A STUDY OF INTERSTELLAR REDDENING AT HIGH GALACTIC LATITUDES

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Abstract. A series of finding lists of A stars in regions at high galactic latitudes has been published in the last few years. Strömgren four-color and Hβ measures have been made of stars in five of the regions, allowing the interstellar absorption in each to be calculated. The two most important regions are the North Galactic Pole and the South Galactic Pole where color excesses of $E_{B-V}=0.00$ and $E_{B-V}=0.02$ were found respectively. An area in front of the Large Magellanic Cloud has a color excess of $E_{B-V}=0.04$.

1. Introduction

During the past few years a spectral survey has been made of areas at high galactic latitudes, spaced along four principal galactic longitudes ($l=0°$, 76°, 180°, and 290°)** and every 15° in galactic latitude. When a majority of the regions in the program have been analyzed, it will be possible to study the distribution of early type stars perpendicular to the galactic plane and to determine the tilts of lines of equal star density within a few kiloparsecs of the Sun.

2. The Observations

The distribution of areas is shown in Figure 1, where each of the areas under study is

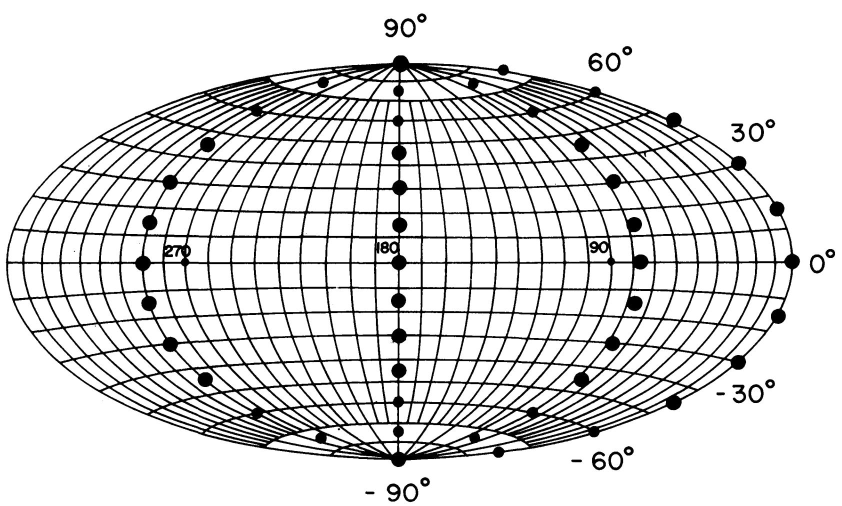

Fig. 1. The areas under investigation in a study of galactic structure perpendicular to the galactic plane plotted by their galactic longitudes and latitudes.

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** New galactic coordinates are used throughout this paper.

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indicated by a solid circle. A series of finding lists of early-type stars, which together constitute a catalogue of stars important in the study of galactic structure, has been published in the *Bol. Obs. Tonantzintla y Tacubaya.*

Schmidt spectral plates and a set of direct plates covering an area of 25 square degrees, are taken in each area. One hour spectral plates, taken at a dispersion of 280 Å mm^{-1}, on IIaO plates reach approximately $V = 13$–14th mag., depending on the Schmidt telescope used. Plates have been obtained with Schmidt telescopes at the Warner and Swasey Observatory, at the Tonantzintla Observatory, and the Cerro Tololo Inter-American Observatory (Michigan Curtis Schmidt telescope). All the stars with classifiable spectra are recorded and then measured for *B* or *V* magnitudes on the direct plates. In order to determine magnitudes from the images on the direct plates, sequences of B and A type stars are set up in each region. The spectral and magnitude data are then combined to yield the stellar density function in each of the directions indicated in Figure 1.

The interstellar reddening must be determined in each region before the stellar density analysis is made. The early-type stars in each area (spectral type A7 or earlier) are measured in the four-color and Hβ systems. The *y* magnitude transforms very well to the *V* magnitude of the *UBV* system and is used in the determination of the photographic magnitudes. The reddening in each region as a function of distance can be determined by means of a formula derived by Crawford (1970):

$$(b - y)_0 = 2.943 - \beta - 0.1\,(\delta m_1 + \delta c_1),$$

where $\delta\, m_1 = (m_1)_{\text{Hyades}} - (m_1)_{\text{observed}}$, and $\delta\, c_1 = (c_1)_{\text{observed}} - (c_1)_{\text{zams}}$. This formula is valid for A stars with $2.70 < \beta < 2.88$. The color excess, $E_{b-y} = (b-y)_{\text{observed}} - (b-y)_0$, can then be plotted as a function of the distance modulus, $m - M$, to determine the run of absorption with distance. Observations of this type have been made in a number of regions in the general program; this paper will summarize the reddenings derived in nine of these.

