

Dust detection by antenna instruments

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Antenna instruments on space missions have been used to detect dust particles and characterize dust populations. The antennas register the transient electric signal generated by the expansion of the impact plasma from the dust impact on the spacecraft body or the antenna. Given the large effective sensitive area, antenna instruments offer an advantage over dedicated dust detectors for dust populations with low fluxes. The dust accelerator facility operated at the University of Colorado has been employed to investigate the physical mechanisms of antenna signal generation. The dominant mechanism is related to the charging of the spacecraft (or antenna) by collecting some fraction of electrons and ions from the impact plasma. We have carried out a number of experimental campaigns in order to characterize the dust impact charge yields from relevant materials, the effective temperatures of dust impact plasmas, and variations of the antenna signals with spacecraft potential, or magnetic field. Here we report on a physical model that provides a good qualitative and quantitative description of the antenna waveforms recorded in laboratory conditions. The model is based on the separation of the electrons from the ions in the impact plasma and their different timescales of expansion. The escaping and collected fractions of charges are driven by the spacecraft potential. Fitting the model to the laboratory data revealed that the electrons in the impact plasma have an isotropic distribution, while ion are dominantly moving away from the dust impact location. The detailed understanding of the antenna waveforms will enable the in-depth analysis of data collected by a number of mission (e.g., Cassini, STEREO, Parker Solar Probe).