OSO-5 Zodiacal Light Measurements 1969-1975

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Introduction:

The Minnesota zodiacal light experiment on board OSO-5 was reactivated in July of 1974, after having been off for 1-1/2 years and operated successfully through August 1975 at which time the satellite was again turned off. This gives another year's worth of data to compare with that taken by the same experiment from January 1969 to January 1973[1,2,3]. This paper reports on the seven year comparison.

Spacecraft and Experiment:

The OSO-5 spacecraft and the position of the Minnesota photometers is depicted in Figure 1. The spacecraft is spin stabilized at 0.5 RPS. The spin axis is held at 90° ecliptic elongation, and at varying ecliptic latitudes, usually within ± 25°. The average motion is 1° per day. The blue photometer, telescope #3, which recorded the zodiacal light measurements reported here, looks out along the anti-sail spin axis. It comprises a broadband system with an effective wavelength of 4180 Å, a 12° circular field of view and a fixed polaroid. A complete description is given in the literature.[4]

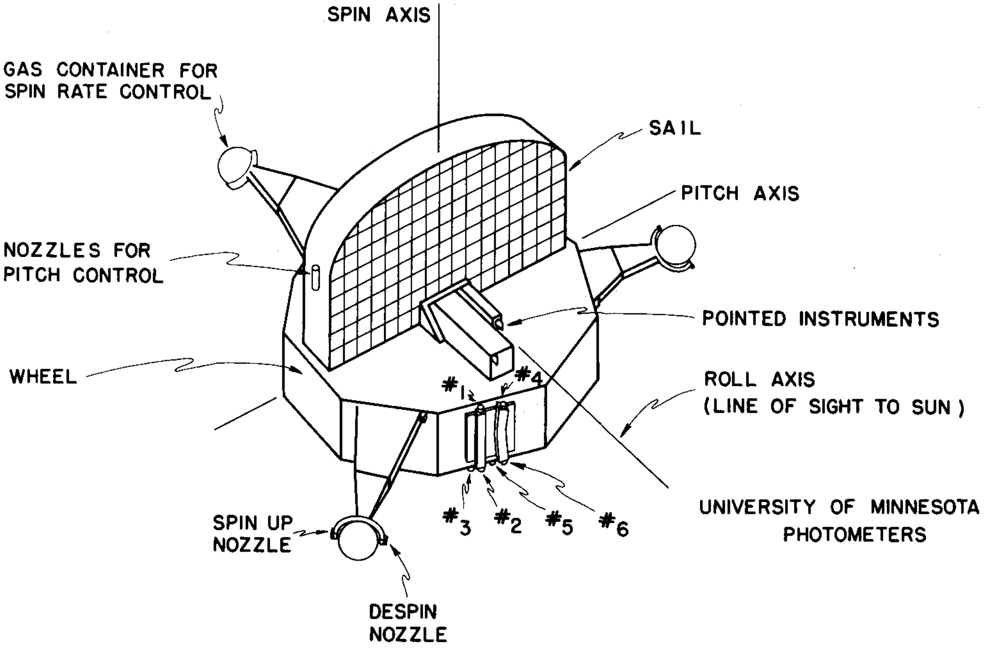

Figure 1. The OSO-5 spacecraft.

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Calibration:

The calibration curves for telescope #3 are drawn in Figure 2. Curve B represents the change in sensitivity of the photomultiplier with time. This is measured by means of a light emitting photo diode turned on for five minutes each day. The mean curve through these readings is shown. Over the course of seven years, eight bright stars suitable for calibration came into the field of view. They are listed along the bottom. These eight stars are best fitted to the photo diode decay curve in a least squares sense to produce curve A, which gives the number of 10th magnitude blue (4180 Å) stars per count. The standard deviation of a point (SDP) here is 4%. This is consistent with the expected errors from temperature fluctuations in the photo diodes and the use of an effective wavelength with a broadband system to ascertain stellar magnitudes.

