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PRELIMINARY RESULTS OF THE HELIOS A ZODIACAL LIGHT EXPERIMENT

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Helios A was launched on December 10, 1974 into a highly elliptical orbit with a perihelion of 0.31 A.U., which was reached on March 15, 1975. The zodiacal light experiment on Helios, described in the preceding paper, worked flawlessly and provided the first observations of the zodiacal light from inside the Earth' orbit. A typical example from the raw data of the 15° - photometer is shown in Fig.1. There is a strong intensity increase towards the sun and a remarkably flat intensity distribution at large elongations. The Milky Way is superimposed

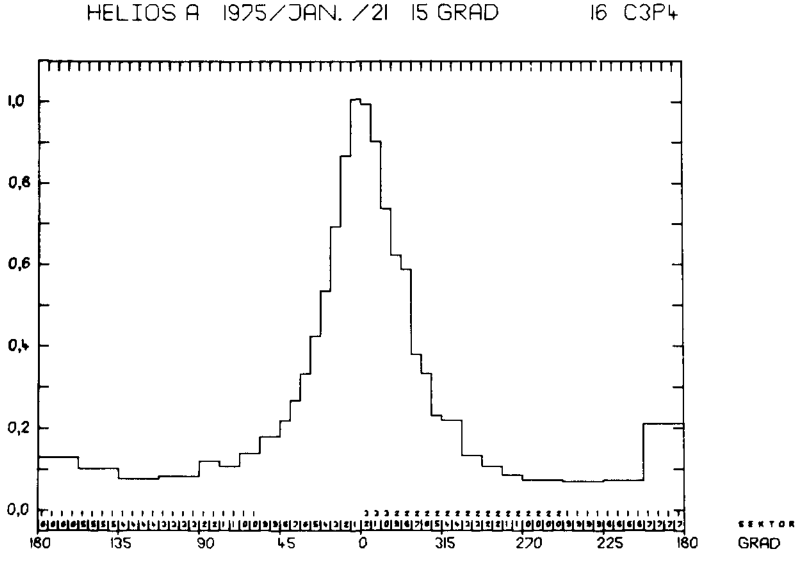

Fig.1: Raw data of the 15° - photometer, visual spectral band. The total observed intensity at $\beta = -16^{\circ}$ is given as a function of helioecliptic longitude $\lambda - \lambda_{\odot}$. The data have been normalized to the average intensity of the two subsolar sectors, no. 1 and no. 32. Heliocentric distance of Helios A is R = 0.84 A.U.

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on the zodiacal light at longitudes 135° to 180° and 315° to 360°. Due to the orbital motion of Helios the star background is being shifted with respect to the zodiacal light, which will facilitate its separation from the total observed intensity. The peak at the right side of Fig.1 is due to the star α CMi, which we intend to use for the calibration of the instrument in addition to the ground calibrations. A preliminary evaluation showed less than 20% difference between the two calibrations. This is typical for other stars and for the other photometers, too, and gives a safe upper limit for the accuracy of the absolute calibration. Temperature effects are comparatively small and have not been corrected so far.

Although for Helios the correction for star background is much less important than for an outward bound space probe like Pioneer 10 or 11, it still remains one of the main difficulties in the data reduction. Therefore we first evaluated the zodiacal light intensity integrated over the whole range of longitudes scanned by the respective photometer. With this geometry the star background is constant, except for the effect of a slow drift of the Helios spin axis by a few tenth degrees, and the trends of zodiacal light brightness should show clearly. Fig.2. shows the integrated intensity for the 15° - photometer, visual

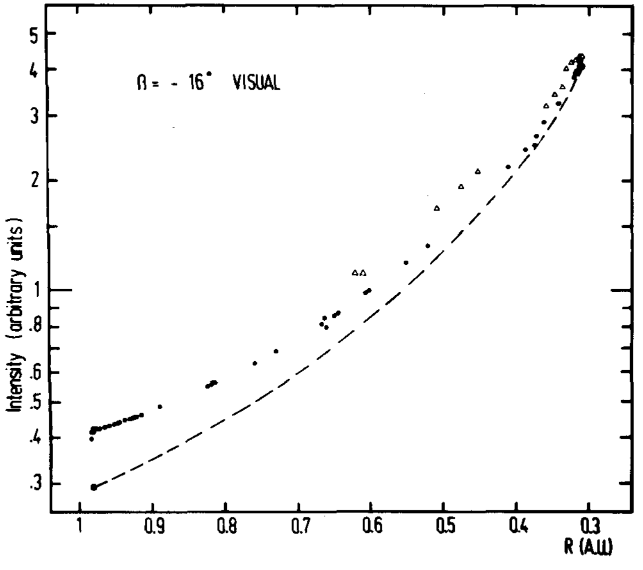

Fig.2: Integrated intensity observed in the 15° - photometer, visual band. Points refer to measurements before, triangles to measurements after perihelion. Intensity after star background correction is given by dashed line.

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band, as a function of heliocentric distance. There is a steady intensity increase by a factor of 10 from 1 A.U. to perihelion. Down to 18 solar radii, the closest approach of the line of sight, we therefore see no effect of a dust free zone. This is not surprising since interplanetary dust has been localized even at 3.4 $R_{\odot}$ by infrared measurements (Peterson 1967). On the way back from perihelion the observed total intensity was higher by 10% to 20%. Changes in the attitude of Helios and the inclination of the Helios orbital plane with respect to the symmetry plane of interplanetary dust both contribute to this effect. It may be noted that the data of Fig.2 show no sudden intensity changes as reported by Levasseur and Blamont (1975). If we subtract the star background as determined from the tables of Roach and Megill (1961) and the Catalogue of Bright Stars (Hoffleit 1964) the resulting integrated zodiacal light intensity is given by the broken line in Fig.2, with an increase from 1 A.U. to perihelion by a factor of 14. The data for the blue and ultraviolet bands of the 15° - photometer look almost the same as those of the visual band. The observed increase in zodiacal light intensity is nearly independent of wavelength.

