ASTRONOMY & ASTROPHYSICS
SUPPLEMENT SERIES

MARCH II **1998**, PAGE 417

Astron. Astrophys. Suppl. Ser. **128,** 417-422 (1998)

Photographic surface photometry of the Southern Milky Way

VIII. High-resolution *U*, *V* and *R* surface photometries of the Southern Milky Way*

B. Hoffmann[1], **C. Tappert**[1,2], **W. Schlosser**[1], **Th. Schmidt-Kaler**[1], **S. Kimeswenger**[1,3], **K. Seidensticker**[1,4], **L. Schmidtobreick**[1], **and W. Hovest**[1,5]

[1] Astronomisches Institut der Ruhr-Universität Bochum, Universitätsstraße 150, D-44780 Bochum, Germany
[2] Dep. Astrofísica, Pontificia Universidad Católica de Chile, Casilla 104, Santiago 22, Chile
[3] now at: Institut für Astronomie der Universität Innsbruck, Technikerstraße 25, A–6020 Innsbruck, Austria
[4] now at: DLR, Institut für Raumsimulation, Linder Höhe, D-51147 Köln, Germany
[5] Fachbereich Informatik der Universität Dortmund, D-44221 Dortmund, Germany

Received April 23; accepted May 9, 1997

Abstract. We present photometries of the Southern Milky Way ($l = 200°... 0°... 60°, |b| \leq 40°$) in the U, V and R-passbands. The resolution is $0.25° \times 0.25°$. Together with the B-photometry (Kimeswenger et al. 1993 = Paper VII), this paper gives final results of the Bochum Super–Wide–Angle–Camera photographs obtained in 1971 at La Silla, calibrated by means of accompanying photoelectric observations. The techniques employed and procedures used for the reductions are the same as described in Paper VII, and the references quoted therein. Therefore, this paper is restricted to those points, where either modifications proved to be necessary or additional information will help to judge the accuracy obtained. For this purpose, the chapters are arranged in the same manner as in Paper VII.

Key words: galaxy (the): structure of — photometry

1. Introduction

In 1971, about one hundred photographs of the Southern Milky Way were taken at La Silla with the Bochum Super-Wide-Angle Camera (Schlosser & Schmidt-Kaler 1978; Schlosser et al. 1975). The majority of the frames were exposed in spectral passbands with filter/emulsion combinations, which matched as closely as possible Sandage & Smith's (1963) photoelectric $UBVR$ system. While these U, B, and V passbands are quite similar to the Johnson (1955) system and thus could be transformed into that standard system by linear colour equations, things are different with the red passband. Sandage & Smith employed a red spectral region, which contains Hα. This we did not consider as an appropriate base for stellar work, since Hα from dispersed interstellar hydrogen is practically omnipresent in the night sky and makes stellar aggregates "looking older" than they really are. Therefore this hydrogen line was omitted and the R-band was restricted to wavelengths above λ 656.3 nm. The finally adopted photographic system U, V, and R (excluding Hα) is given in Table 1.

Table 1. Photographic Colour System. $\lambda_{\rm eff,\,std}$ taken from Johnson (1955) (U and V), and Sandage & Smith (1963) (R)

Passband	U	V	R
Filter/Schott	UG1	GG475	RG665
Emulsion/Kodak	IIaO	103aG	103aF
$\lambda_{\rm eff}$/nm	356	534	681
FWHM/nm	52.5	83.5	21.5
$\lambda_{\rm eff,\,std}$/nm	350	555	690

Additionally we used the following colour equations to transform our photoelectric magnitudes (index "pe") to the Johnson standard system:

$$U = u_{\rm pe} + 0.00(U - B)$$
$$V = v_{\rm pe} - 0.07(B - V)$$
$$R = r_{\rm pe} + 0.06(V - R)$$

Although our R-photometry has been calibrated using stellar colours from Tereshchenko & Kharitonov (1977),

Send offprint requests to: W. Schlosser

* Based on observations collected at the European Southern Observatory, La Silla, Chile.

one should always remember that - in a strict sense - our R-map of the Southern Milky Way (Figs. 1c, 4) represents a colour system of its own.