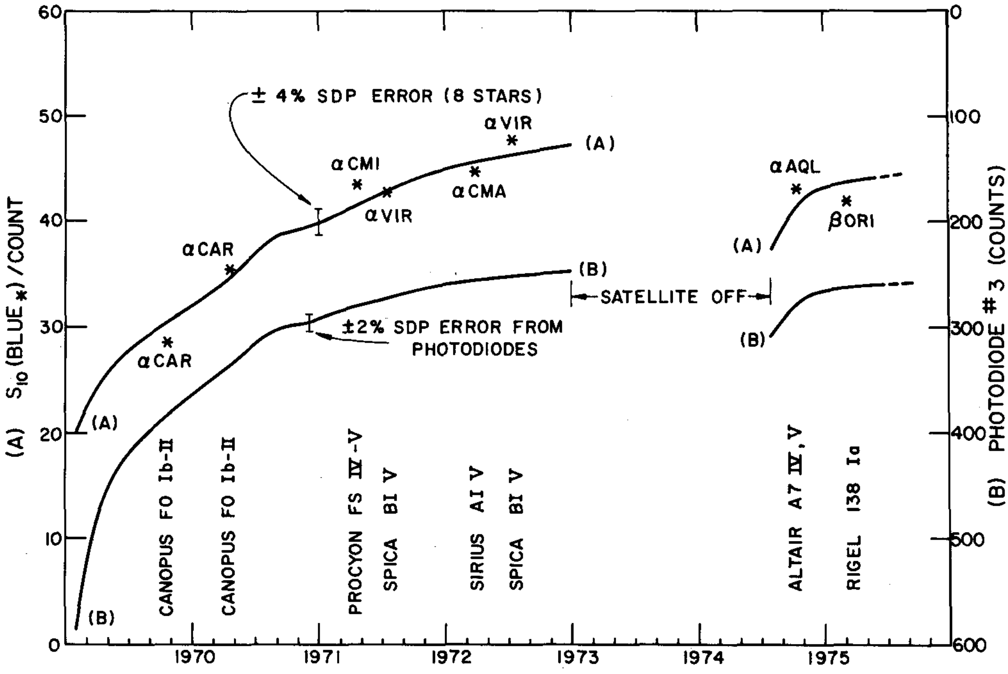

Figure 2: Telescope #3 calibration curves.

It is seen from the curves that a factor of two loss in gain took place over the seven years in a semi-exponential fashion with two points of interest. At turn-on in 1974 after 1-1/2 years rest, a 20% increase in gain took place. Thus some of the degradation was recoverable, related to the instrument being on, and possibly due to the high light levels encountered at sunset turn-on and sunrise turn-off. The small bump in the curve in mid 1970 corresponds to a period

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when substantial re-orientation took place in going from the South to North ecliptic pole. The experiment was off for two weeks during this time.

For comparison, the availability of a more complete set of calibration stars here has raised telescope #3's calibration by 10% above that used previously[1,2,3]. Also the B-V value of .65 used here to convert from B to V is substantially different from that used before[1].

Results:

A representative sample of the polarized amplitude data by year, from -25° to +25° ecliptic latitude is shown in Figure 3. The 1969 data are at E90° ecliptic elongation and the remaining data are at W90°. The standard deviation is ±2.5%. This is consistent with the error expected from the calibration curve, and that due to a ±0.5° uncertainty in the look direction of the spacecraft.

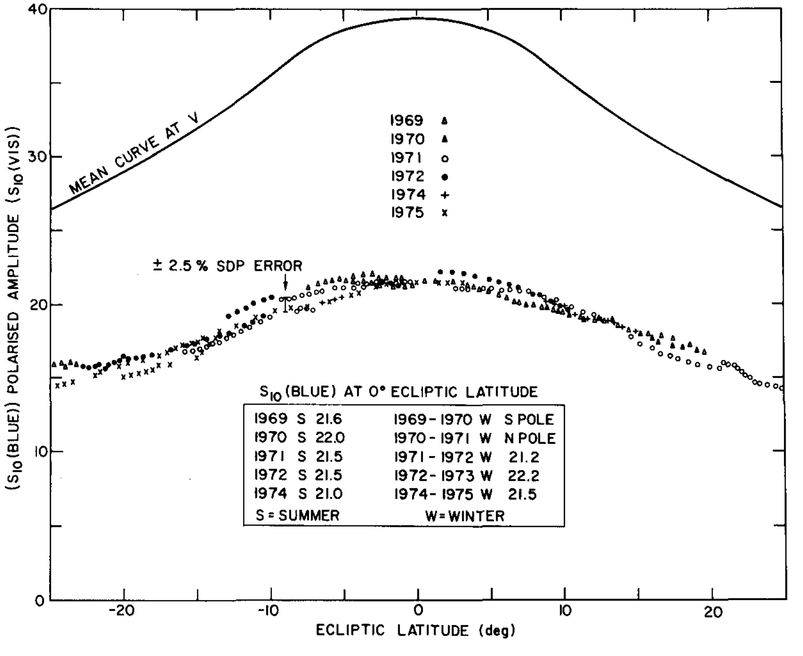

Figure 3: Telescope #3 polarized amplitude data by year.

