21. Dust Storms in Space?

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Silverberg (1970) has explained the "dust storms" observed by the early satellite-borne microphone detectors by postulating that the orbital planes of short-period, low-inclination comets are filled with micrometeoroids. We report here on three separate approaches to test the validity of this hypothesis.

(1) Optical scans of the Gegenschein brightness can yield no useful information on the nearly isotropic sheets of dust predicted by Silverberg.

(2) An attempt to directly collect dust particles during a predicted high flux period by means of a sounding rocket yielded negative results.

(3) Over three years of particle impact data from extremely sensitive detectors flown aboard Pioneers 8 and 9 show no observable dust storms.

Hence Silverberg's hypothesis appears untenable.

However, we should not rule out the possibility that observable showers of very small particles can be blown directly off the nuclei of some comets passing between the Earth and the Sun.

VARIOUS INVESTIGATORS (e.g., Silverberg, 1970; Poultney, 1972; McCracken, Alexander, and Dubin, 1967) have suggested that there are dust streams in interplanetary space in which the flux of micrometeoritic (i.e., mass $<10^{-8}$ gm) particles is enhanced by factors of up to 100 or more over the sporadic background. We discuss here several recent investigations of this possibility.

IN SITU MEASUREMENTS

It has been suggested (Silverberg and Poultney, 1969; Silverberg, 1970) that the periods of apparently enhanced micrometeoritic flux reported by various investigators using satellite-borne microphone detectors can be explained by postulating that small, low density particles are produced in sufficient quantities from debris in the orbits of short period, low-inclination comets to produce dust storms when the satellites pass through the comets' orbital planes. Silverberg (1970) further points out: "In general, there appears to be no dust event seen by the satellites [carrying microphone detectors] which was not near the plane of a periodic comet. Furthermore, no satellite passed through the plane of a low-inclination comet without registering a flux increase."

https://doi.org/10.1017/S0252921100049101 Published online by Cambridge University Press

Several years of observational results now available from the Pioneer 8 and 9 interplanetary dust detectors (Berg and Gerloff, 1970, 1972) make it possible to test the validity of this suggestion.

Table 1 summarizes the characteristics of the five largest dust showers discussed by Silverberg and Poultney (1969). The last column of Table 1 lists the number of counts that would be expected to be observed by the Pioneer 8 and 9 detectors in the same showers (The effective cross section of the Pioneer 8 and 9 detectors for a unidirectional flux near the ecliptic plane is about 0.005 m^2).

Figure 1 shows all counts registered on the front film as a function of time for the Pioneer 8 and 9 detectors during the periods when complete telemetry was available. The count rates are shown separately depending on whether or not the Sun was within the 120° field of view of the detectors.

The times at which cometary enhancements are predicted are also shown, and it is apparent that no dust showers are seen then—indeed no detectable showers appear anywhere in the data. Hence the Pioneer observations are completely at odds with the early microphone observations. In particular we can make the following points:

(1) No comet-associated dust storms were detected to a limit at least a factor of 100 more sensitive than the previously reported highest rates.

(2) The previously reported events were for particles in the mass range 10^{-8} to 10^{-9} gm, whereas the events shown in figure 1 are due to particles smaller than 10^{-11} gm. Indeed, the largest particle observed by the Pioneer detectors in more than three years of operation is 10^{-10} gm (Berg and Gerloff, 1971). Hence the particles presumed to cause these dust storms are much too rare to even have been observed with a total cross section (so far) of 3×10^5 m s, much less cause dust storms involving hundreds of impacts per day.

(3) It is no good to suppose that these storms occur only occasionally, since Silverberg's claim is that they were invariably observed whenever a satellite-borne detector passed through the orbital plane of any short period, low inclination comet whose perihelion distance was less than 1 AU.

Figure 1 also shows the positions of ten of the most active meteor streams (Porter, 1952). In view of the perturbing effects of solar wind and radiation pressure on the orbits of picogram-sized dust particles it is not surprising that no dust storms are observed connected with meteor streams (Millman, 1970; Mazets, 1971).

Figure 2 shows the corrected monthly sums for the three years of available data.

As an example of the limits that can be set on the flux of any possible stream (with low orbital inclination) let us assume a typical duration of 10 hr (3.6×10^4 s), and further assume that three hits in that period define a stream. Then any stream must have a flux of less than 0.02 particle m^{-2} sec^{-1}

COMET ENCKE

In addition to the Pioneer results, a number of other investigations were carried out during the

TABLE 1.—*Five Largest Dust Showers Discussed by Silverberg (1970) and Silverberg and Poultney (1969)*[a]

Satellite	Date(s) of "storm"	Associated comet	Count rate (m^{-2} s^{-1})	Duration of storm (hours)	Predicted no. of counts for a Pioneer-type detector
Vanguard 3	Nov. 16–18, 1959	Honda-Mrkos-Pajdusakova	0.2	70	250
Explorer 1	Feb. 3, 1958	Brorsen-Metcalf	0.2	15	55
Electron 2	Jan. 30–31, 1964	Brorsen-Metcalf	0.11	15	30
Sputnik 3	May 15, 1958	Halley	7	5	630
Electron 2	Feb. 23–25, 1964	Encke	0.0058	44.4	5

[a] Count rates shown are those expected for a Pioneer-type detector exposed to similar storms. The data in the first four columns are from Dubin and McCracken (1962), McCracken et al. (1965), and Nazarova (1968).

