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MICROMETEORITE MEASUREMENTS  
FROM THE MIDAS II SATELLITE (1960 ζ 1)

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## ABSTRACT

Five micrometeorite sensing devices were carried on board the Midas II (1960 ζ1) satellite which was launched into an approximately 500-km circular equatorial orbit on 24 May 1960. The five devices consisted of three acoustic detectors and two wire-grid detectors. Data were obtained for four partial orbits. These data were recorded in real time. There were no breaks in the wire grids which could record impacts of particles larger than 10 microns. Sixty-seven impacts were recorded on the acoustic detectors which had a momentum threshold of  $3 \times 10^{-4} \text{ gm cm sec}^{-1}$  and a total area of  $0.0686 \text{ m}^2$ . These results indicate a flux of  $0.25 \text{ m}^{-2} \text{ sec}^{-1}$  of particles 5 microns in diameter or larger if one assumes a mean velocity of  $15 \text{ km sec}^{-1}$  and a density of  $3 \text{ gm cm}^{-3}$  for the particles. The discrepancy between acoustic and wire-grid data will be discussed. These results will be compared with those obtained from other satellite measurements.

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## MICROMETEORITE MEASUREMENTS FROM THE MIDAS II SATELLITE (1960 ζ1)

To detect micrometeorites in the vicinity of the earth, instruments similar to those used on earlier satellites<sup>1</sup> were carried on the Midas II (1960 ζ1) earth satellite. Midas II was launched on 24 May 1960 into an approximately 500-km circular orbit which was inclined 33° with respect to the equatorial plane of the earth.

Five detectors were mounted on the vehicle as shown in Fig. 1. Three of the detectors were acoustic or microphone type and two were wire-grid type. The dotted lines in the sketch indicate a detector facing outward on the other side of the vehicle.

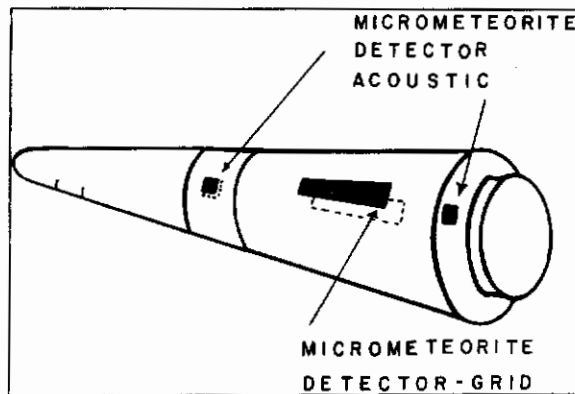


FIG. 1. Earth Satellite 1960 ζ1.

The vehicle was designed to maintain a stabilized attitude with the end (shown on the right in Fig. 1) pointing radially outward from the earth. Attitude stabilization was not achieved. Data obtained from other experiments on the vehicle indicate it was tumbling but they are inadequate to determine the attitude history of the vehicle.

Data from the acoustic detectors were acquired only for impacts that occurred while the vehicle was being interrogated by a receiving station. Provision had been made to acquire data over other

