is lower than the average found for stratospheric interplanetary dust particles. In addition to densities, meteoroid orbits are calculated and found to be largely retrograde. Both the calculated densities and orbits are consistent with a cometary origin for this observed population of meteoroids.

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