Only data with a galactic latitude greater than 30° were used in this comparison. This resulted in the periods 15 February to 15 May and 15 August to 15 November not being used. Readings were also not used when the look direction was within 50° of the Moon, or when the look height was below 400 km. Throughout the remaining data periods at least two measurements per day were reduced. A complete descrip-

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tion of the data reduction process is given in the literature.[1]

The data then fall into two groups -- summer and winter of each year. Two effects are at maximum at these times, the variation expected from the symmetry with respect to the invariant plane, and that due to the changing Earth-Sun distance. To the ±2.5% standard error, neither of these effects evidenced themselves in the data. This is illustrated in the box in Figure 3. The variations from month to month are as large as those seen between winter and summer, and between 1969 and 1975. No variation greater than ±2.5% is seen with time.

The mean curve is also plotted here at V using a solar color index of B-V equal to 0.65 from Allen.[5] The data to an accuracy of ±2.5% are symmetric with respect to the ecliptic plane, and E or W 90° ecliptic elongation. The mean values at 0° ecliptic latitude for the polarized component are: S_{10} Blue = 21.5 and S_{10} Visible = 39.5.

Figure 4 shows the zodiacal light brightness intensity year by year over the same period. Here the standard error is larger, ±6%, due to the problem of subtracting discrete and background starlight from the field. Again no variations with time are observed to ±6%. No significance in the double grouping of the data here is found. The low open circles to the right in 1971 occurred at a time when the

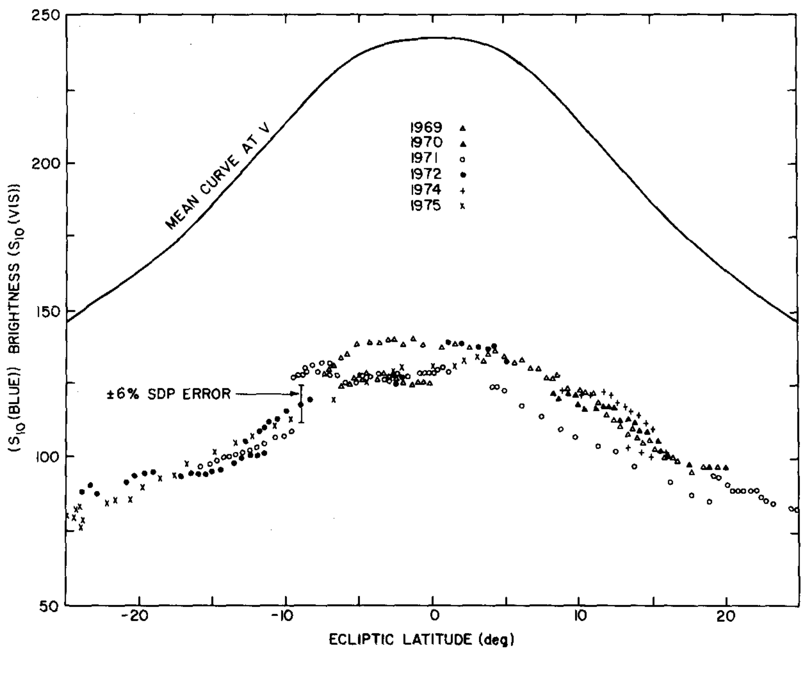

Figure 4. Telescope #3 brightness amplitude data by year.

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spacecraft look direction was changing rapidly, resulting in an uncertainty in the look position of $\pm 2°$. The mean brightness values at 0° ecliptic latitude are: S_{10} Blue = 133 and S_{10} Visible = 243.

The above errors are all relative. They do not take systematic errors into account as they are not necessary to show changes. The systematic errors amount to an additional $\pm 10\%$.

Conclusions:

The results of the first four years have been reported on previously[1,2,3]. The 1974-1975 data reconfirm the earlier conclusion that the brightness and polarization of the zodiacal cloud varied by less than $\pm 10\%$, now over the seven year period from January 1969 through August 1975, as measured by a single well calibrated instrument.

No variations are found with the 11 year solar cycle, lunar phase, an annual period, or geomagnetic activity. Any or all such variations appear to be below the relative errors of $\pm 2.5\%$ for the polarized component and $\pm 6\%$ for the brightness intensity as measured at B at 90° elongation by the Minnesota OSO-5 zodiacal light experiment.

References:

1. Sparrow, J. G. and Ney, E. P., Ap.J. 174, 705 (1972).
2. Sparrow, J. G. and Ney, E. P., Science 181, 438 (1973).
3. Burnett, G. B., Sparrow, J. G. and Ney, E. P., Nature 249,639(1974).
4. Burnett, G.B., Sparrow, J. G. and Ney, E. P., Appl. Optics 11, 2075, (1972).
5. Allen, C. W., Astrophysical Quantities, The Athlone Press (1973).