FOUR YEARS OF ZODIACAL LIGHT OBSERVATIONS FROM THE HELIOS SPACE PROBES: EVIDENCE FOR A SMOOTH DISTRIBUTION OF INTERPLANETARY DUST

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The zodiacal light experiments on Helios 1 and Helios 2 have been continually operating since launch in December 1974 and January 1976, respectively. The data support the view that the distribution of interplanetary dust is rather simple in space and quite constant in time. Instrument and data reduction have been described by Leinert et al. (1978). In the following we present Helios 2 data only.

1. SPATIAL DISTRIBUTION OF INTERPLANETARY DUST

Preliminary results of Helios 1 (Link et al., 1976) lead to the hypothesis that there is the same type of dust everywhere in the inner solar system and that its radial distribution is given by a power law, $n(r,z) \sim r^{-\nu} \cdot f(z/r)$. In this case

- the brightness increase for an observer at heliocentric distance R should be proportional to $R^{-\nu-1}$ for all viewing directions,
- the colour of zodiacal light should not change with R,
- the polarization of zodiacal light also should remain constant.

To prove the above hypothesis these three conditions have to be verified. The validity of the first condition alone strictly only implies that the scattering cross section per unit volume varies as $r^{-\nu}$.

Figure 1 shows the observed gradient of zodiacal light intensity between 1 A.U. and perihelion at 0.3 A.U. The data may well be represented by a power law, i.e. a straight line in this representation. For all elongations, from 17.5° to 135° from the sun, the exponent of intensity increase is -2.3 ± 0.1. This verifies the first condition and corresponds to a power-law spatial distribution with exponent $\nu = 1.3 \pm 0.1$.

The splitting of the data in Figure 1 into a (higher) inbound and a (lower) outbound curve is due to the inclination of the plane of symmetry of interplanetary dust with respect to the ecliptic plane. An additional effect caused by the plane of symmetry is a brightness difference between observations right and left of the sun (dots and crosses in Figure 2). It can be shown that this right-left asymmetry disappears

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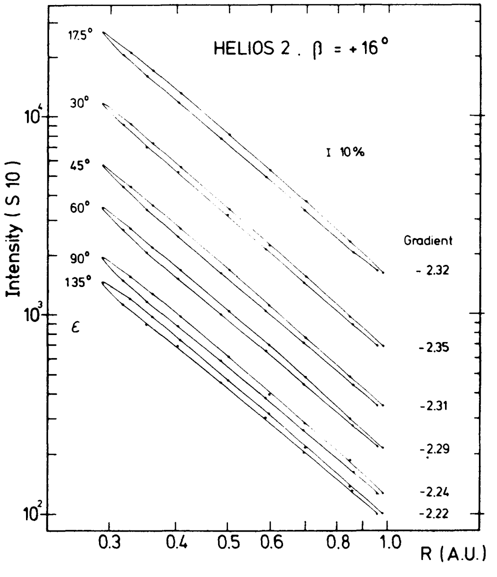


Figure 1. Radial gradient of zodiacal light intensity.

when Helios is at 90° from the line of nodes. Figure 2 shows, how along a selected part of the orbit the right-left asymmetry decreased, disappeared and built up again with opposite sign. This makes it possible to determine the ascending node of the plane of symmetry directly from the data without recourse to model calculations. From eight such zero crossings we obtained $\Omega = 87 \pm 4°$. Similarly, the inclination of the plane of symmetry was determined to be $i = 3.0 \pm 0.3°$ (Leinert et al., 1980).

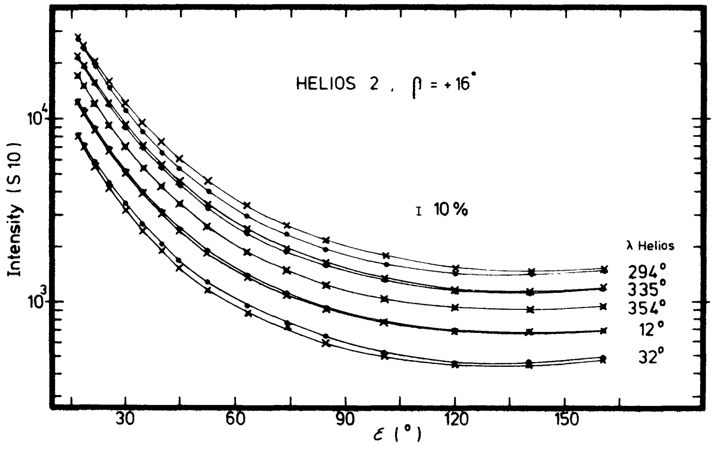
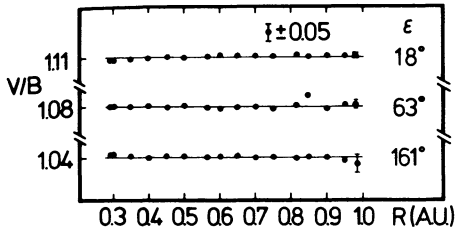
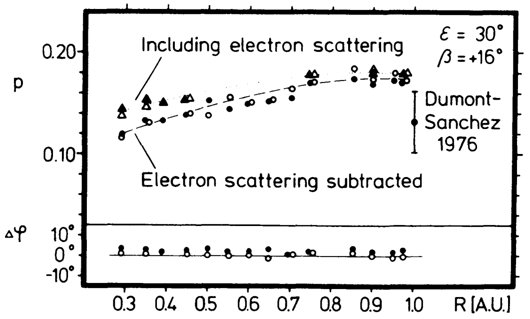


