REPRINTED FROM:

SPACE RESEARCH

PROCEEDINGS

OF THE FIRST INTERNATIONAL SPACE SCIENCE SYMPOSIUM

(NICE, JANUARY 11—16, 1960)

EDITED BY

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1960

NORTH-HOLLAND PUBLISHING COMPANY—AMSTERDAM

IGY MICROMETEORITE MEASUREMENTS

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Abstract: Direct measurements of micrometeorites were obtained during the International Geophysical Year by monitoring the impacts of cosmic dust on satellites and deep space probes. The largest data sample resulted from an experiment using crystal transducers to detect impacts upon the exposed sensitive area. The impact rate on Alpha 1958 was 8.0×10^{-3} meters^{-2} sec^{-1} for cosmic particles of mass greater than 8×10^{-10} g based upon the calibration and an impact velocity of 30 km/sec. The density of cosmic material in space at one astronomical unit is 5×10^{-22} g cm^{-3} for this component of cosmic dust, or approximately 10^{-20} g cm^{-3} based upon a mass distribution assumption. The density of cosmic material measured from Pioneer I is less by more than an order of magnitude than that measured on Alpha 1958; the impact rate was 4.0×10^{-3} meters^{-2} sec^{-1} for particles of mass greater than 10^{-10} grams for similar impact conditions. These measurements are compared in relation to daily and diurnal variations.

РЕЗЮМЕ: Непосредственные измерения микрометеоритов были получены во время Интернационального Геофизического Года наблюдением на сателлитах и воздушных шарах точек попадания космической пыли. Образцы с наиболее интересными данными были получены с кристаллическими датчиками, определяющими попадания на чувствительную поверхность. Основываясь на калибровке и на скорости попадания в 30 км/сек, частота на Альфа 1958 была найдена в 8.0×10^{-3} метров$^{-2}$ сек$^{-1}$ для космических частиц массой больше чем 8×10^{-10} гр. Плотность космического вещества в пространстве на одну астрономическую единицу равняется 5×10^{-22} гр.см$^{-3}$ для этого компонента космической пыли, или приблизительно 10^{-20} гр.см$^{-3}$, основываясь на предполагаемом распределении массы.

Плотность космического вещества измеренного с 1-го Пионера меньше чем в два раза той, которая измерена на Альфа 1958; частота попадания при равных условиях была 4.0×10^{-3} м$^{-2}$ сек$^{-1}$ для частиц массы которых больше чем 10^{-10} гр. Сравнения этих измерений были совершены в связи с каждодневными и дневными изменениями.

Introduction

The interplanetary space contains a gas in the form of plasma, the spectrum of electro-magnetic radiation, and cosmic matter. The cosmic matter includes various elementary particles with great energy such as cosmic rays, solar protons and macromolecular conglomerates of still larger specific energy, the

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cosmic dust. The astronomical study of meteors, and the study of the Fraunhofer component of the sun's corona and the zodiacal light have been the main sources of information concerning cosmic dust in interplanetary space [1, 2, 3]. Information concerning the solid component of interplanetary material has also been obtained from visual, photographic, and radio measurements of meteors, and from astronomical studies of comets, asteroids, the gegenschein, and the interstellar dust [4, 5].

Except for the collection of meteorites that have reached the earth in recent times, the direct measurement and analysis of interplanetary material has been impossible until the successful utilization of rocket launched vehicles. The first steps in the direct measurement of the solid component of interplanetary material have been carried out using rockets, satellites, and space probes. Within the past two years, a number of successful experiments have been undertaken with satellites and space probes by Soviet and American scientists. In particular these experiments involved the measurement of the cosmic dust by counting, with the aid of a piezo-electric transducer, the number of dust particles striking the space vehicles. In this paper, two cosmic dust experiments carried out during the International Geophysical Year are described. One of these experiments on Alpha 1958, launched 1 February 1958, has been reported elsewhere [6, 7]; a second was on the Pioneer I space probe which was fired on 11 October 1958.

Some additional data relative to Alpha 1958 has been tabulated below and the data from Pioneer I is also presented after a description of the experimental equipment is given. From such measurements, the physical nature of the solid component of cosmic dust in the solar system may be determined. The origin of the interplanetary material is not clearly known, and the determination of the space density and the distribution of this material in the interplanetary space may help determine the role of cosmic dust in the solar system. The cosmic dust may consist of matter from comets, asteroids, and galactic dust. Direct measurements of cosmic dust for the determination of the mass distribution, the distribution in space, the dynamics, and composition are of great interest in the understanding of the solar system.

Experimental method and calibration

As reported elsewhere [6, 8], the direct measurements of micrometeorites from satellite vehicles have been made with a sensing device consisting of a crystal transducer and a transistorized amplifier for the detection of the impulse vibrations transmitted along the sensitive exposed surface. Other methods for the detection and measurement of cosmic dust directly are known, but the method using the crystal transducer to record micro-displacements of the sensitive surface has several distinct advantages which led to its use for cosmic dust measurements by a number of investigators. This type of instrumentation is simple in nature and design, and is reliable, light in weight, and has low power and telemetry band-width requirements. It may also be used to monitor a large exposed surface at a high sensitivity level such that a significant data sample may be obtained during an exposure time of the order of days. The higher the sensitivity the greater the number of micrometeorite impulses, because the number density of cosmic dust particles increases with decreasing mass. This method for the measurement of cosmic dust, however, suffers from perturbations which may be recorded as apparent micrometeorite impacts. This difficulty requires that the experiment be carefully tested to minimize such interference, and for future experiments methods of insuring against this type of interference will be included in the instrumentation. On the other hand, the fact that this detection method is sensitive to impulses generated at less than hyper-velocities has aided greatly in the calibration of the equipment.

