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# Preliminary Results of the Micrometeoroid Experiment on Board Helios A

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Abstract. For the first time in situ measurements of interplanetary dust have been performed between 0.3 AU and 1 AU from the sun by the micrometeoroid experiment on board Helios A. The measured particle masses are between $10^{-15}$ g and $10^{-8}$ g and their measured speeds are between 2 km/sec and 20 km/sec. Particle impacts are identified by the time-of-flight spectra of the ions released upon impact. 15 large particles ($m \gtrsim 10^{-12}$ g) were detected from Dec. 15, 1974 to Sept. 5, 1975. They show a strong increase of the impact rate (appr. a factor of 10) between 1 AU and 0.3 AU. The directions from which they impacted the sensor are concentrated between the solar direction and the apex direction of the Helios spacecraft.

The Helios A spacecraft was launched on December 10, 1974 into an eccentric orbit around the sun. Helios A explores the interplanetary space between 0.98 AU and 0.31 AU from the sun. The micrometeoroid experiment (E-10) on board registers individual dust particles crossing the orbit of Helios if they hit the sensitive parts of the sensors. Fig. 1 shows a cross-section of the spacecraft with the mounting of the two sensors and their field of view (one sensor rotated by $90^{\circ}$ in azimuth). The spin axis of Helios is perpendicular to its orbit plane which is identical with the ecliptic plane. While the spacecraft spins once a second around its axis the two sensors scan a full circle in azimuth. Two sensors are installed in order to allow a rough determination of the inclination of the particles' orbits within two channels. One sensor (south-sensor) is facing the southern ecliptic hemisphere detecting particles which have elevations from $-90^{\circ}$ to $-10^{\circ}$. The other sensor (ecliptic-sensor) detects particles with elevations from $-45^{\circ}$ to $+55^{\circ}$ with respect to the ecliptic plane.

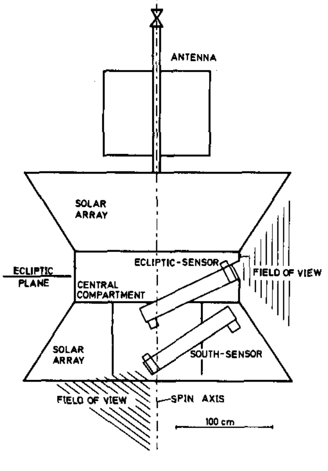


Fig. 1: Helios spacecraft with mounting of the micrometeoroid experiment.

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Fig. 2 shows a cross-section of the south-sensor. The sensor consists of the solar wind protection system, the impact ionization detector and the time-of-flight spectrometer. Two small electronic boxes containing preamplifiers and high-voltage power supplies are directly

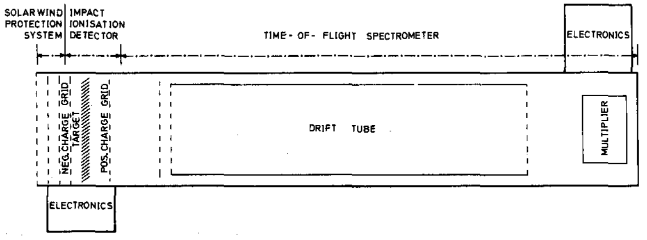


Fig. 2: Helios micrometeoroid experiment, south-sensor.

attached to the sensor. A detailed description has been given by Dietzel et al. (1973). Five quantities are generally measured if a micrometeoroid hits the venetian blind type target: (1) the total negative charge (electrons) and (2) the total positive charge (ions) released upon the impact, (3) the rise-time of the negative charge pulse, (4) the rise-time of the positive charge pulse, and (5) the time-of-flight spectrum of the ions. The instrument is triggered when a signal exceeds the threshold of either the positive or the negative charge channel. With the south-sensor additionally the charge (6) of the dust particles is measured by the charge induced on a grid in front of the target. The ecliptic-sensor is covered by a thin film (3000 Å parylene coated with 750 Å aluminium) as protection against solar radiation. Here the time (7) is measured between the penetration of the film and the impact on the target.

Besides these parameters measured directly from the impact, additional information is gathered and transmitted to earth: (8) various coincidences between the measured signals, enabling one to discriminate between noise and "probable" impacts, (9) the time at which the event occurred, and (10) the pointing direction (azimuth) of the sensor. If a "probable" impact is indicated by proper coincidences, the count on one out of four registers is increased by one, this register is selected according to the amplitude of the positive charge signal (IA). By this method one obtains from the four counters the number of "probable" impacts within 4 positive charge intervals roughly corresponding to 4 different mass intervals of micrometeoroids. All the information on one event is contained in an experiment-data-frame of 256 bits which are transmitted to earth once every 20 sec to 20 min

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(depending on the Helios-earth distance). To date (September 1975) the experiment worked satisfactorily, except for a total of 26 days during the first three months of the mission when the experiment was blocked in a non-measuring mode.