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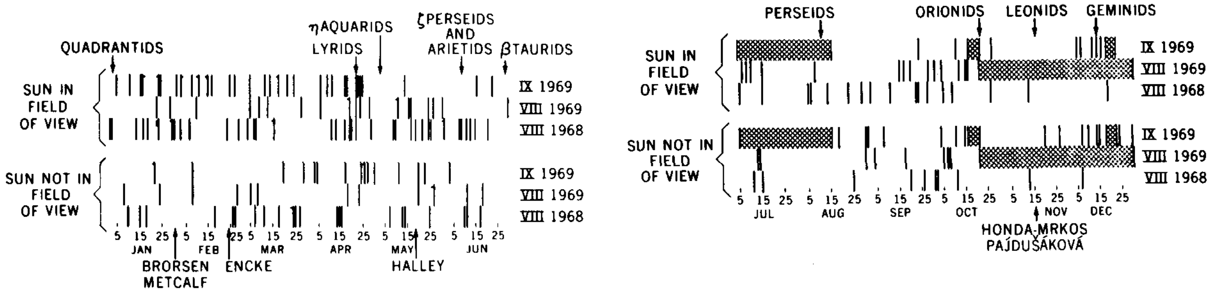

FIGURE 1.—All events registered by the front films of the Pioneer 8 and 9 detectors during 1968 and 1969. The abscissa is satellite longitude. The crosshatched regions indicate periods when daily telemetry was not available. Horizontal tic marks indicate numbers of events greater than one observed on the same day.

favorable opportunity of February 1971, when the Earth passed through Encke's node only six weeks after the comet itself, and a shower of dust particles blown directly off the comet's nucleus was predicted (Roosen, 1970; Poultney, 1972).

Optical Observations

Roosen (1969, 1970) reported on an anomalous shadow observed in the center of the Gegenschein on February 21, 1969, two days before the Earth passed through the node of Comet Encke. It was for a time believed that this observation might support Silverberg's hypothesis. An attempt was made to reproduce the observation in February 1971. Although observations were planned from four separate observing sites in the continental U.S., clouds prevented observations on February 23 and February 24, but observations on the other nights showed no evidence for a shadow. In particular, observations on February 21, 1971, did not reproduce the event observed February 21, 1969.

Indeed, optical scans of the Gegenschein brightness would not be expected to be very efficient in testing the Silverberg hypothesis. Silverberg predicts an almost isotropic sheet of dust stretching some several astronomical units past the Earth. As pointed out by Roosen, the shadow expected for such a collection of dust is only slightly greater than 1 percent deep. Hence the dust could not be detected by the shadow technique unless enough was present to increase the Gegenschein brightness by a factor of three or more. Further, the shadow reported by Roosen was much wider than that

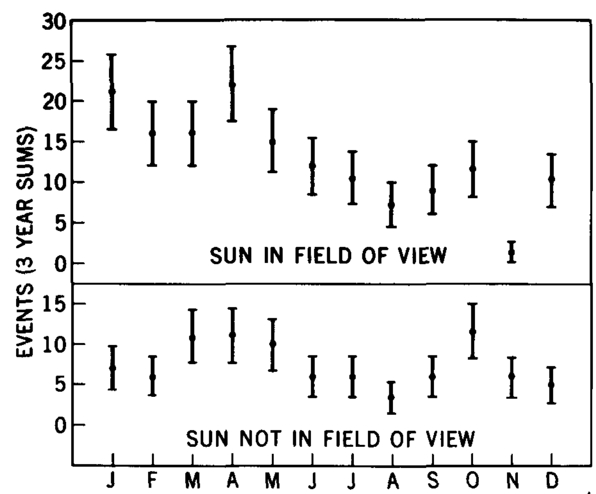

FIGURE 2.—Monthly sums of the 3 years of available data corrected for periods when telemetry was unavailable. The error bars represent probable errors in the number of observed events, assuming Poisson statistics.

predicted for Silverberg's isotropic sheet, and can only be interpreted as due to a relatively small cloud whose center was only about 60 Earth radii from the Earth. Also, since the estimated time of passage of the Earth through the dust sheet is only 5 hours (Poultney, 1970), observations of the antisolar region on days other than February 24 could not include the dust predicted by Silverberg.

Dust in the Upper Atmosphere

One of us (NHF) launched a Luster rocket at 1440 GMT on February 24, 1971, from White Sands Missile Range. The techniques used have been described by Farlow and Ferry (1972) and

Ferry and Farlow (1972). In the range of 80 to 118 km altitude, no increase was observed over the normal contamination background. A very slight enhancement found in the 70 to 80 km interval was also observed on 2 Luster flights from Churchill, Canada in April and May 1970. Hence no increase in mesospheric dust was detected.

Lidar observations by G. S. Kent (1971) in Jamaica also indicate no major enhancement in atmospheric dust on February 24 or on following days, although an enhancement was observed at the time of the Earth's passage through the orbital plane of Comet Bennett in May 1970 (Kent et al., 1971). [It is not surprising that no increase in event rates connected with this comet was observed by the Pioneer detectors, since its orbital inclination was so high (~90°) that any dust would be out of their field of view.]

Hence any dust blown directly off the nucleus of Comet Encke at the favorable 1971 apparition seems to have been indetectable.

CONCLUSIONS

Primarily from the Pioneer 8 and 9 results we can conclude that the flux of picogram sized dust particles near the Earth's orbit has been constant to within the observational limits over three years of observation. In particular, since dust streams are not observed, they cannot explain the microphone-detected events discussed by Silverberg (1970) and Silverberg and Poultney (1969). However, the possibility of rare events due to dust blown directly off a cometary nucleus (such as that reported for Comet Bennett by Kent et al., 1971, and discussed by Silverberg, 1970, and Poultney, 1971) cannot be completely ruled out.

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