THE LDEF INTERPLANETARY DUST EXPERIMENT

S.F. Singer
George Mason University, Fairfax, VA 22030
J.E. Stanley
University of Virginia, Charlottesville, VA 22903
P. Kassel
NASA Langley Research Center, Hampton, VA 23665

SUMMARY. The Long Duration Exposure Facility was launched for the first time on April 6, 1984 by the NASA space shuttle Challenger. An array of solid-state detectors record the arrival time and approximate direction of an impacting particle. Two levels of detector sensitivity provide an indication of particle energy and mass. The active area is nearly 1 m^2. We therefore expect count rates of about 30 per day over an exposure time of about a year. The orbit of the particle cannot be obtained, except statistically. We know the orientation of the detector, the position of LDEF in earth orbit, and the position of the earth in relation to other celestial bodies. From this information we can extract essential orbit information.

An earlier flight on the Explorer 46 satellite gave first evidence of the existence of submicron-sized particles, mostly associated with fresh meteor streams. We hope to obtain more precise data and estimate lifetimes in interplanetary space.

To study the fate and origin of IP (interplanetary) dust, we measure various kinds of time variations. Among the most interesting is the secular variation, i.e., the flux in various meteor streams, as a function of the passage of a comet.

One of the challenging problems will be to distinguish IP dust from man-made space debris. The separation will depend on knowing something of the orbits of debris. Probably more important will be the chemical analysis of the particles. The two types of information are in a sense complementary.

INTRODUCTION

Impact and penetration experiments are different in character from optical observations of IP dust (such as zodiacal light - Z.L.) and from collection experiments. Impacts give the time of arrival and often the direction of the particle's motion, in addition to its momentum or kinetic energy. A great variety of interesting characteristics can in principle be derived from impact measurements: particle orbits, concentration, size distribution; further analysis must combine

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impact results with those of optical, collection, and other experiments.* (For a fuller discussion, see Hawaii Zodiacal Light Symp. (1) and Ref. 5). Now, IR emissions and crater statistics (on spacecraft and lunar samples) provide additional methods of observation.

For example, the analysis of the Pioneer penetration experiment (2) has allowed us to say something about the orbits, concentration, size distribution, and optical albedo of particles beyond the earth's orbit (3). Especially useful was the analysis of Pioneer data obtained near Jupiter (4).

EXPLORER 46 RESULTS

But the analysis of the Explorer 46 data, first reported at the Ottawa IAU Colloquium (7) and amplified at a conference at Cornell University (8), has given the following new results:

(i) The existence of submicron-sized particles ($\sim 0.1\mu$ and of mass $\sim 10^{-16}$ gm) was deduced from the fact that the higher-sensitivity impact detectors showed a higher counting rate. We further deduce that radiation pressure is not an important perturbing force (7, 8).

(ii) While "old" meteor streams (Halley's Comet) showed no increase, recently refreshed streams (Encke's Comet) showed the largest increases. From this result we deduce:

(a) The submicron particles are injected directly by a comet and not produced in a secondary manner by the meteor streams. The calculated injected mass of $\sim$ 5000 tons appears reasonable (7, 8).

(b) The "lifetime" of submicron particles (in the meteor stream orbit) is about three years. We have deduced that electromagnetic perturbing forces could explain the observed lifetime (7, 8), assuming that the particles had acquired a (reasonable) potential of about three volts.

PROSPECTIVE LDEF RESULTS

The Explorer 46 data were quite limited. However, the LDEF experiment should provide much higher counting rates, direction of arrival, and also much better time resolution. This in turn should allow us to say something about:

(i) particles in hyperbolic orbits (β- meteroids from the sun's direction) (9),

(ii) particle swarms (possibly lunar ejecta (10),

(iii) morning-to-evening asymmetry (1),

(iv) effects of the earth's orbit eccentricity (1),

(v) presence of interstellar dust.

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* It should be noted here that impact (or penetration) detectors do not measure the dust particle concentration directly, nor the flux. They measure the flux above a certain threshold (which depends on mass and relative velocity of the particle). (See e.g., Ref. 1, or 5, 6).

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Following the completion and analysis of the first LDEF experiment, it would be most desirable to repeat it during and following the passage of Halley's Comet. In addition, one would like to carry out the experiment at different orbital altitudes above the base of the exosphere. Many of the interesting phenomena depend on altitude in a unique manner (see 1, 5, 6).

SPACE DEBRIS

The question has been raised to what extent the Explorer 46 data (and LDEF) are contaminated by space debris (produced, e.g., by rocket firings). The impact detector cannot, of course, distinguish the source of a single impact; but statistical analysis can separate space debris from IP dust.

(i) Explorer 46 observed a high rate of impact for a few hours just after being put into orbit.

(ii) The increases during meteor streams clearly demonstrate the predominant presence of IP dust.

(iii) The lifetime of space debris would be limited because of the density of the residual atmosphere. Therefore, one should see a decay of debris impact following, say, a rocket firing and, of course, a time association.**

The LDEF data, because of their much higher quality (count rate, timing, and direction) should allow a more detailed analysis of this phenomenon.

** We are aware of the suggestion that submicron particles be artificially injected into orbits around the earth (Ian Strong, Los Alamos, this volume). Such an experiment might provide a controlled means of studying the space debris problem.

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