This experimental method has been studied theoretically and experimentally to determine the functional dependence for calibration purposes. It has been found that this sensor is sensitive to the *momentum* of the impacting particles and that the variation from a strict momentum dependence at meteoric impact velocities, between 10 and 70 km/sec. is small. If the velocity of the impact is known, the mass may be determined to within a factor of three and more like two.

The calibration [9] has been carried out by impact tests at low velocities and hypervelocities, and the problem has been considered theoretically. The crystal transducer and amplifier react to momenta variations at the input in a linear manner. Only a particular frequency component of the input at approximately 10^5 cps is amplified and detected. For the elastic case it has been shown that the frequency distribution $g(\omega)$ is proportional to the momentum, and hence the selected frequency component is also proportional to the momentum. The detected amplitude-time curve obtained experimentally by dropping a particle directly on the crystal was fitted analytically to a Gaussian curve, $f(t) = Ae^{-a^2t^2}$, where "A" is the pulse amplitude and "a" is a constant relating to the pulse width. The frequency distribution is then given by the Fourier transform

$$g(\omega) = \frac{A}{2\pi} \int_{-\infty}^{\infty} \mathrm{e}^{-(a^2t^2 + i\omega t)} \mathrm{d}t$$
$$= \frac{A}{a\sqrt{2}} \mathrm{e}^{-\omega^2/4a^2} .$$

For the elastic case [10], the amplitude $A = c_1 r^2 v^{6/5}$ and the dependence on pulse width gives $a = c_2 r^{-1} v^{1/5}$, where "r" is the particle radius. "v" the velocity, and the "c's" are constants. Then $g(\omega) \alpha r^3 v e^{-\omega^2 \beta r^2 v^{-2/5}}$. $\beta =$ constant $\approx 10^{-9}$. But $\omega^2 \beta r^2 v^{-2/5} \approx 0$ for the velocities, particle radii, and frequencies involved, and $g(\omega) \alpha r^3 v$ or the momentum of the particles. Thus, the electrical impulse is proportional to momentum, because the frequency distribution, $g(\omega)$, is proportional to the momentum.

The calibration was made for inelastic impacts as well as elastic impacts. A series of experiments were carried out to determine the sensitivity to particle impacts over a wide range of masses and velocities. It was found that the momentum dependence was valid over the entire range of masses and velocities producible by laboratory methods in the sensitivity and frequency ranges of the micrometeorite detection equipment.

The low ranges for velocity of impact were obtained by dropping glass spheres on the sensitive surface over a velocity range from 20 cm/sec to 400 cm/sec and mass range from 0.4 to 200 micrograms. These tests were corrected for viscous drag, the dropping height varying from a couple of millimeters to a few centimeters. Since these impacts were elastic, the impulses were measured in some cases through several rebounds. This calibration indicated that the equipment was sensitive to the momentum of impact.

The calibration at the high range of velocity was carried out with cylindrical, explosive-charge accelerators. Single steel particles with diameters from 38 to 300 microns were accelerated to velocities as high as 4 km/sec and impacted upon the sensitive surface and the velocity and impulse were measured. Fig. 1 is a curve of the signal obtained from the microphone as a function of the momentum of the impact. These tests indicated that the micrometeorite detection equipment was sensitive to the momentum of the impact over a range of momenta covering four orders of magnitude. At velocities of 4 km/sec, the impact is inelastic, and a hypervelocity crater is formed on the impacted surface. Comparisons were made on the same equipment by dropping glass spheres. After corrections were made for elastic and inelastic impacts, it was found that both methods gave consistent results within a factor of two. Thus, the micrometeorite detection equipment was found to be sensitive to the momentum of the impact over a large range of masses and for a range of velocities from 2×10^{-4} km/sec to 4 km/sec.

The velocities of meteoroid impacts upon the satellite may vary between 10 km/sec and 70 km/sec, a range of velocities resulting in crater formation and the ejection of material which would affect the momentum transferred. It appears, however, that at meteoric velocities the momentum transfer with cratering is not much different from the momentum transferred during