As only 10 % of the data have arrived at the experimentors' facility at the time of writing, the results have to be regarded as preliminary. The most complete set of data is available for larger particles ($m \geq 10^{-12}$ g at $v$ = 10 km/sec). By evaluating the event-counters for the 3 upper charge intervals it was possible to locate all "probable" impacts. Using special data processing at the German Space Operations Center (GSOC) the complete data of 19 out of 21 "probable" impacts could be picked out of real-time-data. Evaluating these data, it was found that 15 events thereof are micrometeoroid impacts. The real impacts were identified by the presence of a time-of-flight spectrum.

The data cover the time between December 15, 1974 (experiment switch-on) and September 5, 1975. This corresponds to one complete orbit of Helios and the second inward part to 0.4 AU.

The data do not show a significant difference between the impact rate at the ecliptic sensor (6 impacts) and at the south sensor (9 impacts).

Fig. 3 shows the impact rate as detected by the Helios micrometeoroid experiment per 0.1 AU interval as a function of the heliocentric distance R. The error bars indicate the statistical one-σ error and the 0.1 AU interval, respectively. The data are not yet corrected for the instrumental deadtime, which is estimated to be, at maximum, 30 %. The impact rate increases steeply with decreasing heliocentric distance. It is more than a factor 10 greater at 0.3-0.4 AU than at 0.9-1.0 AU. There is qualitative agreement with the result of the zodiacal light experiment on Helios which found an increase of the dust density towards the sun with $R^{-1.3}$ (Link et al., 1976). Since the average impact speed increases with decreasing heliocentric distance,

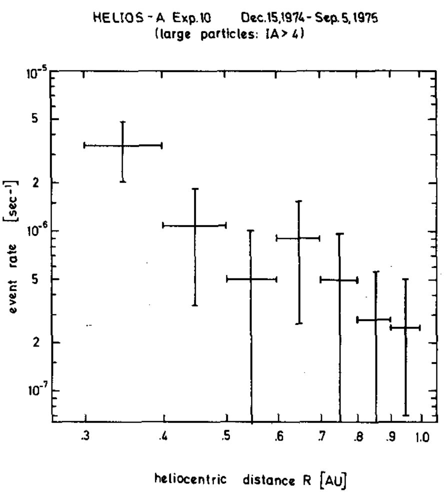


Fig. 3: Radial distribution of the impact rate.

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the rate increases faster than the particle number density.

In Fig. 4 the pointing of the sensor at the time of the impact is shown as a function of the heliocentric distance. Each impact is plotted at its heliocentric distance R and the sensor pointing $\varphi$ . The error bars represent the mean width of the sensor's field of view. Only two impacts were recorded during the outward path of the Helios orbit compared with 13 impacts inward.

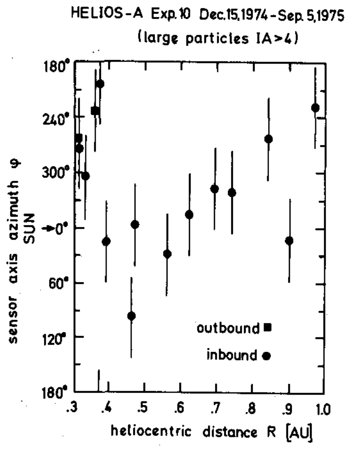


Fig. 4: Azimuth and heliocentric distance of detected impacts.

Since the inbound path of the orbit was almost completed twice and the outbound path only once this ratio is not yet regarded as significant. Most of the impacts were recorded from a direction $-120^{\circ}$ (or $240^{\circ}$)$\lesssim \varphi \lesssim 30^{\circ}$ which was also found by the Pioneer 8 and 9 spacecrafts (Berg and Grün, 1973). Because of the high eccentricity of the Helios orbit, micrometeoroids detected at the sensor azimuth $\varphi = 0^{\circ}$ must not necessarily come from the solar vicinity but also particles on circular orbits may be encountered from this direction. The conclusions drawn from this data are:

- 12 of the 15 micrometeoroids detected are compatible with particles in circular orbits. These particles would be encountered during Helios' course inward between $-90 \lesssim \varphi \lesssim 90^{\circ}$ depending on the heliocentric distance R and on the influence of radiation pressure on the particles. During Helios' course outward they would be encountered from $90^{\circ} \lesssim \varphi \lesssim 270^{\circ}$.
- 11 of the 15 micrometeoroids can also be interpreted as particles in hyperbolic orbits moving away from the sun. They would be detected from $-90^{\circ} \lesssim \varphi \lesssim 0^{\circ}$ depending on the heliocentric distance, the influence of the radiation pressure and their perihelion distance.
- at least 3 of the 15 micrometeoroids had high eccentric orbits. They were recorded on Helios' course inward at $90^{\circ} \lesssim \varphi \lesssim 270^{\circ}$.

A more complete discussion of the data, including charge measurements and spectra, is forthcoming.

Acknowledgement

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