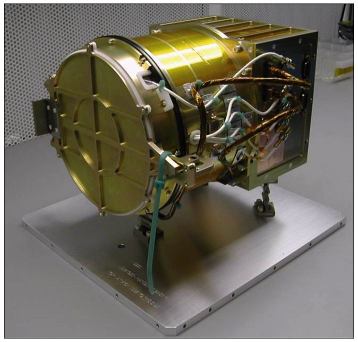


Nano-Dust Analyzer

E. Grün[1, 2], Z. Sternovsky[1,3], M. Horanyi[1,3], A. Collette[1,3], E. Möbius[4], S. Auer[5], A. Juhasz[6], R. Srama[2,7]

[1]Laboratory for Atmospheric and Space Physics, and Department of Physics, University of Colorado at Boulder, USA
[2]Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany
[3]Colorado Center for Lunar Dust and Atmospheric Studies, U. of Colorado, Boulder, USA
[4]Institute for the Study of Earth, Oceans, and Space, U. of New Hampshire, Durham, NH, USA
[5]A&M Associates, Basye, VA, USA
[6]KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary
[7]Institute of Space Systems, University of Stuttgart, Stuttgart, Germany

LASP
LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS
UNIVERSITY OF COLORADO AT BOULDER

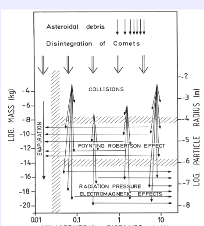
NLSI/CCLDAS

Abstract

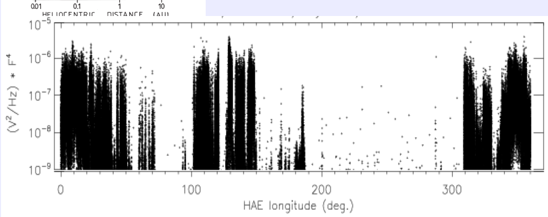
Recently, the STEREO WAVES instruments recorded a large number of intense electric field signals, which were interpreted as impacts from nanometer sized particles striking the spacecraft with velocities of about the solar wind speed [1]. This high flux and strong spatial and/or temporal variations of nanometer sized dust grains at low latitude appears to be uncorrelated with the solar wind properties. Early dust instruments onboard Pioneer 8 and 9 and Helios spacecraft detected a flow of submicron sized dust particles coming from the direction of the Sun. These particles originate in the inner solar system from mutual collisions among meteoroids and move on hyperbolic orbits that leave the Solar System under the prevailing radiation pressure force [2]. The observed fluxes of inner-source pickup ions also point to the existence of a much enhanced dust population in the nanometer size range [3].

A new highly sensitive instrument is being developed within NASA's Heliophysics Program to confirm the existence of the so-called nano-dust particles, characterize their impact parameters, and measure their chemical composition. The instrument is based on the Cassini Dust Analyzer (CDA) that has analyzed the composition of nanometer sized dust particles emanating from the Jovian and Saturnian systems but could not be pointed towards the Sun. By applying technologies implemented in solar wind instruments and coronagraphs a highly sensitive dust analyzer will be developed and tested in the laboratory. The measurements will enable us to identify the source of the dust by comparing their elemental composition with that of larger micrometeoroid particles of cometary and asteroid origin and will reveal interaction of nano-dust with the interplanetary medium by investigating the relation of the dust flux with solar wind and IMF properties.