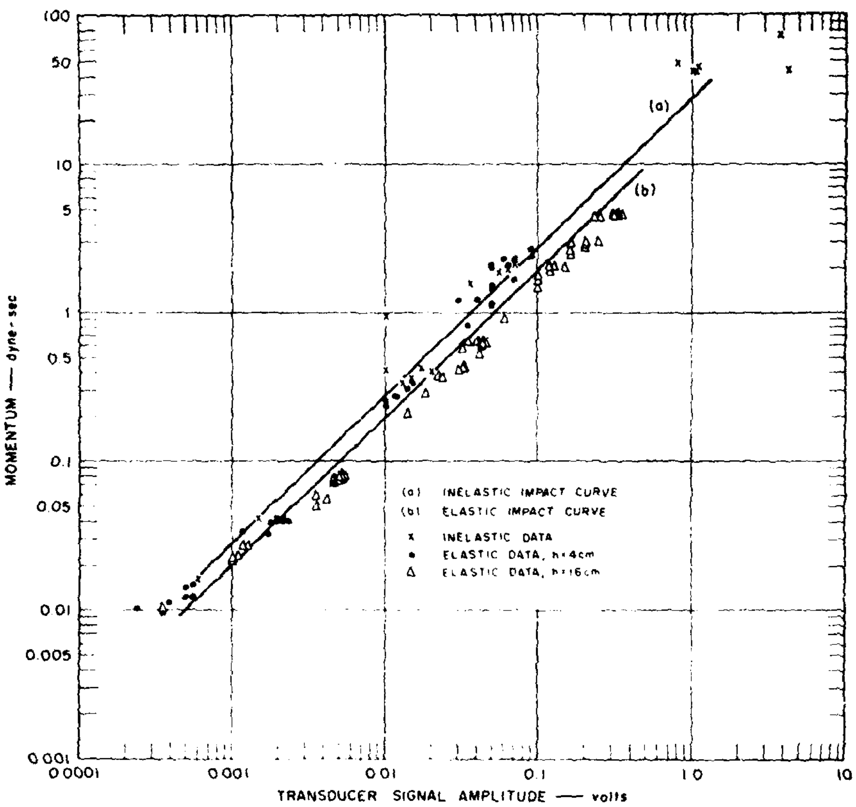


Fig. 1. Transducer output as a function of momentum. Inelastic data corresponds to velocities up to 4 km/sec.

elastic impacts based upon conservation requirements. Bjork [11] has recently computed the momentum contribution from cratering compared to the initial particle momentum. The largest value of this momentum contribution at 70 km/sec velocity was two and one-half times the initial particle momentum. In the calibrations of equipment for satellites and space probes, the calibration is carried out for elastic impacts and is probably accurate for determining the mass of the impacting particle of known velocity to within a factor of two at a given point on the sensitive surface.

Alpha 1958

The experiment and results of the micrometeorite experiments on Alpha 1958 has been described [7]. This satellite was launched at 0348 G.T. on

1 February 1958 in a low inclination orbit with a perigee altitude of 374 km, apogee of 2 555 km and a period of 115 minutes. The effective threshold momentum level for the micrometeorite experiment was 2.5×10^{-3}g cm/sec over a sensitive exposed area of 0.23 meters². The tabulation of data from Alpha 1958 is given in table 1. In this table, the time of each pass which showed a micrometeorite impact is tabulated for each of the receiving stations.

TABLE 1

Micrometeorite data — Alpha 1959

(Listing Z-time of passes with impacts, no. of passes, total telemetry time by receiving station, total and corrected no. of impulses and total time.)

Station	Date Feb.	Z-time (Sec)	No. of Hits	Time for Pass (Sec)	Total No. of Hits	Total Time (Sec)	Total No. of Passes
San Diego, California	1		1	77	1	2507	20
Blossom Point, Md.	1	20:41	2	527			
	2	00:45	3	696			
	3	01:38	4	259			
					9	5713	26
Fort Stewart, Georgia	2	19:33	1				
	2	21:39	2	221			
	2	23:39	11	366			
	3	01:41	12	261			
	3	03:44	1				
	3	20:30	3	390			
	4	00:37	2	276			
	4	04:38	2	264			
	7	01:23	3	239			
	7	22:22	1				
					36	12464	51
Havana, Cuba	1	03:54	8	143(launch)			
	2	00:47	1				
	2	23:40	7	174			
	3	01:42	2	7			
	3	03:44	2	192			
	3	20:28	2	267			
	4	04:42	1				
	7	22:17	1				
	10	21:01	1				
	11	21:58	1				
					26	9544	50
Quito, Ecuador	1	07:58	3	137			
	2	19:30	2	233			
	3	07:50	2	142			
	3	18:24	2	290			

TABLE 1 (continued)

Station	Date Feb.	Z-time (Sec)	No. of Hits	Time for Pass (Sec)	Total No. of Hits	Total Time (Sec)	Total No. of Passes
	10	16:47	1				
	11	03:12	1				
	11	15:42	1				
					12	5207	39
Lima, Peru							23
Woomera, Australia	2	18:33	5	159			
	2	20:33	4	787			
	2	22:38	2	691			
	3	00:43	7	832			
	3	02:58	2	180			
	3	19:29	1				
	4	01:47	2	412			
	4	18:26	1				
	6	22:21	1				
	10	17:59	1				
	11	00:05	1				
	11	16:54	1				
	11	20:55	1				
	11	22:55	1				
					30	18413	43
Antigua, B. W. I.	3	03:49	1				
	4	19:29	1				
	10	16:53	2				
					4	7473	34
JPL	3	05:39	7	338			
					7	731	3
Santiago, Chile	1	10:04	1				
	1	14:13	1				
	2	09:00	2	590			
	2	15:12	2	687			
	3	09:58	2	527			
	3	14:05	5	663			
	4	08:52	1				
	4	10:53	3	937			
	4	12:57	2	659			
	4	15:03	2	972			
	7	07:38	2	291			
	7	09:39	1				
	9	07:30	1				
	10	08:25	2	379			
					27	19140	41
Patrick Air Force Base	3	22:26	1				

TABLE 1 (continued)

Station	Date Feb.	Z-time (Sec)	No. of Hits	Time for Pass (Sec)	Total No. of Hits	Total Time (Sec)	Total No. of Passes
	10	20:53	1				
	11	21:52	1				
					3	3633	8
Temple City, California	3	01:32	2	213			
	3	03:34	4	293			
	4	02:28	1				
					7	1410	11
Amateur Station							
(Coeyman)						389	2
(Ehrlich)	2	02:45	1				
	2	23:38	5	192			
	3	01:39	5	187			
	3	03:38	1				
	4	02:41	1				
	4	04:37	1				
					15	2643	14
(Franklin)	1	22:05	1				
						540	3
(Kuntz)						269	1
(Welch)	11	01:04	1				
					1	225	2
		Grand total			178	93,734	371
		Corrected total			145	78,752	

The total time is recorded including the times for the passes during which no impacts were recorded. The impact rate for the twelve-day period was 8.0×10^{-3} impacts meters^{-2}sec^{-1}. based upon a corrected recording of 145 impacts in 78 750 seconds. The correction removes 8 impacts during the launch and injection into orbit.