2. Data

For this work, we selected 23 frames, namely nine for the U-domain, seven for V and seven for R (Table 2). The plates were then calibrated by means of ESO's ETA-wedge spectra (see Paper VII). This gives relative intensities of the night sky (including all the atmospheric and zodiacal light effects). Parallel to these exposures simultaneous, photoelectric measurements were made by one of us (TSK) with the 61 cm Bochum telescope at La Silla, which then were used to determine atmospheric extinctions, colour transformations, zero points of absolute intensities and airglow values for different zenith distances. All plates were digitized using the PDS machine of the Astronomisches Institut der Westfälischen Wilhelms-Universität at Münster. The diaphragm was 50 μm $\times$ 50 μm, corresponding to about (10... 14 arcmin)^2 in the sky. Special care was taken to reveal possible time-dependent sensitivity changes of the scanning system, which, however, proved to be of excellent stability. The paper strip chart records of the photoelectric measurements were processed by means of a standard digitizer table commercially available for personal computers.

3. Reductions

Geometric transformation:
There are no alterations with respect to Paper VII. The mean error was ± 10 μm or $\pm 0.03°$ in the sky.

Gradation curve and absolute calibration:
With the U and V passbands well inside the domain of sensitivity of the respective emulsions, no problems were encountered during reduction, which followed closely the procedures laid down in Paper VII. In the red spectral region, however, the long wavelength cut-off of the passband coincided with that of the 103-aF emulsion. At the limiting wavelengths of their sensitivity, emulsions tend to steepen up their gradation curves. So special care had to be taken to establish the true run of these curves.

Atmospheric effects:
While in the visual spectral region the effect of airglow is very much like that in the B-band (Paper VII), in the red and ultraviolet spectral region the airglow affects the Milky Way much more. This is due to the higher emission in the red, and/or to the lower surface brightness of the Milky Way in the U-band. Columns 3-5 of Table 2 give the airglow values for all plates. As defined in Paper VII (Eqs. (8) and (9)), I_{A_0} is the zenith brightness in S10 units, while C^2 is connected directly to the mean altitude of the airglow layer $h_{\rm eff}$ and determines its variation with respect to zenith distance z.

Table 2. Parameters of airglow correction

Plate	Date(1971)	I_{A_0}(S10)	C^2	$h_{\rm eff}$(km)
U28	Mar.26/27	32$^{*)}$	0.970$^{**)}$	98$^{**)}$
U29	26/27	51	0.970	98
U31	26/27	60	0.970	98
U32	26/27	72	0.970	98
U33	27/28	40	0.970	98
U36	27/28	52	0.970	98
U55	Apr.01/02	130	0.970	98
U56	Apr.01/02	65	0.970	98
U57	Apr.01/02	70	0.970	98
V14	Mar.23/24	120	0.970	99
V17	23/24	120	0.970	98
V19	23/24	180	0.966	108
V49	Mar.31/Apr.01	140	0.963	118
V53	Mar.31/Apr.01	175	0.958	117
V95	Apr.26/27	150	0.972	88
V96	26/27	150	0.973	88
R27	Mar.25/26	532	0.979	69
R73	Apr.17/18	533	0.965	115
R79	19/20	533	0.965	115
R82	21/22	760	0.950	165
R88	23/24	577	0.975	81
R89	23/24	577	0.975	81
R107	28/29	532	0.979	69

$^{*)}$ all photoelectric zenith airglows multiplied by a factor of 0.43 to allow for cut-off of emission lines in the photographic system
$^{**)}$ Parameter C^2 and effective height of emission layer set to average 0.970 resp. 98 km (U-band only)

Zodiacal light:
The corrections were made using the data published by Levasseur-Regourd & Dumont (1980). The transformations into the respective passbands were done by multiplying these data with the appropriate solar intensity ratio.

Elimination of foreground stars and averaging of individual plates:
The procedures of elimination and averaging were the same as in Paper VII. When the photometries were combined to $U-B$, $B-V$, $V-R$ maps (B from Paper VII), a few small areas of "astrophysically impossible" colours showed up, which are thought to result from inadequately eliminated stars or star clusters. In Table 3 data obtained from a composite picture of Hovest (1995) contains the positions of the areas (Fig. 5), where our photometries have to be treated with caution.

Errors and comparisons with other photometries:
As in Paper VII, the three photometries are compared to others available. In Table 4 the relations are presented. The comparison for the B band photometry is taken from Paper VII. Except for the early work of Elsässer & Haug

Table 3. Areas of photometries which might be affected

gal. longitude l	gal. latitude b	Object	not totally eliminated in Photometry
355°.5	+20°.5	Jupiter	B
372°.5	−11°.2	σ Sag	V
316°.0	−1°.0	α Cen	V
290°	−5°	IC 2602 in Carina	$B^{*)}$, V
227°.5	−9°.0	α CMa	B, V

*) overreduced.

