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THE COLOR CHARACTERISTICS OF THE EARTH-MOON LIBRATION CLOUDS

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ABSTRACT

The OSO-6 Zodiacal Light experiment has provided evidence for the backscatter of light from the Earth-Moon libration regions at 5000 A. Additional measured data at 4000 A and 6100 A show similar characteristics. The combined three-color data lead to libration region color indices slightly bluer than the average surrounding sky background. The differential b-v for the L4 region is approximately -0.05.

INTRODUCTION

The photometric results obtained from the OSO-6 Zodiacal Light experiment have been shown to be a sensitive measure of the sky brightness in the anti-sun region by Roach, et.al., (1973). Using these data, a detailed analysis of variations in the counterglow direction has shown a photometric enhancement in the region of the Earth-Moon libration point by Roach (1975). This analysis has been extended to include the three wavelength bands of data available at: 1) 4000 A ± 200 A; 2) 5000 A ± 200 A; and 3) 6100 A ± 200 A.

OBSERVATIONS

The observations were obtained over a period of sixteen successive lunations (7200 orbits from September 1969 to February 1971). Data were taken every orbit in each of the three wavelength bands for a series of solar elongation angles. This analysis is from data taken in the anti-sun direction, a portion of which is shown in Figure 1. These linear data counts are uncorrected for the instrument sensitivity at each wavelength.

The perturbations observed in these data have been identified as due to the South Atlantic Anomaly effects on the instrument; discrete stars in the field of view, which have a characteristic signature 30 orbits wide; and discrete perturbations attributed to the counterglow

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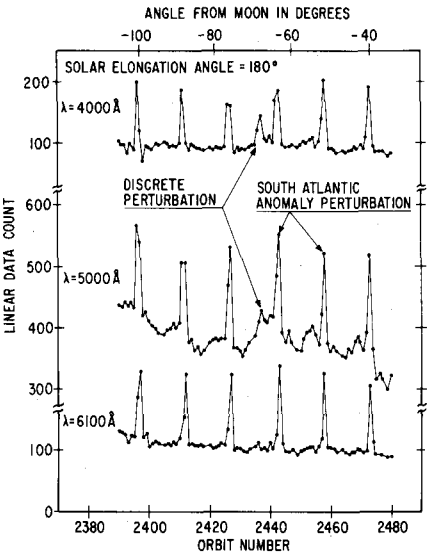

Figure 1 - A Portion of the Linear Count Data from the Instrument for Three Wavelength Bands; Lunation Number 5, L_4.

from Earth-Moon libration clouds. One of these latter perturbations is shown in Figure 1 at 68 degrees from the Moon. It is quite evident in the 4000 A and 5000 A data and is just a suggestion in the 6100 A data.

If the environmental effects and discrete stars are removed from the total sky observation and the background sky is removed by underdrawing, then a residual count remains. Previously I showed that accumulation of this residual count at 5000 A for the sixteen lunations gave an enhancement at the L4 and L5 60 degree positions from the Moon. Inspection of the 4000 A and 6100 A data show similar enhanced characteristics for these libration regions. Rather than analyzing each wavelength band independently I have used a sky temperature parameter based on the color indices for this instrument.

ANALYSIS

In the previous work with these data, discrete stars and the counterglow data have been used to calibrate the instrument photometric characteristics; Roach, et. al., (1973) and Roach (1975). In this analysis, I have used a calibration developed by F. E. Roach (1975) from discrete stars observed, to provide the color calibration of the instrument. This calibration is given in Table 1.

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Table 1
STARS USED FOR COLOR INDEX CALIBRATION

Star	b-v (OSO-6)	B-V (literature)
α Librae	-0.021	-0.195
β Sco	-0.031	-0.08
α Sco	2.575	1.80
α Leo	0.177	-0.12
ϕ Sgr	0.146	-0.10
σ Sgr	0.019	-0.20
γ Sgr	0.983	1.18
σ Sco	0.019	0.14
δ Vir	1.185	1.57
ξ Vir	0.145	0.11

In Table 1, the color index b-v for the OSO-6 instrument is compared to the general astronomical color index B-V from the literature.

F. E. Roach has derived the following relationships for the instrument color calibration using these data and setting the indices equal to zero at a black body temperature of 11000 degrees:

$$b\text{-}v = 2.5 \log \frac{R(5000)}{R(4000)} - 0.781$$

$$b\text{-}r = 2.5 \log \frac{R(6100)}{R(4000)} + 0.894$$

$$v\text{-}r = 2.5 \log \frac{R(6100)}{R(5000)} + 1.675$$

These color indices have been used to develop an effective sky temperature calibration based on black body calculations. Respective sky temperatures were calculated for each index as well as an average sky temperature for the three indices. The average background sky temperature is approximately that of the Sun in the 5500 to 6000 degree range. The analysis to date has been based primarily on the sky temperature derived from the b-v index, but all four temperature parameters show similar characteristics.

Using the underdrawing technique to eliminate discrete stars, the environmental effects and the background, I have accumulated the residual sky temperature for the sixteen successive lunations in the L_4 region. This is shown in Figure 2 and the average increase in sky

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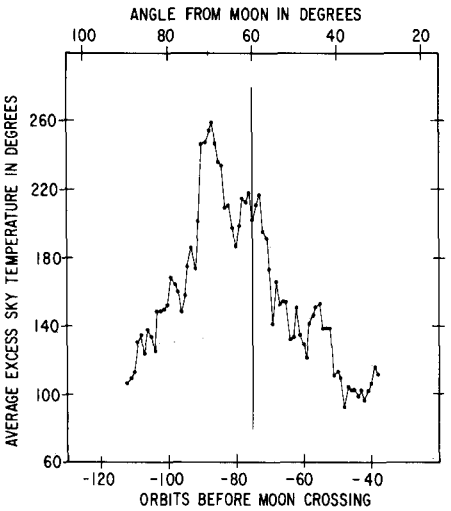

Figure 2 - The Residual Sky Temperature Accumulated and Averaged for Sixteen Lunations in the L_4 Region. Data Have Been Smoothed by Running 7's. The Vertical Line is the Location of the Libration Point L_4.

temperature for the counterglow from the libration cloud region is approximately 120 degrees. The width of this enhanced sky temperature region is approximately 30 degrees at the half maximum position, similar to that of the 5000 A enhanced region. The secondary peak at about 70 degrees from the Moon is the effect of the two major perturbations at orbit 2440 (shown in Figure 1) and orbit 6917 (Roach, 1975).

This increase in the residual sky temperature parameter around the L_4 60 degree point from the Moon, is twice that of the residual away from this region and is, therefore, significant. An increase in effective sky temperature indicates that the excess counterglow from the libration cloud region is slightly bluer than the background counterglow. The equivalent color excess in the b-v index is approximately -0.05. This slightly blue signature for the libration clouds suggests that relatively small particles are the major constituents of the clouds. However, these measurements were made looking through the Earth's penumbra and Schmidt and Kovar (1967) have shown that the Earth's atmosphere causes a focusing of blue sunlight at about the lunar orbit distance. Therefore, the blue libration cloud counterglow may be due to this blue sunlight reflecting from larger and longer-lived particles.

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