The data from Alpha 1958 have been plotted in fig. 2, giving the number of impacts over the twelve-day period as a function of local time. The number of impacts plotted in the ordinate is the average for the three hours centered around the abscissa hour. The area under the upper boundary of the plot is the integral of all the impulses recorded on Alpha 1958. The shaded area between 1600 and 2400 hours represented the number of impulses which were measured in an interval of about five successive satellite orbits. Less than eight hours of the twelve days of the time of operation of the experiment elapsed, or only three percent of the time of operation of the experiment. The average impulse rate during the 22 and 23 hour of local time was twenty times higher than the average for impulse rate over the twelve-day period.

The plot of the solid black section of fig. 2 shows an apparent diurnal variation in the influx of meteoritic particles as would be expected. The diurnal variation is about three to one. The lightly shaded area may therefore represent a large perturbation in the influx rate of particles or a "shower" of meteoritic particles. A large daily variation of the influx of particles is also evidenced from fig. 3 which shows the average daily impact rate on the satellite over the twelve-day period.

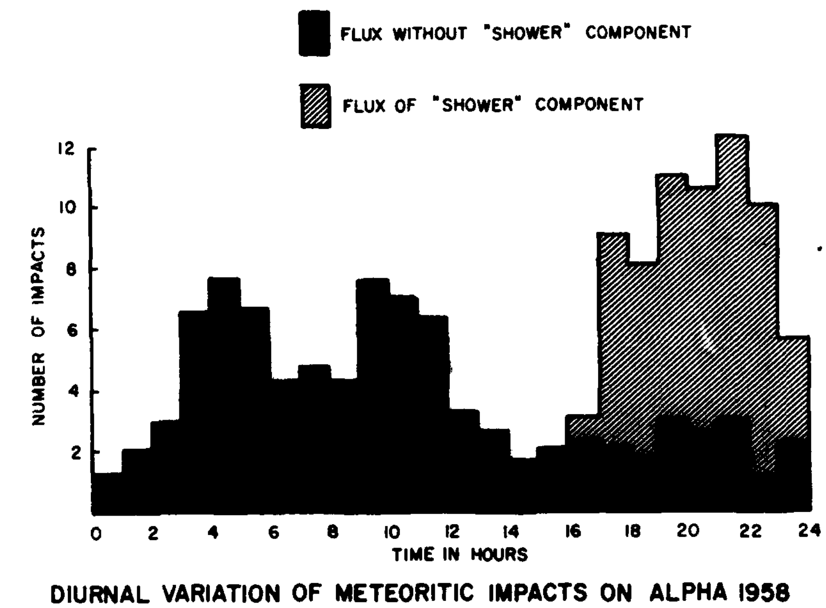


Fig. 2. Diurnal variation of micrometeorite impulses recorded on Alpha 1958.

Pioneer I

A micrometeorite detection experiment was included in the instrumentation packages prepared by the Space Technology Laboratories in the series of three Thor-Able firings toward the moon. The second launching, Pioneer I, at 0842 G.T. on 11 October 1958 reached a distance of nineteen earth radii from the earth's center; the results of the micrometeorite experiment are reported below.

The transducer and amplifier for the detection of micrometeorites on Pioneer I was nearly identical to that used on Alpha 1958, except for a two level read out of the impulse obtained by tapping the output of the amplifier