Table 4. Comparison with other photometries

U	LR	$= 0.97(\pm0.18)T - 12(\pm4)$
	P	$= 1.11(\pm0.12)T - 5(\pm12)$
	PM	$= 0.84(\pm0.02)T - 10(\pm3)$
	S	$= 1.19(\pm0.03)T - 18(\pm5)$
B	C	$= 0.83(\pm0.04)K + 23(\pm5)$
	M	$= 0.82(\pm0.12)K + 39(\pm23)$
	S	$= 1.18(\pm0.03)K + 16(\pm3)$
	LR	$= 0.93(\pm0.08)K - 3(\pm7)$
	To	$= 0.90K + 24$
V	D	$= 1.03H$
	LR	$= 0.94H$
	EH	$= 1.64(\pm0.13)H + 36(\pm8)$
	S	$= 1.13(\pm0.09)H - 88(\pm14)$
R	S	$= 1.09(\pm0.04)H - 464(\pm36)$

All values in S10 units;
photometries: C (Classen 1976), D (Dachs 1970), EH (Elsässer & Haug 1960), H (Hoffmann et al. 1990, 1993), M (Mattila 1973), LR (Leinert & Richter 1981), P (Pröll et al. 1980), PM (Pfleiderer & Mayer 1971), S (Seidensticker et al. 1982), T (Tappert et al. 1993), To (Toller 1989).

(1960) all relations stay within ±19% in scale. It seems probable, however, that our scale is correct within ±5%.

4. Results

Figures 1a-c give the final photometries in U (after Tappert et al. 1993) and V, R (after Hoffmann et al. 1990, 1993) for $l = 200°... 0°... 60°$, $|b| \leq 40°$. For the same photometries, a colour-coded set of maps is presented in Figs. 2-4. As concerns the U band, a detailed map of the galactic center region has been given earlier (Schmidt-Kaler & Schlosser 1988).

Note added in proof: A database of all major photometries (including those of Papers VII & VIII) is being built up at the CDS, Strasbourg. It will be accessible through the World Wide Web at `http://cdsweb.u-strasbg.fr/cgi-bin/qcat?VII/199`

Acknowledgements. The authors are grateful to Prof. Dr. W.C. Seitter and her staff of the *Astronomisches Institut der Westfälischen Wilhelms-Universität Münster* for granting measuring time and technical support. We also thank the Deutsche Forschungsgemeinschaft (DFG) for financial support (Schm 160/35-1).

References

Classen C., 1976, PhD Thesis, University Bonn, Germany
Dachs J., 1970, A&A 6, 155
Elsässer H., Haug U., 1960, Zeitschr. f. Astroph. 50, 121
Hoffmann B., Kimeswenger S., Schlosser W., Schmidt-Kaler Th., Seidensticker K.J., 1990, in: The Galactic and Extragalactic Background Radiation, Bowyer S. & Leinert C. (eds.) IAU Symp. 139, p. 203
Hoffmann B., Schlosser W., Schmidt-Kaler Th., Tappert C., 1993, Astron. Ges. Abstr. Ser. 9, 171
Hovest W., 1995, Diploma Thesis, University Dortmund, Ruhr-University Bochum, Germany
Johnson H.L., 1955, Ann. d'Astrophys. 18, 292
Kimeswenger S., Hoffmann B., Schlosser W., Schmidt-Kaler Th., 1993, A&AS 97, 517, Paper VII
Leinert C., Richter I., 1981, A&AS 46, 115
Levasseur-Regourd A.C., Dumont R., 1980, A&A 84, 277
Mattila K., 1973, Sterne und Weltraum 12, 246
Pfleiderer J., Mayer U., 1971, AJ 76, 691
Pröll H.J., Schmidt-Kaler Th., Schlosser W., 1983, A&AS 51, 17, Paper III
Sandage A., Smith L., 1963, ApJ 137, 1057
Seidensticker K.J., Schmidt-Kaler Th., Schlosser W., 1982, A&A 114, 60, Paper II
Schlosser W., Schmidt-Kaler Th., 1978, Vist. Astron. 21, 447
Schlosser W., Schmidt-Kaler Th., Hünecke W., 1975, Atlas der Milchstraße in vier Spektralbereichen, Bochum
Schmidt-Kaler Th., Schlosser W., 1988, in: The Outer Galaxy, Blitz P.L. & Lockman F.J. (eds.) Lecture Notes in Physics, 306, p. 107
Tappert C., Hoffmann B., Schlosser W., Schmidt-Kaler Th., 1993, Astron. Ges. Abstr. Ser. 9, 172
Tereshchenko V.M., Kharitonov A.V., 1977, Zonal Spectrophotometric Standards, Library Board, London, UK
Toller G.N., 1990, in: The Galactic and Extragalactic Background Radiation, Bowyer S. & Leinert C. (eds.) IAU Symp. 139, p. 21

