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PROSPECTS FOR AN ORBITAL DETERMINATION AND CAPTURE CELL EXPERIMENT. William C. Carey and Robert M. Walker, McDonnell Center for the Space Sciences, Physics Department, Washington University, St. Louis, MO 63130 USA.

A dust experiment which combines measurements of the elemental and isotopic composition of individual particles with orbital information would contribute fundamental, new scientific information on the sources contributing to the micrometeoroid population. The general boundary conditions for such a system are: a) it must be capable of measuring velocities in the range of 10 km/sec to 100 km/sec with several percent accuracy, b) it must collect particles in such a way that the debris atoms are locally concentrated so that precise isotopic measurements are possible, c) it should collect particles over a wide range of sizes starting with a lower limit of 10 μm, d) it should incorporate materials that will not compromise the isotopic measurements and e) it should be large enough to obtain statistically meaningful results within a reasonable exposure time.

Using calibration experiments we have previously shown that it is possible to make abundance measurements of major elements to $\pm 50\%$ and isotopic measurements of selected elements at the level of several per mil for impacting particles as small as 10 μm in size.[1-3] The fundamental approach of the capture cell is to collect the material of interest within a small area and analyze this region using a sensitive SIMS method of surface analysis. An entrance foil and a target plate are placed in close proximity and atoms from the impact are collected on the underside of the entrance foil, and on the top surface of the target plate.

One approach to the problem of measuring the velocity of a particle has been described by S. Auer [4]. Results from two devices, both of which rely on the fact that a charged particle passing next to a conducting wire will induce an electrical signal in the wire, were described. Combinations of grids of wires separated by 10 cm were used to determine the x, y, t coordinates of a particle at two different crossing planes separated by $\sim$10 cm (Fig. 1A). Such an array can be made $> 90\%$ transparent and if the system works, decouples the velocity measuring device from the subsequent capture cell configuration. One advantage of such a system is that the capture cells can be removed for return to the laboratory, leaving the electronic systems intact.

However, the system relies on the assumption that individual dust particles will possess a charge when they arrive at the detector. Typical estimates for the potential of an interplanetary dust particle in free space are $\sim$1 to 10V,[6] which would be sufficient to make this scheme viable. Unfortunately such calculations are probably irrelevant for particles arriving at near earth orbit where collisions with electrons and ions in the exosphere will probably determine the potential.[5] It is likely that particles with differing compositions will charge differentially and thus an inevitable bias is introduced into the detection - collection process. The array of unshielded wires may also lead to severe electrical noise problems in the space station environment.

The system has the distinct advantage of separating the velocity determination and capture cell portions of the sensor, making it possible to preserve the principle of using the capture cell to produce large local concentrations of impact atoms.

Another approach is to use a thin metal foil at the top of a closed velocity determination - capture cell instrument (Fig. 1B). The arrival of the particle could be measured by collection of a plasma pulse on a system of grids immediately below the top foil. A second foil grid collector separated some 10 cm away would be used to time the passage. In this system the second detection foil would double as the collector.

The major disadvantage of such a system is that the top foil tends to disrupt the particle, producing fragments which would result in multiple perforations of the secord foil thus losing directional information and dispersing material over such a wide area that istopic analysis is no longer possible. This is particularly true of very fragile, friable particles that are known to exist in the interplanetary dust and which may be of high scientific interest. If such a system is used, it is clear that the entrance foils mus. be made as thin as possible.

Interplanetary dust particles show large differences in their hydrogen isotopic composition and there is also a suggestion of carbon isotopic effects. Advances in technology may also permit measurements of the oxygen isotopic composition in the future. It is thus essential to avoid thin film materials such as plastics that would introduce unwanted isotopic contamination.

The capture cell design also needs additional testing and study. Most particles will be small and the impact debris from them needs to be well localized to be measurable. At the same time, larger particles are inherently more interesting because they are less sensitive to nongravitational perturbations of their orbits. This suggests that the capture cell should be constructed of a series of collector-target foils of increasing thickness and separation rather than the single foil, plus thick target plate assembly as used in our LDEF I experiment.(1)

Although the open wire detector system would be ideal in principle, there is no guarantee that it will work in practice, and we believe that several velocity determination and capture cell concepts should be tried. Thus additional flight opportunities are required before an optimum instrument can be designed for the space station. Because of the low flux of interplanetary dust, experiment modules at least 1 m^2 in size must be flown for periods of $\sim$1 year for statistically significant results to be obtained. Sufficient electrical power must also be provided. One evolutionary approach, consistent with the time available for design and construction would be to fly advanced capture cells on LDEF II and complete velocity measurement and capture modules on a following LDEF (or other) flight opportunity.

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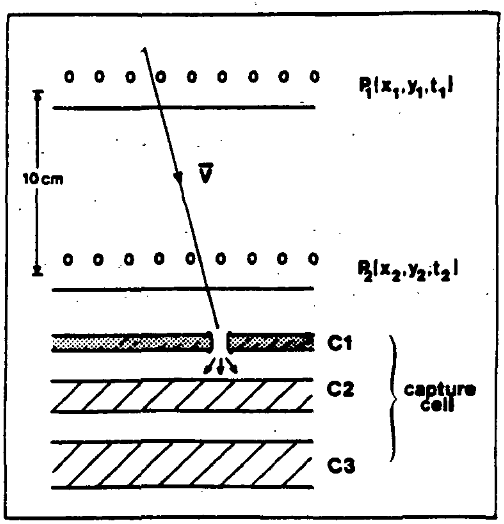

Figure 1a: A schematic (not drawn to scale) showing an 'open' Auer-type sensor configuration. The incident particle velocity vector $\vec{v}$ is determined from *particle charge* measurments P_1 and P_2. C1, C2 and C3 are the primary, secondary and tertiary collecting surfaces of the capture cell respectively. Note that the capture cell portion of the sensor is separate from the measurement of $\vec{v}$.

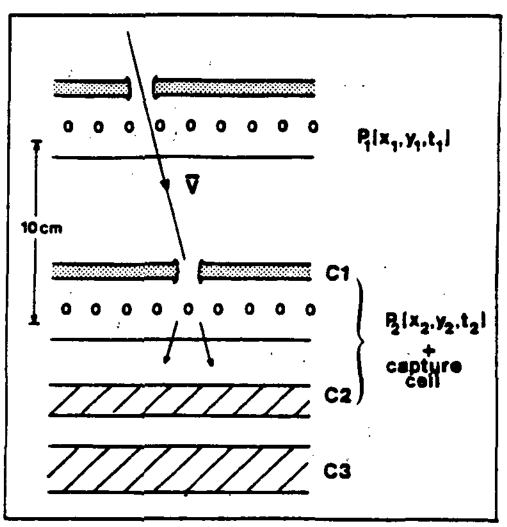

Figure 1b: A schematic of a closed sensor configuration, in which $\vec{v}$ is determined from *impact plasma* measurements P_1 and P_2. In this case, the capture cell portion of the sensor is involved in the measurement of $\vec{v}$.