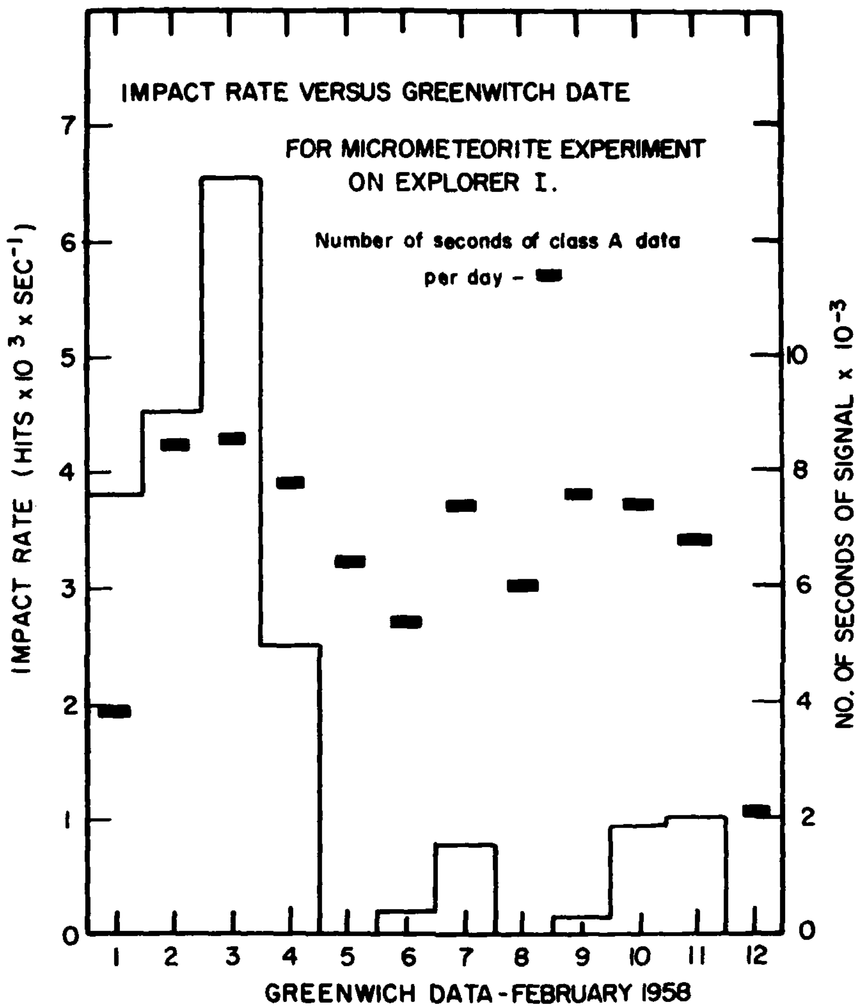


Fig. 3. Impact rate by day on Alpha 1958.

after the second stage of amplification. A block diagram of the equipment showing this arrangement is given in fig. 4. Fig. 5 is a photograph of the equipment showing the microphone mounted to a sensitive aluminum surface, the amplifier, and the logic circuits. The sensitive surface was 7075–ST6 aluminum with an exposed area of 0.038 square meters and was mounted at six points by rubber grommets on the cylindrical center section

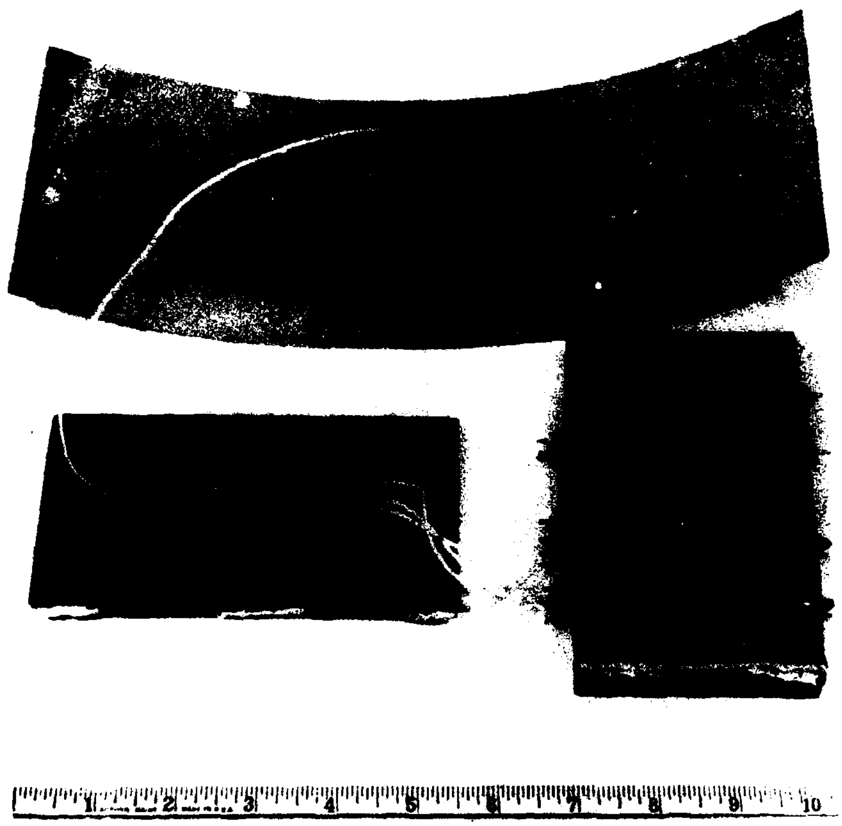


Fig. 5. Photograph of Pioneer I micrometeorite detection equipment.

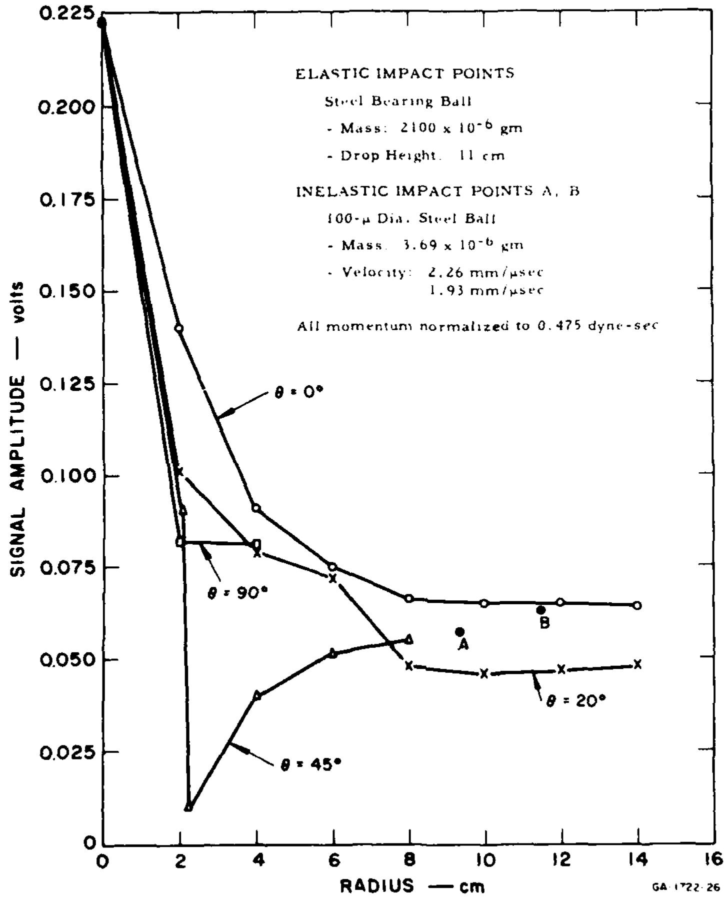


Fig. 6b. Pioneer I aluminium plate calibration using elastic and inelastic impacts.