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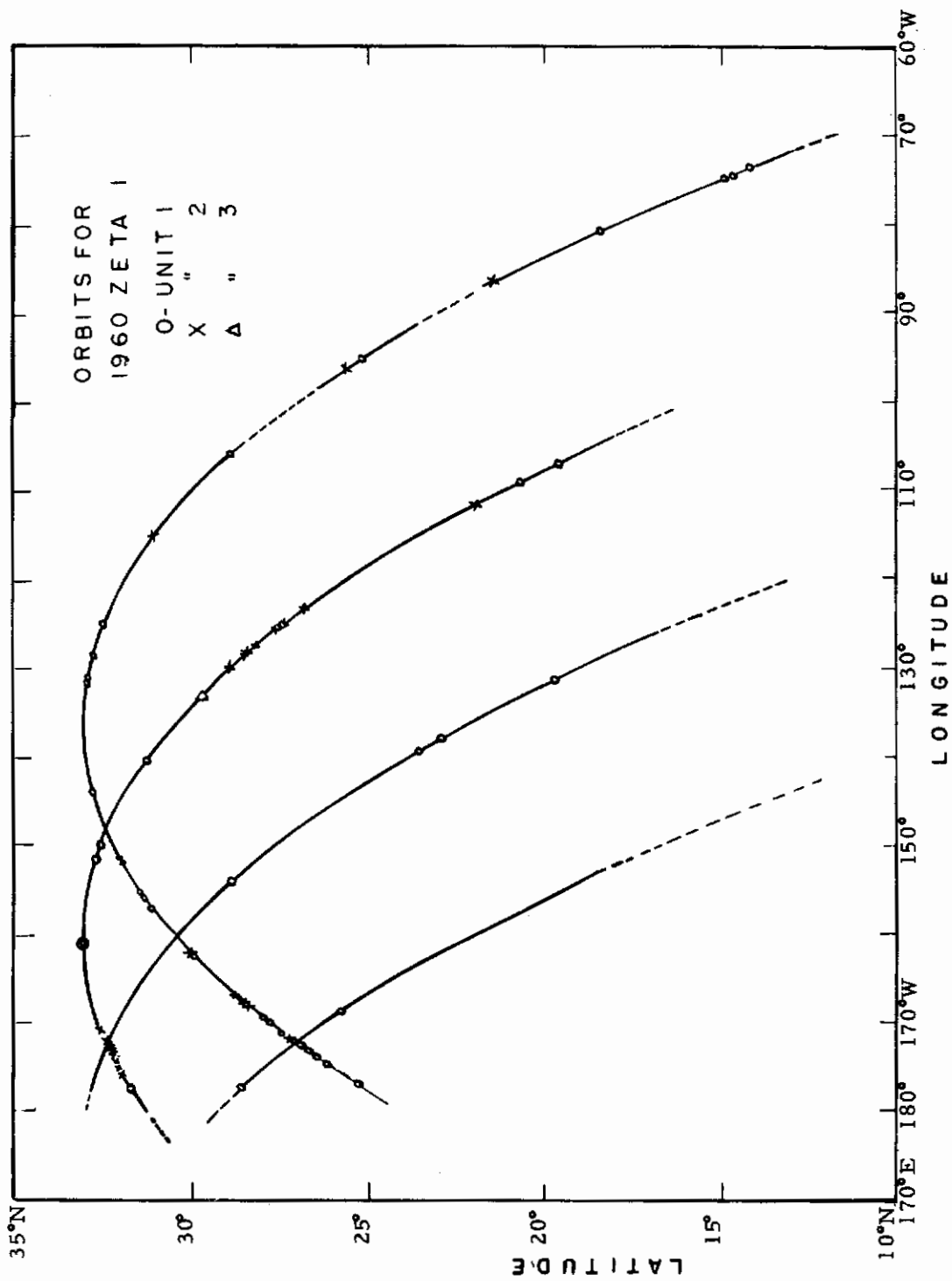


FIG. 2. Occurrence of Micrometeorite Impacts.

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portions of the orbit but the vehicle recorders did not operate. The wire grids are inherently data-storage devices. Breaks in the wires that occur during any part of the orbit can be detected by periodically monitoring the continuity of the wires, and the number of breaks is accumulated.

Data from parts of four orbits were obtained before the telemetry system failed, by stations located in Hawaii, California, and Florida. Approximately 4000 seconds of data were acquired from the acoustic detectors, while the grids provided data for 25,000 seconds of exposure.

Although the amount of data is small compared to that accumulated from other satellite vehicles, these are the first reported measurements at this altitude. In the light of recent hypotheses<sup>2,3</sup> regarding the altitude variation of micrometeorite flux, it is felt that these results, although scanty, merit reporting.

Sixty-seven impacts were recorded on the three acoustic units, and they were distributed over the four partial orbits for which data was acquired, as shown in Fig. 2. The solid lines indicate the portions of the flight path where a "clean" or noise-free signal was received. Since the total exposed area of the three acoustic plates was 686 cm<sup>2</sup>, the data represents a mean flux of 0.25 particles/m<sup>2</sup>/sec. The mean momentum sensitivity of the three acoustic units, as determined by dropping spherical glass beads on the plates, was  $3 \pm 1 \times 10^{-4}$  gm cm/sec. No shielding corrections have been applied. Assuming a mean velocity of 15 km/sec, the sensitivity represents a flux measurement of particles of mass greater than  $2 \times 10^{-10}$  gm. Further, if spherical particles of mean density 3 gm/cm<sup>3</sup> are assumed, the impacting particles would be larger than 5 microns in diameter.

No wire grids were broken. An area of 790 cm<sup>2</sup> of grids was exposed. The wire diameter was approximately 20 microns. Previous work<sup>4</sup> has indicated that hypervelocity particles 10 microns in diameter or larger should break this size wire. Therefore the flux of particles larger than 10 microns in diameter is less than  $5 \times 10^{-4}$  particles/m<sup>2</sup>/sec.

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If one assumes the type of distribution function that is commonly arrived at from various data considerations such as Whipple's meteoric risk curve,<sup>5</sup> then the data from the two types of detectors appear to be inconsistent. That is, the ratio of fluxes from the two types of measurements is greater than 500 where the particle sizes differ by a factor of 2 or so, depending upon the assumptions made regarding velocity and density.

One might thus disregard the acoustic measurements with the assumption that the units were not working properly or that either vehicle noise was being introduced or thermal noise was occurring within the units themselves. This is the usual manner of accounting for high flux rates observed from the first day's data of practically all satellite vehicles.