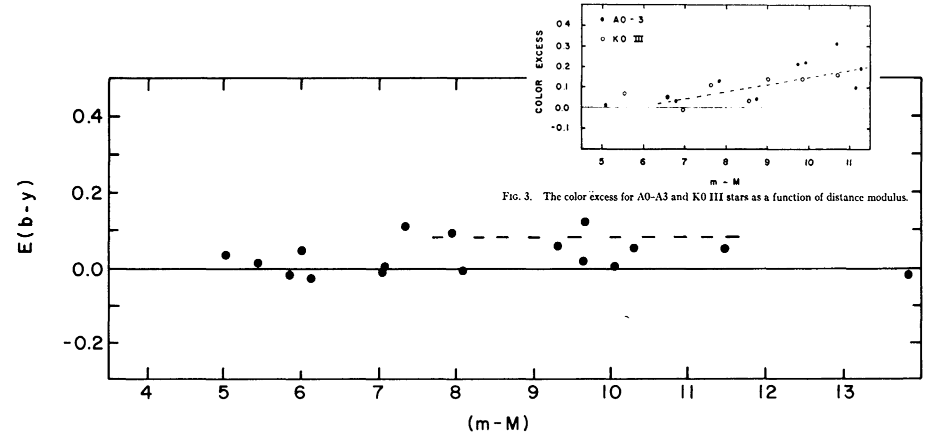

Fig. 2. The color excess in 1HLF2 plotted against the distance modulus. The insert in the upper right is an estimate (Philip, 1966) derived from Schmidt spectral types and UBV photometry.

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3. The Reddening

The first area to be studied was 1HLF2 ($l=76°$, $b=-30°$) (Philip, 1966). In this study the reddening was derived by using the Schmidt spectral types to yield an intrinsic $B-V$ color, which was then subtracted from the observed $B-V$ color. At a distance modulus of 11, a color excess of 0.2 mag. was derived. More recently these same stars have been measured in the four-color and Hβ systems and a color excess of $E_{B-V}=0.07$ derived. (The A and B type stars in 1HLF2 are still being measured and the derived reddening estimate may change slightly in the final analysis.) The two estimates of the reddening are shown in Figure 2 in which the color excess, E_{b-y}, is plotted against the distance modulus. The small insert in the upper right is a reproduction of Figure 3 from Philip (1966) in which E_{B-V} is plotted vs $m-M$. E_{b-y} is plotted vs $m-M$ in the large figure. ($E_{b-y}=0.7E_{B-V}$). The observations reported here were made in the four-color system; the color excesses have been converted to E_{B-V} since most of the reddenings reported in the literature are in the UBV system.

The reddening in 4HLF6 ($l=180°$, $b=-60°$) is presented in Figure 3. In this region $E_{B-V}=0.013$. The reddening at the SGP is presented in Figure 4 ($E_{B-V}=0.002$). The

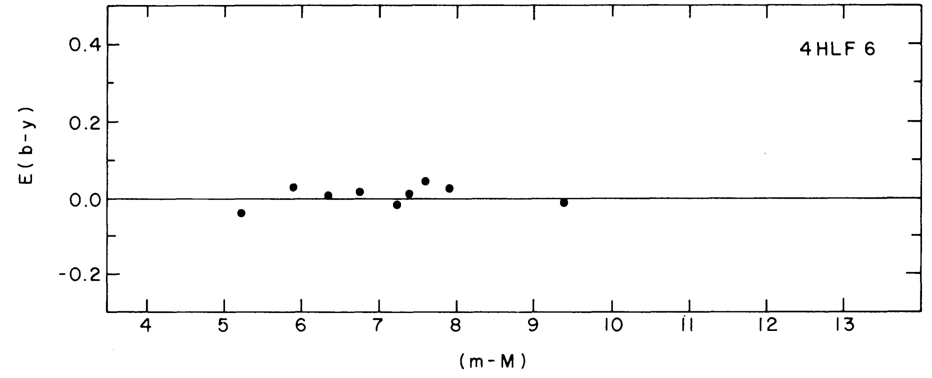

Fig. 3. The color excess in 4HLF6.