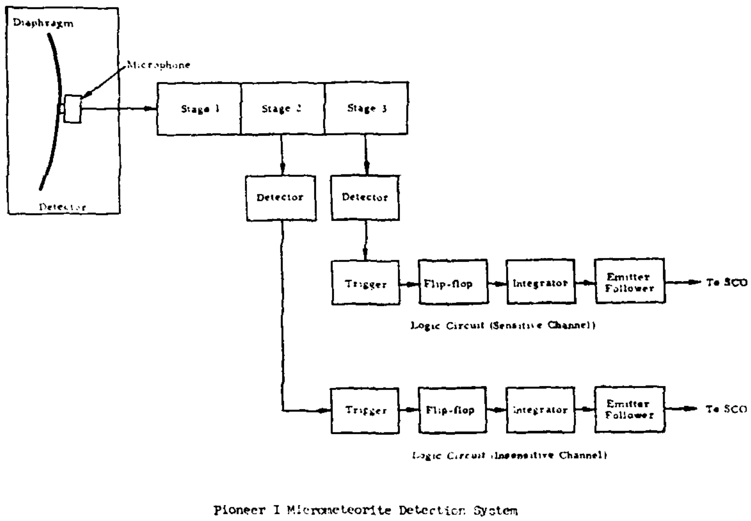
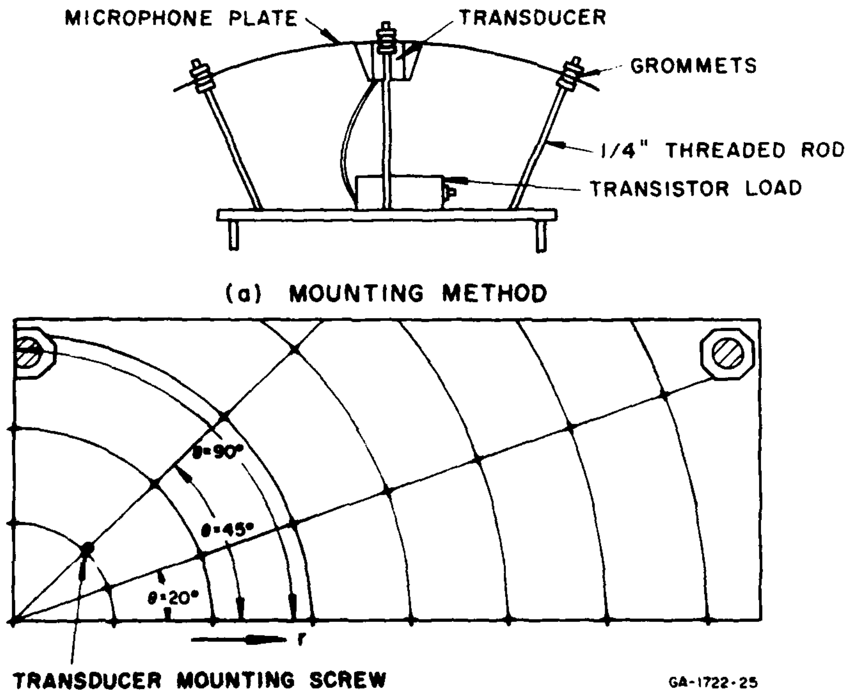


Fig. 4. Block diagram of Pioneer I micrometeorite system.



(b) PLATE GRID SYSTEM

Fig. 6a. Pioneer I aluminium plate mounting for calibration.

of the payload. The two sensitivity levels of the apparatus as calibrated and averaged over the diaphragm were 1.5×10^{-4} g cm/sec and 0.5×10^{-2} g cm/sec. Fig. 6a and fig. 6b describe the calibration of the sensitive surface. In fig. 6b both low velocity and hypervelocity particles were used.

The results of the micrometeorite experiment on the Pioneer I flight are summarized in tables 2a and 2b. The total time of telemetry was 1.1×10^{5} sec

TABLE 2a

Table of Micrometeorite Impulse Indications. (Giving Time After Launch of Impulse on Telemetry, and Number of Radii of Earth's Center.)

Time After Launch in sec $\times 10^{-3}$	No. of Earth Radii From Earth's Center	
1.2	1.9	
2.88	3.2	
3.24	3.4	
3.60	3.7	
3.78	3.8	
6.72	5.7	On both channels
7.20	6.0	
8.10	6.5	
11.04	7.8	
14.94	9.4	
20.46	11.3	
30.12	13.3	
57.42^{3}		
57.54^{2}	18.0	Data questionable
57.60		
57.66		
105.66	17.8	
116.62	16.4	
133.08	13.0	
134.52	12.6	
164.24	9.6	

with the total of seventeen recorded impacts on the sensitive channel, and only one recorded impulse on the channel with low sensitivity. At 57.4×10^{3} seconds after launch in an interval of 240 seconds, a series of seven impulses were recorded. These may possibly have been impacts, but are not included in the flux levels because of the peculiar nature of the impulses on the telemetry record. The impact rate on Pioneer I for a threshold level of 1.5×10^{-4} g cm/sec was 4×10^{-3} meters^{-2}sec^{-1}.

