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A NEW INSTRUMENT TO MEASURE CHARGED AND NEUTRAL COMETARY DUST PARTICLES AT LOW AND HIGH IMPACT VELOCITIES*

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Recently, we have developed a new class of dust particle detector, the PVDF dust detector (1), designed for space missions such as the Halley Comet missions where the particle impact velocity is very high (2). In this paper, we demonstrate that this same PVDF detector (operating in a different mode) also has the capability of detecting dust particles having low velocity (~ 100 m/s). This low velocity detection capability is extremely important in terms of planned missions requiring measurement of low velocity dust particles such as comet rendezvous missions (3).

During the course of experimentally demonstrating that PVDF detectors will detect low velocity dust, we were able to develop an additional detecting element (charge induction cylinder) which, when combined with a PVDF detector, yields a system which will measure the charge (magnitude and sign) carried by a cometary particle as well as the particle velocity and mass for impact velocities in the range ~ 100–500 m/s. Thus, this system should make it possible to analyze in detail the characteristics of charged (and neutral) cometary dust at low velocity.

Since the cylinder-PVDF detector system has a relatively small geometry factor, we have included an array of PVDF detectors having a total sensing area of ~ 0.1 m^2 for measurements in regions of space where the dust flux is expected to be low. The characteristics of the detectors in this array have been chosen to provide optimum mass sensitivity for both low-velocity cometary dust as well as high-velocity (~ 15 km/s) asteroid associated and interplanetary dust. The PVDF detectors in the array are of the type we have used in the dust counter experiments from the University of Chicago, called DUCMA, which are presently aboard each of the two USSR VEGA spacecrafts which will encounter Halley's comet in March, 1986. The characteristics of these detectors and our DUCMA instruments have been described in detail (1,2).

The array portion of our DUST COUNTER experiment is shown in fig. 1 and will measure the flux and differential and integral mass distributions of cometary particles having mass > ~ 8×10^{-11}g, and of asteroidal (or interplanetary) dust having mass > ~ 8×10^{-14}g. Figure 2 shows the response of detector B to a high-velocity dust particle. Figure 3 shows the portion of our DUST COUNTER which will measure the magnitude and sign of the charge carried by cometary dust particles as well as their velocity and mass and fig. 4 shows an example of experimental results obtained. From the response of the charge induction cylinder, the sign and magnitude of the charge and particle velocity are determined. The particle mass is determined from the output signal from detector C.

Figure 5 shows the lowest mass thresholds of our DUST COUNTER experiment in relation to expected cometary (4) and interplanetary (5) dust spectra. The Dust Counter mass thresholds shown in fig. 5 have been determined from detector calibrations carried out at the Heidelberg (FRG) dust accelerator facility (1-12 km/s) as well as from calibrations using a dust accelerator developed earlier at the University of Chicago (6) to which we have added our charge induction cylinder to measure the charge and velocity of the accelerated dust (200 m/s, 400 m/s). The DUST COUNTER described here has the unique advantage of providing a combination of measurements for studying the physics of the comas of comets at both low and high impact velocities (4,7).

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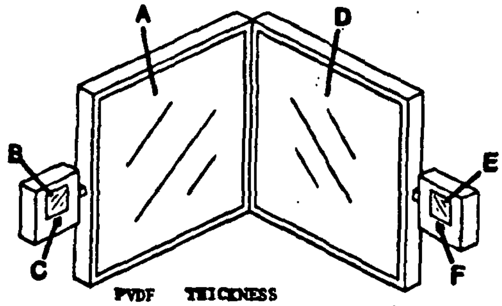

PVDF DETECTOR	THICKNESS (μm)	AREA (cm²)
A	25	500
B	6	10
C	6	1
D	25	500
E	6	10
F	6	1

Fig. 1 Schematic of DUST COUNTER sensor system. A-F are PVDF dust detectors.

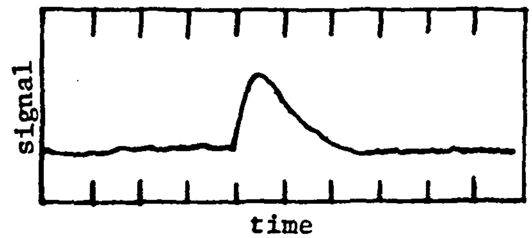

Fig. 2 Signal from detector B of sensor system resulting from dust particle of mass 7.2×10^{-13} g and velocity 9.3 km/s. Signal amplitude is equivalent to 5.1×10^{5} electron charges. Horizontal scale = 20 μs/div.

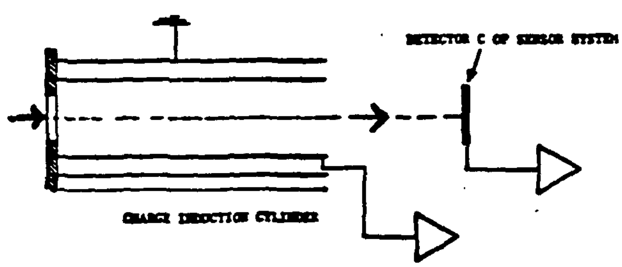

Fig. 3 Portion of DUST COUNTER for measurements of cometary dust particle charge, velocity, and mass.

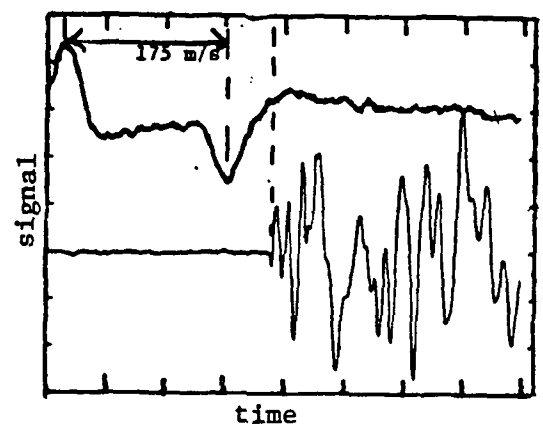

Fig. 4 Signals from cylinder (upper trace) and detector C of sensor system (lower trace) resulting from *a charged dust particle having velocity 175 m/s.* Horizontal scale = 125 μs/div.

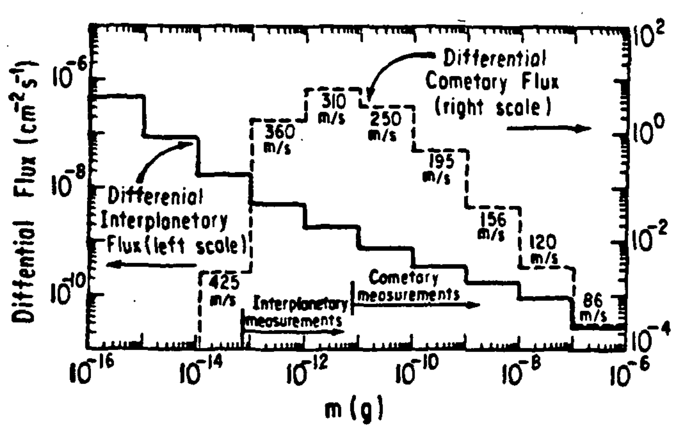

Fig. 5 Expected differential flux of cometary and interplanetary dust. The lowest mass thresholds of the DUST COUNTER are indicated.