The 30° - photometer leads to similar results (Fig.3). The total integrated intensity increases by a factor of 8. After subtraction of star background we

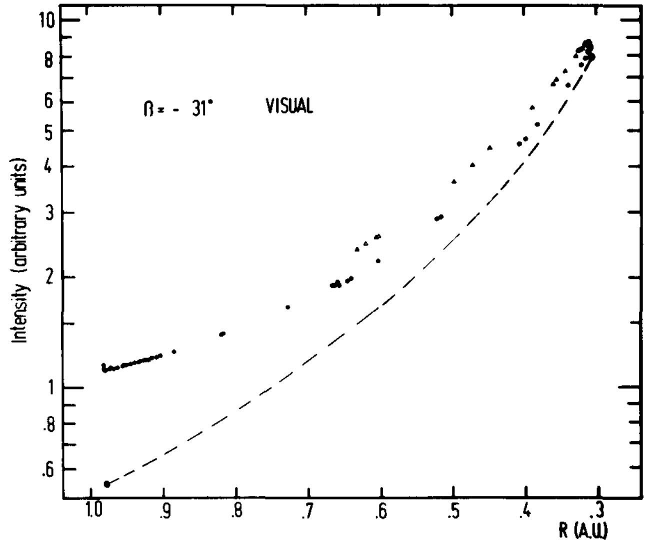

Fig.3: Integrated intensity observed in the 30° - photometer, visual band. Symbols are explained in Fig.2.

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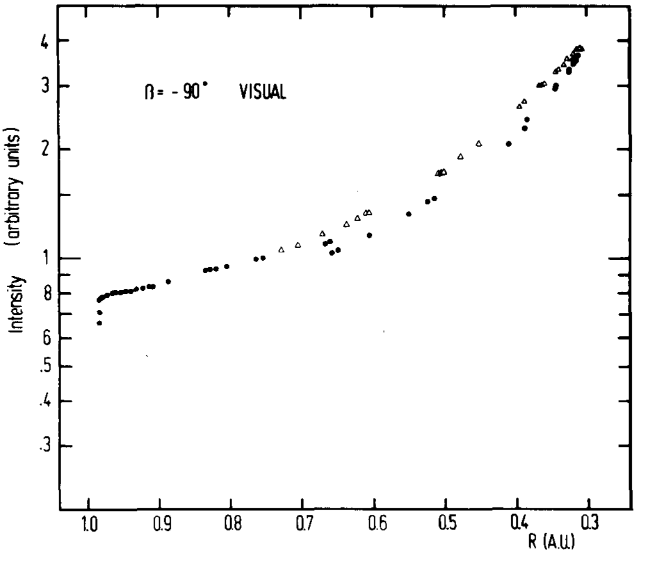

Fig.4: Integrated intensity observed in the 90° - photometer, visual band. Symbols are explained in Fig.2.

find an increase of zodiacal light intensity by a factor of 14 to 15 for the visual, blue and ultraviolet bands. Again higher intensities are observed on the way back from perihelion.

In the 90° - photometer the evaluation of the data (Fig.4) is more difficult because of the strong star background in the vicinity of the Large Magellanic Cloud. Reliable stars counts in this field around the South Ecliptic Pole would be of great value for us. A change in the attitude of Helios by 1°, as performed at a heliocentric distance of R = 0.7 A.U. already produced a change in the signal by 8%. On the basis of the preliminary attitude determination of Helios we were not able to define the star background with sufficient accuracy. However, we checked that the observed increase in total brightness was compatible with an increase of zodiacal light intensity by a factor 14.5, provided the zodiacal light intensity at the south ecliptic pole at 1 A.U. is between 53 and 63 S10 units (solar type stars of m_V = 10.0 per square degree), which is a realistic value. The increase of zodiacal light intensity seems to be nearly independent of the viewing direction.

We also find no important change in the polarization of the zodiacal light between 1 A.U. and perihelion. The degree of polarization for the sum of zodiacal light and star background near perihelion is 8% to 12% for the subsolar sectors of the 15^o-and 30^o-photometer and 14% to 16% for the 90^o - photometer, which is consistent with earthbound observations.

Since the change in zodiacal light brightness is nearly independent of viewing direction, wavelength and direction of polarization, we may adopt the simple model that the radial dependence of the spatial density of interplanetary dust is given by a power law $n(r) \sim r^{-\nu}$ and the scattering function is constant over the volume considered. In this case the zodiacal light intensity varies with heliocentric distance R according to the power law $I_{zl} \sim R^{-\nu-1}$. From our measurement a value of $\nu \approx 1.3$ follows, which describes the spatial distribution between approximately 0.08 A.U. and 1.5 A.U. There is good agreement with the Pioneer space probe experiment of Hanner et al. (1976), which give $\nu \approx 1.5$ for $R > 1$ A.U. This spatial distribution is slightly steeper than the dependence $n(r) \sim 1/r$ resulting from the Poynting - Robertson - effect acting on particles in circular orbits, and it is quite different from the distribution of radio meteors, which according to Southworth and Sekanina (1974) show a minimum near 0.7 A.U.

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