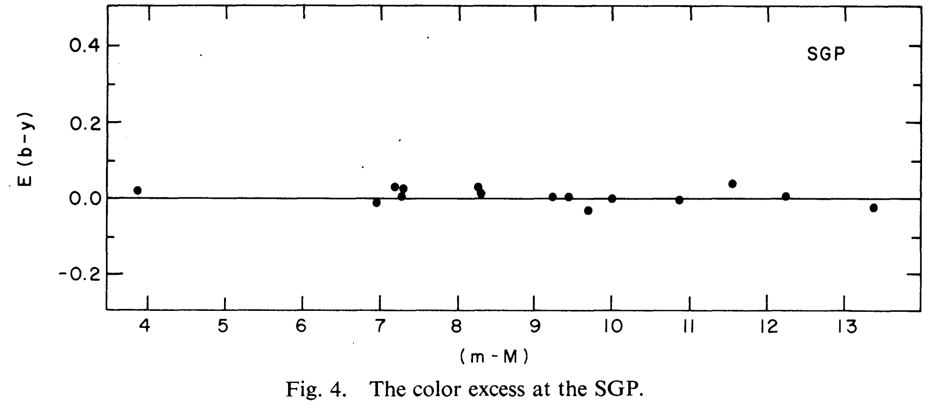

Fig. 4. The color excess at the SGP.

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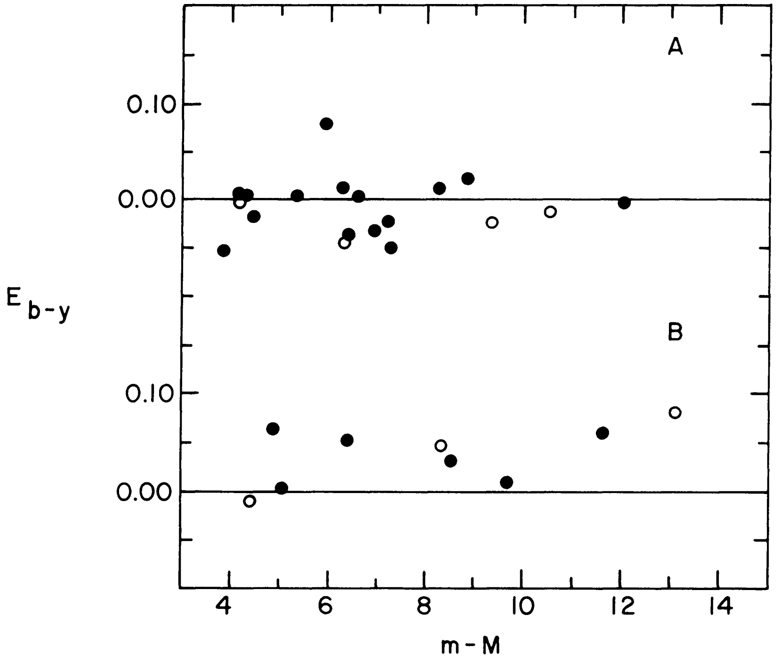

Fig. 5. The color excess at the NGP. The regions A and B are defined in Figure 6.

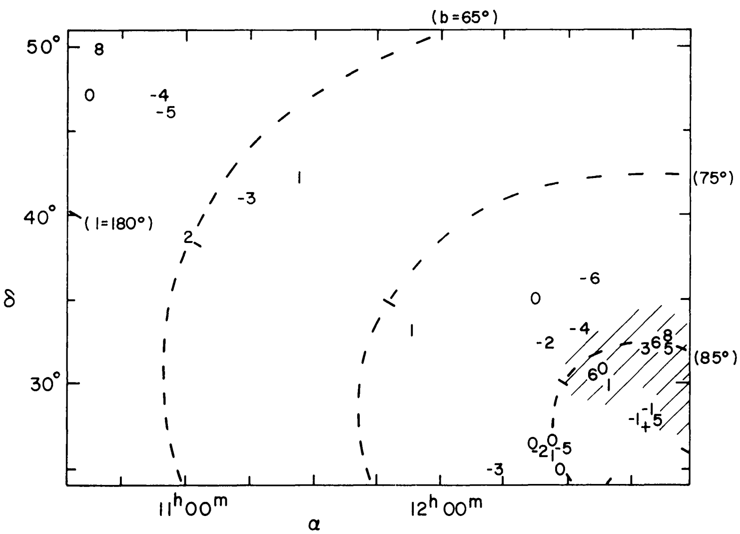

Fig. 6. The distribution of color excesses at the NGP. Area B is a small area just North of the NGP.

