# PLANS FOR RELEASE OF SIMULATED INTERPLANETARY MATERIALS INTO LOW EARTH ORBIT

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ABSTRACT. A number of experimental releases into low earth orbit of small, but detectable, quantities of very fine particulates are planned for the next several years. The principal materials are chemically and physically similar to those generally assumed to be the major constituents of interplanetary and circumstellar dusts (silicates, silicon carbide, graphitic materials). Later releases will include multi-phase releases of non-volatile particulates and volatile ices, simulating cometary material. Both ground-based and Space-Shuttle-based observations will be made in the visible and infra-red to study particle-plasma interactions, cometary physics and cloud dynamics in orbit.

Since opportunities for observing the behavior of such well-characterized materials in space are likely to be rare, and the effective duration of significant concentrations will be very short, we wish to have early input from the scientific community so as to maximize the scientific return. We will be receptive to all suggestions including collaborations in making the observations.



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## 1. INTRODUCTION

The program described here was presented orally at I.A.U. Colloquium No. 85 while it was in its formative stages. The purpose in presenting it at such an early time was twofold.

First, the objection has been raised that perhaps not much may be learned from such simple observations that cannot be deduced from laboratory measurements. There is some truth to this in the sense that it would be very surprising to find significant differences between measured scattering of the solar illumination and that measured in laboratory apparatus such as the scattering chamber described below. On the other hand, the behavior of the grain cloud under the influence of the ionizing component of the solar radiation, in a very tenuous atmosphere containing magnetic and electric fields is not easily predictable. Desirable diagnostics include determination of alignment, coagulation and plasma interaction. Such simpler studies, during which we will develop methods for material preparation, storage, release and diagnosis are necessary preliminaries to projected later releases of grains combined with ices and plasma-forming materials. Spectroscopic studies of the behavior of such simulated cometary materials cannot easily be reproduced in the laboratory. On the whole, the response to the proposed program has been encouraging.

The second reason for an early presentation was to elicit input from others, whether positive or negative. We have had a certain amount of both, which has been valuable to us. There have been suggestions for ensuring the dispersion of the grains, details of earlier failures and objections based on possible contamination of other experiments in LEO and the upper stratosphere by material tailored to mimic interplanetary grains. Our proposed tagging of the grains by modifying isotopic ratios of some of the composing elements was considered difficult to detect by many workers. The suggestion, by Professor Lamy, of incorporating small, but easily detectable amounts of unlikely elements has been adopted. Simple equipment already in wide-spread use will easily distinguish our grains from all other natural and artificial materials. One must also keep in mind that the quantities to be released (~ few kgm) should be compared to the naural infall of meteroids ($\gtrsim 10^5$ kgm/day).

## 2. GRAIN COMPOSITION AND PREPARATION

In part, the impetus for beginning this work was due to the existence at Los Alamos, in the Materials Science and Technology Division, of equipment for producing uniform, superfine powders of refractory substances in useful quantities--hundreds of grams per day, using plasma chemical synthesis techniques. Volatile precursors (e.g., $Fe(CO)_5$, $SiH_4$, $CH_4$, etc.) are injected into a radio-frequency plasma heating system, where they react before reaching an expansion chamber in which grain nucleation takes place. These grains, 5 nm to 50 nm in size, coagulate into tangled chains of overall dimensions ~10 μm. Similar grain structures are seen in many condensation processes.

Specific impurities are inserted with the feed gases by injecting volatile precursors containing the elements of interest.

## 3. GRAIN CHARACTERIZATION

The grains will be characterized for physical and optical properties in the laboratory. Physical characterization, e.g., the size distribution, elemental composition and crystalline forms will be measured using transmission electron microscope and x-ray diffraction techniques, and these properties correlated with the optical properties.

Optical properties will be measured using a light-scattering apparatus whose construction is now almost complete. The grains will be suspended in air in a scattering chamber, and illuminated by a solar simulator light source. The detector, a monochrometer-optical multichannel detector assembly, is on a rotating arm pivoted about the scattering chamber, allowing wavelength and angle resolved detection of the scattered light. The aim of the optical characterization is to quantify the scattering properties of irregular-shaped grains, which are not amenable to theoretical calculation.

Instrument operation and the taking of data is completely computer-controlled. Improvements now being investigated include polarization sensitive detection, monitoring aerosol mass using a quartz element mass monitor, and extending the wavelength coverage into the UV and IR.

## 4. PACKAGING AND RELEASE MECHANISMS

The most difficult part of the program is to devise a method of packaging the grains for later release in space. There are a number of constraints and other requirements. A cloud of grains must be formed rapidly which will scatter the solar illumination to the observing station(s) on the ground. Each grain must scatter independently with minimal multiple-scattering. The cloud must be observable from its initial appearance in the west until it sets in the east several minutes later, without growing too large.

There is every reason to believe that a compact mass of grains simply released into orbit will remain compact, the individual grains aggregating in clumps. To avoid this we are investigating packaging grains into a matrix consisting of a sublimating solid or low-boiling point liquid, which will inhibit coagulation and aid in the slow dispersal of the grains in space. Binder dispersal may be enhanced by heating the binder-aerosol combination to control the aerosol release rate.

The first release attempts will be made from small sub-satellites, with a total mass of around 50 kg, ejected from a Get-Away-Special (G.A.S) canister on a Space Shuttle. This will take place near the end of a mission, the sub-satellite being triggered from the ground to eject the grains after the Shuttle has de-orbited, obviating Shuttle environment contamination.

## 5. GROUND AND SPACE BASED OBSERVATIONS

Only ground-based observations of the optical and dynamical behavior of the aerosol clouds will be made during the initial particle releases. The releases will be timed so that the cloud is illuminated by the sun, but will be passing the observing station just before dawn or just after dusk so that the background sky is dark. The optical observations will be made from the DARPA Maui Optical Station (AMOS) and the Maui Optical Tracking and Identification Facility (MOTIF) on the summit of Mt. Haleakela, H.I. The telescopes there are designed to track rapidly moving objects which cannot, in general, be followed by more slowly moving astronomical telescopes. The principal instruments are a 1.6 meter Cassegrain telescope (AMOS) and twin 1.2 meter telescopes on a common mount (MOTIF). Associated instrumentation will probably include a multi-spectral photopolarimeter and an infra-red polarimeter operating in the 10 μm to 30 μm range. A laser beam director is available to probe the clouds using LIDAR techniques.

In the late phases of the program it is hoped that observations can be made directly from the Shuttle. The quantities of material needed would be much smaller, and spectral observations could be extended well into the ultra-violet and infra-red.

## 6. CURRENT STATUS

The basic scattering apparatus for optical characterization of the grains is nearly completed. A large environmental test chamber has been acquired for laboratory studies of grain dispersion and aggregation. Authorization has been received to reserve spaces in GAS canisters, and sub-satellite design has begun.

We hope to perform the first release which will primarily an engineering, dispersal and observationals systems test, during 1986.