1.1.5

STAR COUNTS IN THE BACKGROUND SKY OBSERVED FROM PIONEER 10

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Abstract

Star counts in the sky region observed by Pioneer 10 at 4.64AU from the sun, where the contribution of zodiacal light is negligible, were made using the Palomar Sky Survey Atlas. Brightness of the integrated starlight derived from our star counts agrees, in general, with the Pioneer 10's observation.

1. Introduction

For several years, we have been measuring the photographic and red magnitudes of the stars in various regions on the Palomar Sky Survey Atlas with a star-counting instrument. The main purpose of our star counts is to estimate the integrated brightness and color of the star-fields for the elimination of the background light in the study of the zodiacal light.

Detailed explanation of our star-counting instrument and method of measurement have been given at the IAU-Colloquium No. 11 at Edinburgh in 1970 (Tanabe and Mori, 1971) and some results obtained by this instrument have been published (Tanabe, 1973).

In the meantime, in August 1973 the Asteroid-Jupiter probe Pioneer 10 observed the background sky brightness at a heliocentric distance of 4.64AU, where the contribution from the zodiacal light is negligible (Hanner et al., 1974), and a part of these results was reported by Weinberg et al. (1974).

Accordingly, we started to make star counts in the same sky region to obtain the brightness of the integrated starlight for comparison with the Pioneer 10's results and, if possible, isolation of the diffuse galactic light.

2. Measurements and Results

Fig. 1 shows a part of the sky observed by Pioneer 10. The fields of view of the Pioneer 10's telescope (FOV) are projected after a small correction following information from Weinberg (1975). Five small squares indicate the regions we measured. Each area of our regions is 0.871 square degrees, which corresponds to a square of side 5cm on a Palomar

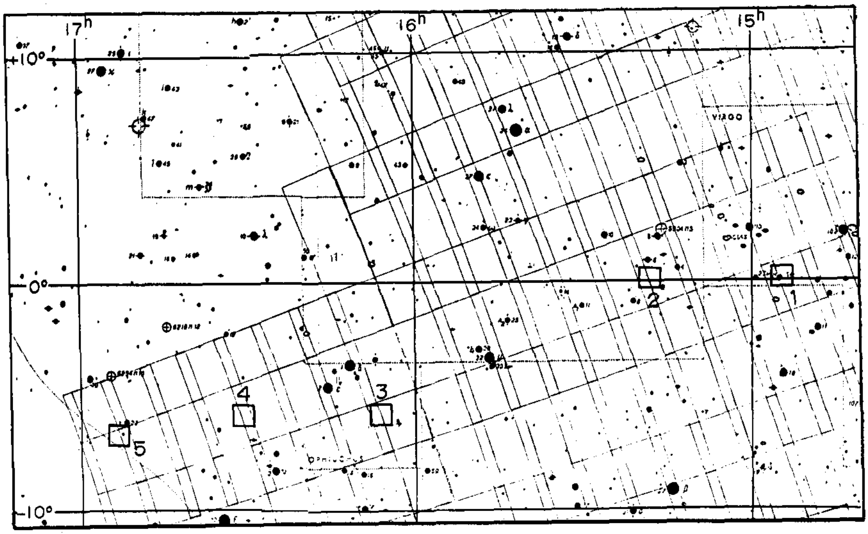

Fig.1. A part of the sky observed by Pioneer 10 with projection of the FOVs. Five small squares indicate the regions we measured.

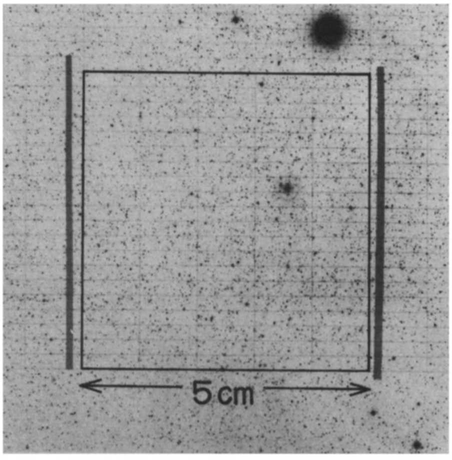

Fig.2. An example of measured regions on the Palomar Sky Survey Atlas.

Atlas print. This area may be too small in comparison with that of the FOV, but since measurements over the full area of the FOV require a long time by our manually operated instrument, we have selected those areas which are located in the central parts of the Palomar Atlas prints.

As an example of the regions we measured, a photograph of region No. 5 on the Palomar Atlas print is shown in Fig. 2. We have measured the diameters of 8694 star-images in this area and obtained the magnitude of each star with an experimental diameter-magnitude relation found from the standard stars. Besides the stars, about 5000 nebulae were counted.

Results of our star counts are shown in Table 1. The equatorial and galactic coordinates, total number of measured stars and brightnesses of integrated starlight in $S_{10}(p)$ and $S_{10}(r)$ units, the equivalent number of 10th-magnitude stars per square degree, obtained from blue (3500~5000A) and red (6200~6700A) photographs for each region are listed.

https://doi.org/10.1017/S0252921100051344 Published online by Cambridge University Press

Table 1. Results of star counts ($m_p \geq 7.5$).

Region	α (1950) δ		ℓ^{II}	b^{II}	Stars	$S_{10}(p)$	$S_{10}(r)$
1	$14^h54^m.7$	$+0° \; 4.7$	356°.1	+49°.3	2049	23.6	89.2
2	15 18.7	+0 7.1	2.1	+44.9	3184	22.1	74.0
3	16 6.9	−5 47.4	5.9	+31.8	5327	15.0	77.6
4	16 30.9	−5 44.5	10.0	+27.0	5552	32.2	102.6
5	16 53.5	−6 37.3	12.6	+21.9	8694	35.7	200.0

3. Comparison with Pioneer 10's Results

Reported Pioneer 10's results are expressed in $S_{10}(v)$ units. These values were derived from observations in blue band (3900~5000A) on the basis of the solar color index. Accordingly, to compare our results with them, we obtained the brightness of $S_{10}(v)$ units using our results only from blue photographs with following processes.