reddening at the NGP is presented in Figure 5 and 6, (Figures 1 and 2 of Philip and Tifft, 1971). The color excesses in two regions A and B are shown as a function of distance modulus in Figure 5. In A, $E_{B-V}=0.05$, in B, $E_{B-V}=0.00$. (Region B is indi-

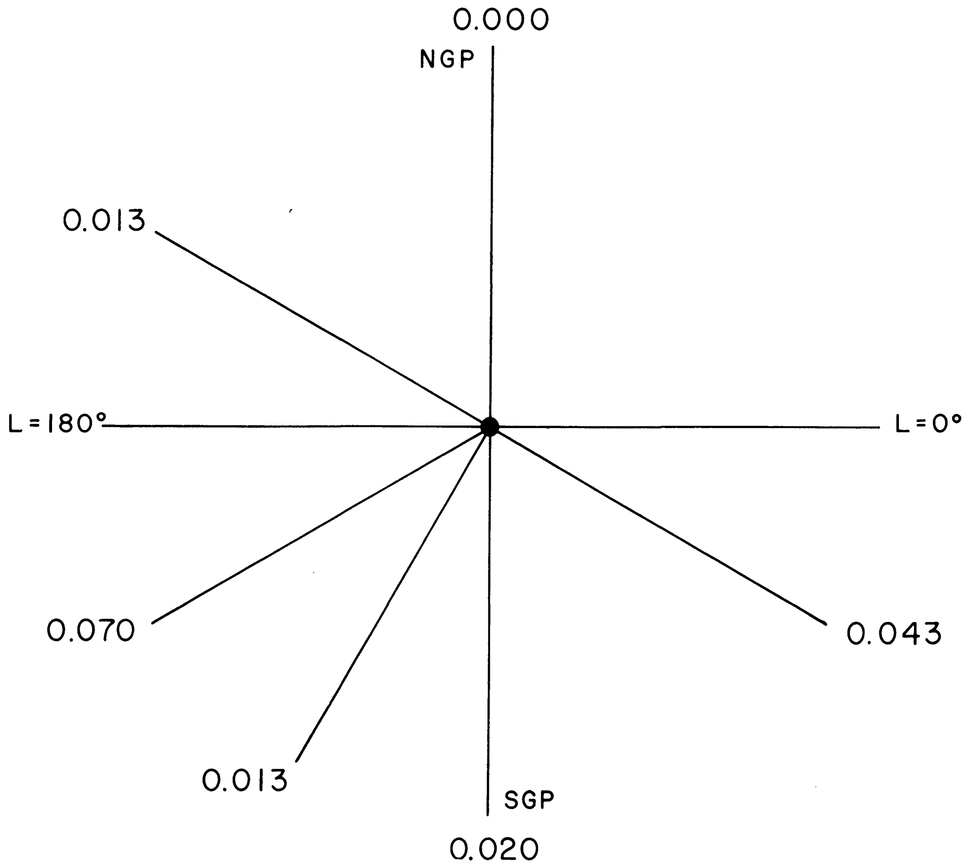

Fig. 7. E_{B-V} for certain galactic latitudes at galactic longitudes 0° and 180°.

cated in Figure 6 as the diagonally shaded area.) The hollow circles in Figure 5 indicate stars with $2.88 < \beta < 2.91$ which are slightly outside the limits set by Crawford (1971). In Figure 6, the NGP is marked by a small cross in the lower right. The numbers indicate the values of $b-y$ to the nearest hundredth.

The marked increase in accuracy of estimates of the color excess, made by means of the $b-y$, β relation as a function of distance modulus relative to estimates of the color excess made from knowledge of the Schmidt spectral type and $B-V$ color, can be seen by comparing the scatter of the points in Figures 2–5 with the scatter in the small insert in Figure 2. The major cause of the increased scatter is due to the fact that the grid of possible spectral types is not fine enough at the low dispersion of Schmidt spectral types. The difference also may be due partly to small systematic errors in the Schmidt spectral types, both as a function of magnitude and temperature class (in the range A0–A7) which are now under study.