Observations



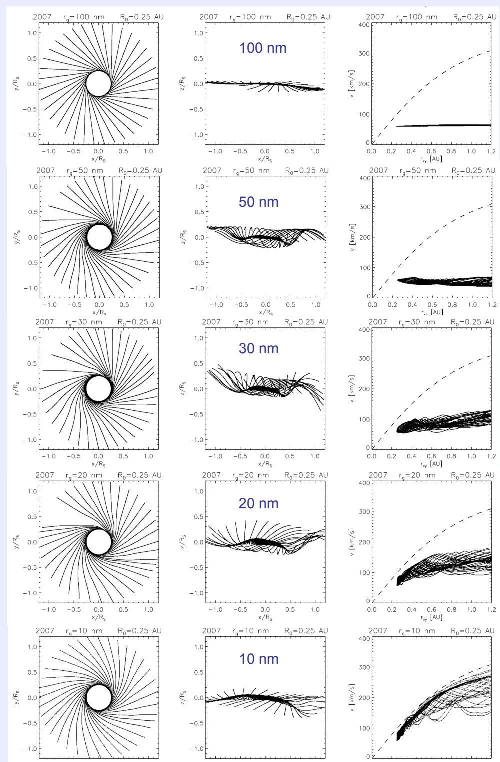
Mass flow of meteoritic matter through the solar system based on observations and theoretical considerations. Most of the interplanetary dust is produced by collisions of bigger meteoroids, which represent a reservoir continually being replenished by disintegration of comets or asteroids. Most of it is blown out of the solar system as submicron-sized grains. The remainder is lost by evaporation after being driven close to the Sun by the Poynting-Robertson effect.



Average power observed by the WAVES instrument on STEREO A as a function of ecliptic longitude in 2007 (Meyer-Vernet et al., 2009). These signals are interpreted as charge bursts generated by impacts of intense streams of nano-dust onto the spacecraft skin.

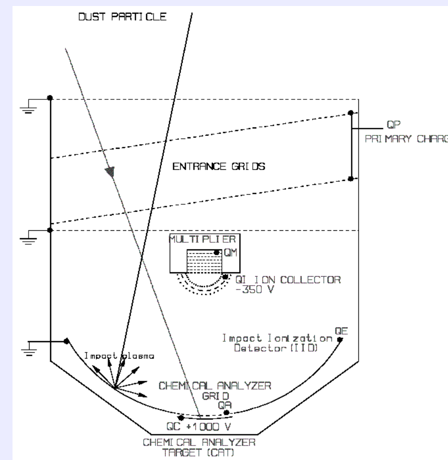
Dust Dynamics

Mutual high-speed collisions among meteoroids in the inner solar system will generate a size spectrum of fragments ranging from nano meter sized particles to those of the size of the largest of the two colliders. Particles smaller than about 1 micrometer will be driven out of the solar system by the prevailing radiation pressure force and electromagnetic interaction with the solar wind magnetic field. Inside about 0.2 AU nanometer sized particles are trapped by the magnetic field and eventually they will evaporate [4]. Particles starting at r > 0.2 AU are picked up by the rotating magnetic field of Sun. They will be ejected and cross the Earth orbit at high speeds. For a "complete" pick-up the grains assume the E x B drift velocity and they reach about v = 300 km/s at the distance of 1 AU. Magnetic sector crossings modify this velocity and the trajectory. Trajectories of nanometer sized grains have been modeled in order to characterize the flux of these particles at 1 AU.



Instrumental Challenges

All previous dust instruments avoided having the Sun in the Field-Of-View (FOV). In the search for the nano-sized dust particles coming from the direction of the Sun, however, this will not be possible. Below is the list of challenges that need to be addresses in developing a Nano-Dust Analyzer: 1) heat load, 2) solar wind particles, and 3) UV radiation. In order to identify and characterize potential sources of the nano-dust chemical analysis of the grains should be done. Several concepts of previous dust analyzers on various missions (Helios, Giotto, Vega, Stardust, Cassini) have been studied. Preliminary results indicate that a dust analyzer of the Cassini CDA type [5] may be best suited to be modified to meet the challenges. In addition this instrument has detected and analyzed nanometer sized dust stream particles escaping from the Jupiter system at several 100 km/s speed [6].



Schematic cross section of the Cosmic Dust Analyzer, CDA. The sensor consists of four entrance grids, the hemispherical target, and the ion collector with the multiplier in the center. Signals on the two inclined grids provide measurements of the induced dust charge and of the particle velocity. Dust particles (two cases are indicated) can impact either on the big gold plated impact ionization target (IID) or the central rhodium chemical analyzer target (CAT). Charge sensitive amplifiers collect the charges at the two target electrodes (QE; QC), at the acceleration grid (QA), at the ion grid (QI), and the multiplier (QM).

References

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