As mentioned above, our measured area is so small that there is anxiety of being influenced by small-scale irregularities of the stellar distributions. For example, though a Pioneer's single FOV containes many stars of magnitude 7.5 or 8.0, distributions of these stars are so infrequent that they are not always present in our area.

To avoid this positional selection effect, therefore we used only the integrated value from 10th to the limiting magnitude in our data as a representative value of the integrated faint-star brightness for corresponding FOV, assuming that these faint-star distributions are rather uniform in a single FOV.

In order to obtain the total brightness of the stars fainter than magnitude 6 for each FOV, we counted all stars between photographic magnitudes 6 and 10 using the Star Catalog of the Smithsonian Astrophysical Observatory (1966) after conversion from visual to photographic magnitude with Seares' formula (1925) and added these to the above faint-star brightness in $S_{10}(p)$ units. The brightnesses of the nebulae (1.6~0.7 $S_{10}(p)$) were also added by estimating each magnitude.

Conversion from $S_{10}(p)$ to $S_{10}(v)$ units was based on the solar color index (Allen, 1973); $P - V = B - V - 0.11 = +0.54$.

Fig. 3 is a plot of our results on the figure in the paper of Weinberg et al. (1974). The upper full line shows Pioneer's observed brightness and the dashed line corresponds to the residual brightness after removal of the stars of blue magnitude ≤ 6. Dots indicate Roach and Megill's values (1961) derived from star counts data (van Rhijn, 1925).

Recently, Weinberg (1975) informed us of a corrected version of Pioneer 10's values, which involves more detailed calibration. These results are represented by the lower dashed line.

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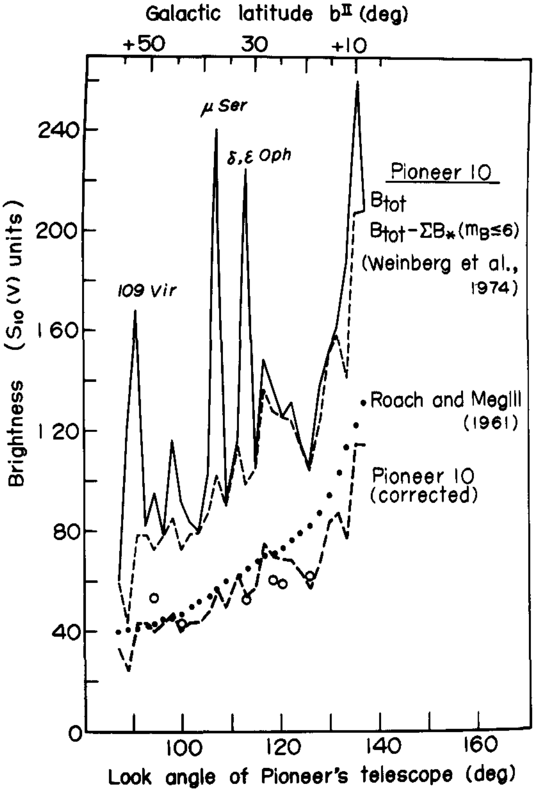

Fig.3. Comparisons of our results (open circles) with those of Pioneer 10 and Roach and Megill's values.

Our results for each corresponding FOV are plotted using open circles. Near the galactic latitude 25°, we obtained values for two adjacent FOVs from the result of our region NO. 4, because this region is on the boundary of two FOVs.

From this figure, it can be seen that our results, except region No. 1, agree well in general with Pioneer's observations, but they are slightly lower than Roach and Megill's values.

The discrepancy at region No. 1 must be due to a local effect of our measurement. Our star counts data show that the number of stars between photographic magnitudes 10 and 12 in this region is about 3/2 times those of next two adjacent regions; Nos. 2 and 3, whose galactic latitudes are lower than that of No. 1. The excess at region No. 1 is mainly due to the contribution from these stars.

Detailed study of the diffuse galactic light requires star counts in wider regions, comparable to the FOV.

4. Supplementary Remarks

For further analyses of the Pioneer 10's data or reductions of other zodiacal light observations, results of our star counts obtained in some basically important sky regions for the photometry are listed in Table 2. Some of them have been published already (Tanabe, 1973). Each measured area centered at the listed position is 3.48 square degrees, except the Celestial N. Pole, the area for which is 3.22 square degrees because of the halo due to the bright Polaris. They do not include the light from the nebulae.

Table 2. Integrated starlight ($m_p \geq 7.5$).

	Celestial N.Pole*	Ecliptic N. Pole*	Galactic N.Pole*	Galactic S.Pole	Equinox Vernal	Equinox Autumnal
α (1950)	$19^h43^m.0$	$18^h12^m.1$	$12^h38^m.7$	$0^h29^m.7$	$0^h4^m.9$	$12^h4^m.9$
δ	$+90°0'$	$+66°2'$	$+29°29'$	$-29°35'$	$+0°32'$	$-0°32'$
$S_{10}(p)$	22.0	29.0	17.7	21.0	17.6	15.0
$S_{10}(r)$	67.1	70.5	60.2	66.9	51.7	40.0

* Tanabe (1973)

We wish to thank Dr. J. L. Weinberg of the State University of New York at Albany, who kindly gave us detailed informations about Pioneer 10's observation.

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