The estimates of E_{B-V} in nine regions are summarized in Figures 7 and 8. Areas at $l = 0°$ and $b = -30°$, $\pm 90°$, $l = 180°$ and $b = \pm 30°$ and $-60°$, are summarized in Figure

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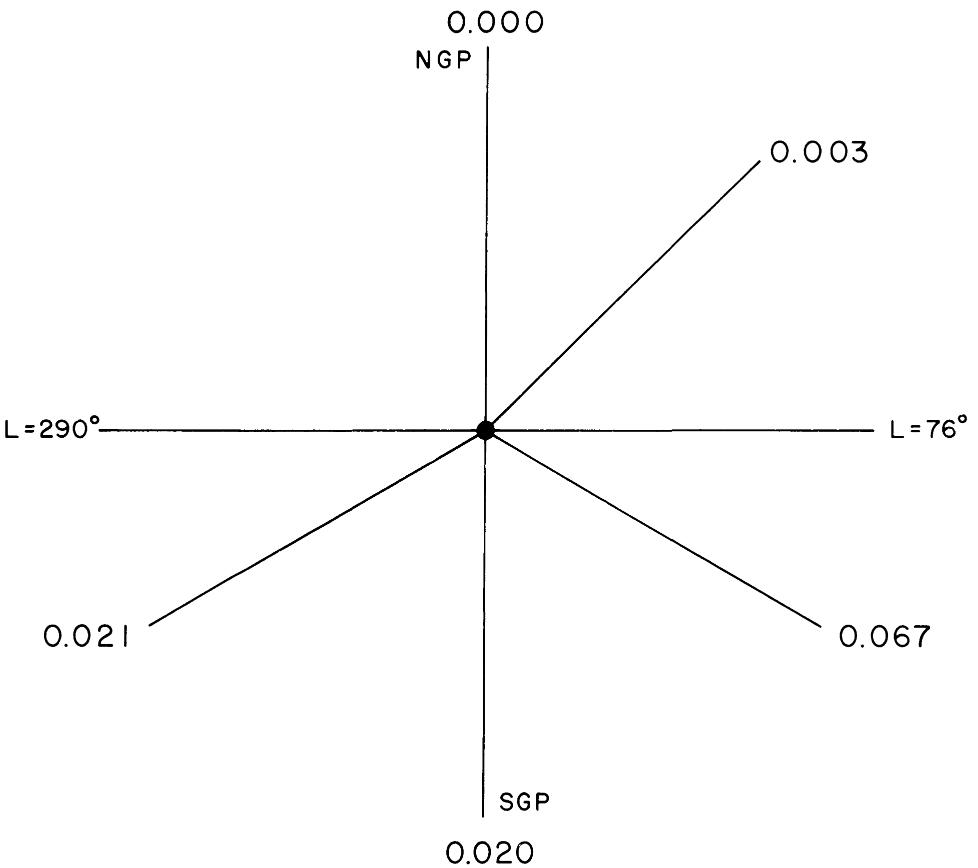

Fig. 8. E_{B-V} for galactic latitudes at galactic longitudes 76° and 290°.

7. The number at each position is the estimate of E_{B-V} in that region. Areas at $l=76°$ and $b=+45°$, and $-30°$, and $l=290°$, $b=-30°$ are shown in Figure 8.

There is a smooth progression from very low reddenings at the galactic poles to estimates of a few hundredths at latitudes of $\pm 30°$. As more finding lists of early-type stars are completed and the stars in them measured in the four-color and Hβ systems, the reddening at high galactic latitudes can be mapped more exactly. At the present time, it can be seen that the reddening at the galactic poles is very small which means that measurements of colors of stars in these areas are very nearly the intrinsic colors. In agreement with current ideas that the Sun is a few tens of parsecs north of the galactic plane, the data suggest that absorption north of the plane is less than that to the south.

Acknowledgements

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Appendix

A summary of the finding lists of early-type stars published and in preparation will be found below

Paper	Reference	Area	l	b	No. of stars	Area of survey sq deg
I	Philip (1967)	1HLF4	76°	−45°	33	25
II	Philip and Sanduleak (1968)	SGP	−90°		180	230
III	Philip and Drilling (1970)	4HLF4	180°	−45°	88	45
IV	Drilling and Philip (1970)	3HLF4	0°	−45°	146	45
V	Philip and Relyea (1971)	1HLF3	76°	+45°	16	19
VI	Philip and Stock (1972)	Extended SGP	22° to 225°	−45° to −50°	539	434
					1002	798

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