The data from table 2 is plotted in fig. 7 with the impulses marked on the trajectory curve of Pioneer I. The distance from the earth is given in earth

TABLE 2b

Time Intervals Without Telemetry. Total Telemetry Time = 1.1×10^5 sec

Time After Launch in Seconds	Telemetering Inoperative in sec $\times 10^{-3}$
1.8×10^3	1.6
5.8×10^3	0.4
2.39×10^4	0.7
3.26×10^4	14.9
4.82×10^4	1.6
5.27×10^4	0.6
5.52×10^4	1.1
5.77×10^4	3.7
6.59×10^4	2.8
7.09×10^4	11.9
1.204×10^5	0.8
1.552×10^5	to impact

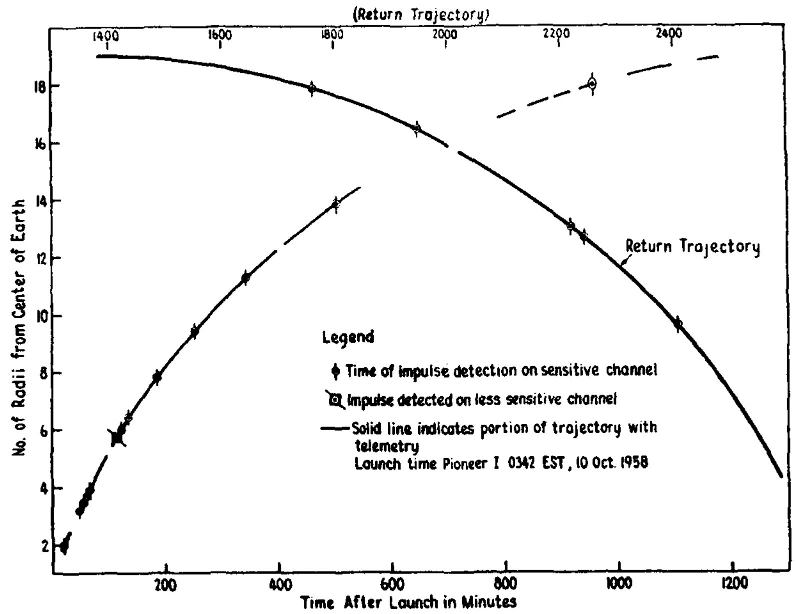


Fig. 7. Distribution of micrometeorite impulses along the trajectory of Pioneer I. Times when telemetering was not recorded are also indicated.

radii as a function of time after launch, and the solid line represents the portion of trajectory during which telemetry data were recorded.

Discussion

The results of the micrometeorite measurements of Alpha 1958 and Pioneer I may be compared. For Alpha 1958 an area of 0.23 meters^2 was exposed for 7.9×10^4 seconds to give an area-time product of 1.9×10^4 meters^{2}sec. The impact rate measured was 8×10^{-3} impacts meters^{-2}sec^{-1} for a threshold momentum level of 2.5×10^{-3} g cm/sec. For an assumed compact velocity of 30 km/sec an impacting particle detected has a mass of 8×10^{-10} grams or greater. The mass influx upon the earth would be approximately 1.3×10^{-11} gm^{-2}sec^{-1} for this component of interplanetary matter. This is equivalent to 6×10^8 g/day or 6×10^2 tons/day over the earth's surface for this component of interplanetary matter. A daily accretion rate of interplanetary matter up to 10^4 tons per day for all components of mass of cosmic dust is indicated from these measurements.

The density of matter at one astronomical unit may also be computed for the assumed velocity of 30 km/sec. This density of material is 5×10^{-22} g cm^{-3} for this component of interplanetary matter. This density of matter in space may be as high as 10^{-20} gcm^{-3}, using the mass distribution function for interplanetary matter obtained from radio meteors. These values of the density of matter in space may be compared to measurements obtained from zodiacal light studies [1, 2, 3]. The validity of the data from Alpha 1958 is in part supported by the diurnal variation as shown in fig. 2 on the assumption that a cosmic dust "shower" occurred near the end of the second day in orbit. There are two reasons for supporting the "shower" hypothesis. An intense sporadic E condition in the ionosphere was recorded in the vicinity of those receiving stations recording the maximum impulse rate on the satellite during the period of the "shower". The sporadic E condition was recorded at White Sands, New Mexico, with a critical frequency or 7 Mc/sec and seven multiple reflections over the period of the "shower". The chances of such an intense sporadic E occurring during the early evening during the month of February at the latitudes of the observation is only about three percent. It has been suggested repeatedly in the literature that meteor ionization is a source of sporadic E. The second reason for consideration of the "shower" hypothesis is the occurrence at a time of day which would normally be a minimum in the influx rate of cosmic material because of the heliocentric motion of the earth.