For several reasons it is felt that the acoustic data should not be discarded. First: The microphones and plates were acoustically isolated from the vehicle. There was only one instance where all three acoustic units were triggered during the 1-second interval between readouts. This triple coincidence, shown in Fig. 2, was not included in the total count or in the flux calculations. Second: Although the microphone and grid measurements appear to be inconsistent with each other, more recent information is now available that shows that the values obtained are reproducible. A preliminary reduction of the data from the Satellite 1961  $\alpha 1$  has been completed. These results are not yet in final form and may vary slightly. They are presented here for comparison purposes only. Satellite 1961  $\alpha 1$  was in a circular polar orbit at approximately the same altitude (about 500 km) as 1960  $\zeta 1$ . Similar experiments of approximately the same sensitivities were carried. Data were obtained from parts of 23 orbits, again only over readout stations. The data from the acoustic units yield a mean influx of 0.34 particles/m<sup>2</sup>/sec. It should also be pointed out that while the measured acoustic flux shows statistical variations over the 23 orbits it does not appear to decrease with time. Also, on Satellite 1961  $\alpha 1$ , eight breaks occurred in the wire grids. These all occurred after the



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first interrogation somewhat as follows: No break during the first orbit; three breaks in the next seven orbits; one break in the second seven orbits; and, finally, four breaks in the last eight orbits. This leads to a flux of particles detectable by the wire grids (that is, larger than 10 microns in size) of  $8 \times 10^{-4}$  m<sup>2</sup>/sec. The ratio for the Satellite 1961 a 1 acoustic-grid measurements is about 400 as compared to greater than 500 for Midas II. A complete report on the Satellite 1961 a 1 measurements will be published shortly.

The similarity of the measurements from Satellites 1960 ζ 1 and 1961 a 1 cannot be ignored. Despite the apparent inconsistency, the values appear to be reliable. Varying the assumed values for velocity and density within reasonable limits does not change the particle diameters appreciably since the cube root of these values is involved in the calculation. It may be necessary to re-examine the calibration of these devices using hypervelocity techniques now available to resolve the apparent discrepancy. The possibility of a large variation in the distribution function can be eliminated. The acoustic units on board 1961 a 1 had two momentum sensitivities. The lower sensitivity range should (with the previously assumed values for velocity and density) have a threshold of 10 microns. The recorded fluxes are not consistent with the wire-grid data.

The remaining possibility that can be suggested is that fluffy particles of very low density, which might not be able to break the wire grids, are the major constituent of the acoustic flux. This possibility does not agree with empirical formulas of hypervelocity penetration, but cannot be entirely discounted. This hypothesis cannot be checked in the laboratory at this time since techniques for accelerating fluffy particles do not yet exist.

Finally, the relationship between the acoustic data reported here and the altitude variation of micrometeorite flux should be pointed out. Figure 3 shows a curve which is similar to that reported by Whipple.<sup>2</sup> The acoustic flux as measured from 1960 ζ 1 (corrected to a value of  $10^{-9}$  gm by assuming a mass distribution function which is proportional

to  $m^{-1.2}$  and a velocity of 15 km/sec) has been added. The corrections are the same as those applied to the other satellite points in Whipple's paper. The early acoustic rocket data, about which there is some dispute, have been deleted and a new curve with a slope of  $-1.1$  has been fitted to the points. With the exception of the Zodiacal cloud, all the points were obtained with satellite acoustic detectors.

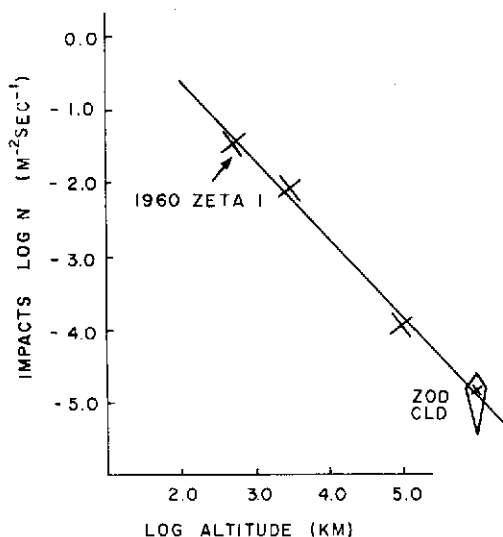


FIG. 3. Meteoritic Impact (mass =  $10^{-9}$  gm) versus Altitude from the Earth. (Revised from Whipple, F.L.<sup>2</sup>)

In conclusion, the data reported here establish that a discrepancy exists between the acoustic and the wire-grid measurements which must be resolved before the dust content of the interplanetary medium is understood. However, if one considers the acoustic measurements in a purely relative manner, it appears that there is a geocentric variation in the micrometeorite flux.

## ACKNOWLEDGMENTS

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