Figure 2. Determination of the node of plane of symmetry.





Figures 3 and 4. Colour (left) and polarization (right) of zodiacal light as function of heliocentric distance of Helios 2.

The colour of zodiacal light is shown in Figure 3. The ratio of visual to blue intensity is normalized to the solar value, numbers > 1.0 corresponding to a reddening of the zodiacal light. There is no systematic variation with heliocentric distance (condition 2), but a slight reddening is present, increasing towards small elongations.

The polarization (Figure 4) is given both for observations right and left (open symbols) of the sun. The direction of polarization is essentially perpendicular to the scattering plane, the deviation $\Delta\varphi$ being at most a few degrees. The degree of polarization, p, was found higher at 1 A.U. than given by Dumont and Sanchez (1976). It decreases towards the sun, even if no correction for electron scattering is made. A relative increase of the dielectric component of interplanetary dust with respect to the absorbing component might cause such a change. However, in view of the validity of the first two of the above three conditions it still appears a reasonable first order approximation to assume a constant particle mixture which is radially distributed according to a power law.

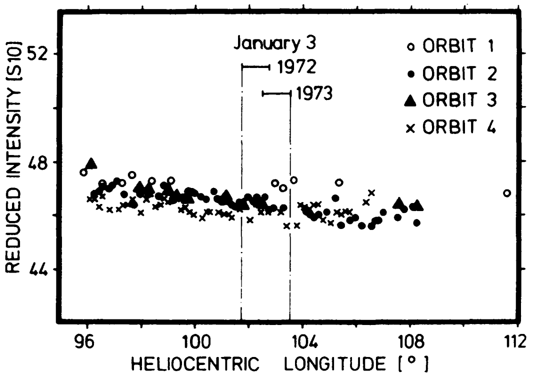


Figure 5. Search for the Quadrantid meteor stream.

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2. TEMPORAL CONSTANCY OF ZODIACAL LIGHT

Short period increases of zodiacal light intensity of 10 S10 and more were reported by Levasseur and Blamont (1975) and interpreted as due to meteor streams. For positions of Helios 2 close to 1 A.U. we searched the observations at the north ecliptic pole for the effect of the Quadrantid meteor stream, which had been detected by these authors on January 3, 1972 and 1973. Figure 5 shows, for four consecutive orbits, the observed intensities, reduced to 1 A.U. heliocentric distance and a position in the plane of symmetry. No variations significantly greater than the scatter of some tenths S10 units were detected. Also there were no meteor streams apparent during the remainder of the orbit. Optically detectable meteor streams appear to be much rarer and less important in relation to the average zodiacal light than previously assumed.

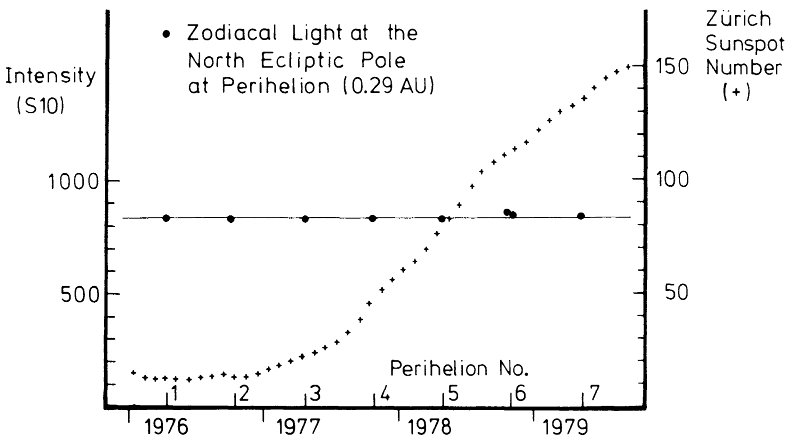

Figure 6. Example for the constancy of zodiacal light.

In Figure 6 we plotted the zodiacal light intensity at the north ecliptic pole, as observed during the seven perihelion transits of Helios 2. There is no systematic change with time or solar activity. The zodiacal light and with it the interplanetary dust cloud appears to be a rather smooth and stable phenomenon.

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