The data from the Pioneer I experiment was obtained on an exposed surface of 0.038 meters^2 over a time interval of 1.1×10^5 sec. The area time product for this experiment was 4.2×10^3 meters^{2}sec, nearly five times less than Alpha 1958. The impact rate, 3×10^{-3} meters^{-2}sec^{-1}, was half as great as Alpha 1958. The threshold sensitivity of the detector was 1.5×10^{-4}

g cm/sec, which was sixteen times more sensitive than Alpha 1958. Thus, the flux of the component of interplanetary matter measured on Pioneer I was 2×10^{-13} g m^{-2}sec^{-1} compared to 6×10^{-12} gm^{-2}sec^{-1} for the component measured on Alpha 1958. If the distribution of matter is such that the mass density of each component of interplanetary matter is nearly constant, then the density of matter as determined from the Pioneer I measurements is thirty times less than that measured on Pioneer I. The Alpha 1958 data indicated daily fluctuations as great as an order of magnitude may exist. However, if the fluctuations of this order of magnitude, as well as seasonal variations from February to October, are not shown to be of the range of difference of these two measurements, then another possible explanation for this variation may be presented. The sensor of Pioneer I was spin stabilized in space upon injection into orbit. The sensitive surface was a part of the cylinder whose axis was the spin axis. The angle of the payload spin axis was approximately 15° out of the plane of the ecliptic and at an angle of about 45° with a radial line from the sun. The sensitive surface is effectively oriented in the plane of the ecliptic less than 20 percent of the time, compared to an isotropic, spherical surface. If the cosmic dust is concentrated in the ecliptic as evidenced by zodiacal light measurements and the distribution of asteroids, then the combined factors of the daily variation and the distribution in the interplanetary space would explain the variation in the two sets of data. The recent measurements of cosmic dust on Eta 1959 lend support to this hypothesis because the daily variations are not large enough to explain the discrepancy, and the influx rates indicate that there is not a large seasonal variation. Thus, on the assumption that the data from Pioneer I represents an accurate sampling of cosmic dust, then there is an indication that this component of cosmic dust is concentrated in the ecliptic, or that the distribution function is such that there is a decrease in the number density of particles of mass of the order of 10^{-10} grams compared to the expected distribution function. The latter explanation is not a satisfactory one, since only one particle was detected on the less sensitive channel of Pioneer I which was calibrated to detect particles of mass near 2×10^{-9} grams. This sensitivity is slightly greater than for Eta 1959, and the impact rate is nearly an order of magnitude less than Eta 1959.

Finally, the distribution of particle impacts on the altitude-time plot, fig. 7, for Pioneer I is of interest in that the impact rate close to the earth while the vehicle is receding from the earth differs from the rate along the remaining part of the trajectory. The impact rate differs by a factor of six with the larger flux occurring while the space probe is receding and less than six radii from the earth. Two explanations for such a behavior may be considered if one wishes to consider this small data sample as significant. One explanation allows for such a variation from the extent of the daily variations already detected. The second explanation is connected with the relative variation of velocities of the cosmic dust and the space probe as affected by the gravitational potential. The space probe near the earth has an initial outward component of velocity of nearly 10 km/sec and the cosmic dust is perturbed by gravitational potential so as to increase its velocity upon approaching the earth. Thus, a differential velocity greater than 20 km/sec may occur between particle and space probe at the two ends of the vehicle trajectory. Because the threshold level for the mass of particles which may be detected is proportional to the first power of the impact velocity, the effect may be explained in this manner if the number density of the cosmic dust increases with decreasing mass. With a significant data sample and a known distribution function, an effect of this nature may be used to compute the average velocity of cosmic dust relative to the earth. If the effect is real, the variation is indicative of a low velocity for the cosmic dust relative the to earth.

Finally, these measurements of the mass influx rate of cosmic dust may be of interest in determining various effects relating to geophysics at ionospheric altitudes. In addition to a possible relationship to certain types of sporadic E, the accretion of extra terrestrial material on the earth contributes to the atmospheric structure at altitudes near 100 km. For example, the influx of material as measured from Alpha 1958 was of the order of 10^{-14} g $cm^{-2}sec^{-1}$. These particles disintegrate in the earth's atmosphere by sputtering and ablation. Assuming that the atoms may be spread over a 10 km altitude region, have holdup times of the order of a day, and that such elements as sodium or calcium are present in the cosmic dust at concentrations of about one percent, then of the order of 10^3 atoms per cm^3 are added to the atmosphere per day, based upon the mass influx of cosmic dust measured on Alpha 1958. Such a hypothesis has been considered to explain the sodium flash and the sodium detected in the night airglow, and the effect of minor constituents in explaining the nocturnal E region [12, 13].

Conclusions

Direct measurements of cosmic dust in the vicinity of the earth have been made and the space density of interplanetary material near the earth was found to be approximately 5×10^{-22} g cm^{-3} for the component of cosmic dust detected. Additional speculations and remarks based upon the data have been presented concerning the detection of a diurnal variation in the influx of cosmic dust, the presence of an apparent cosmic dust "shower", the magnitude of the daily variation in the influx rate of cosmic dust, the distribution of cosmic dust in relation to the ecliptic, and the velocity of the dust relative to the earth. Additional measurements would be of very great interest.

Acknowledgments

These experiments were performed with the support of the National Science Foundation, the United States Committee for the International Geophysical Year, and the Air Research and Development Command. The Jet Propulsion Laboratory and the Space Technology Laboratories prepared the payload and assisted in securing the data. F. K. Dearborn, E. Baker, and B. Sensinig carried through the data reduction of Alpha 1958. S. Baker and C. P. Sonett did the major work on the Pioneer I logic circuits and data reduction. Professor J. L. Bohn was responsible for the design and construction of the detector. To those mentioned and to the others who helped carry out these experiments, the author extends his sincere appreciation.

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