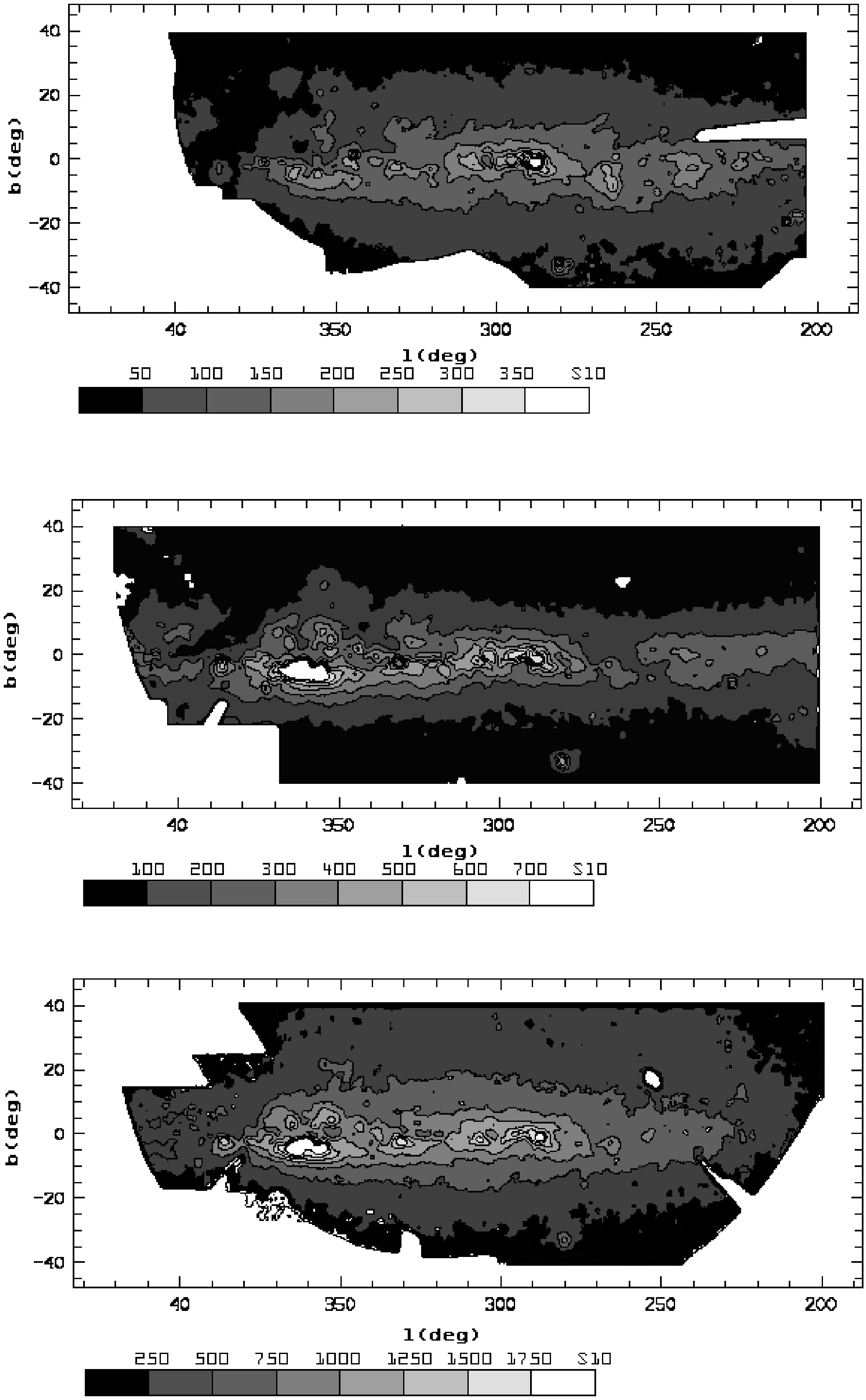

Fig. 1. Contour plots of the photometries of the Milky Way in the *U* **a**), *V* **b**) and *R* **c**) band

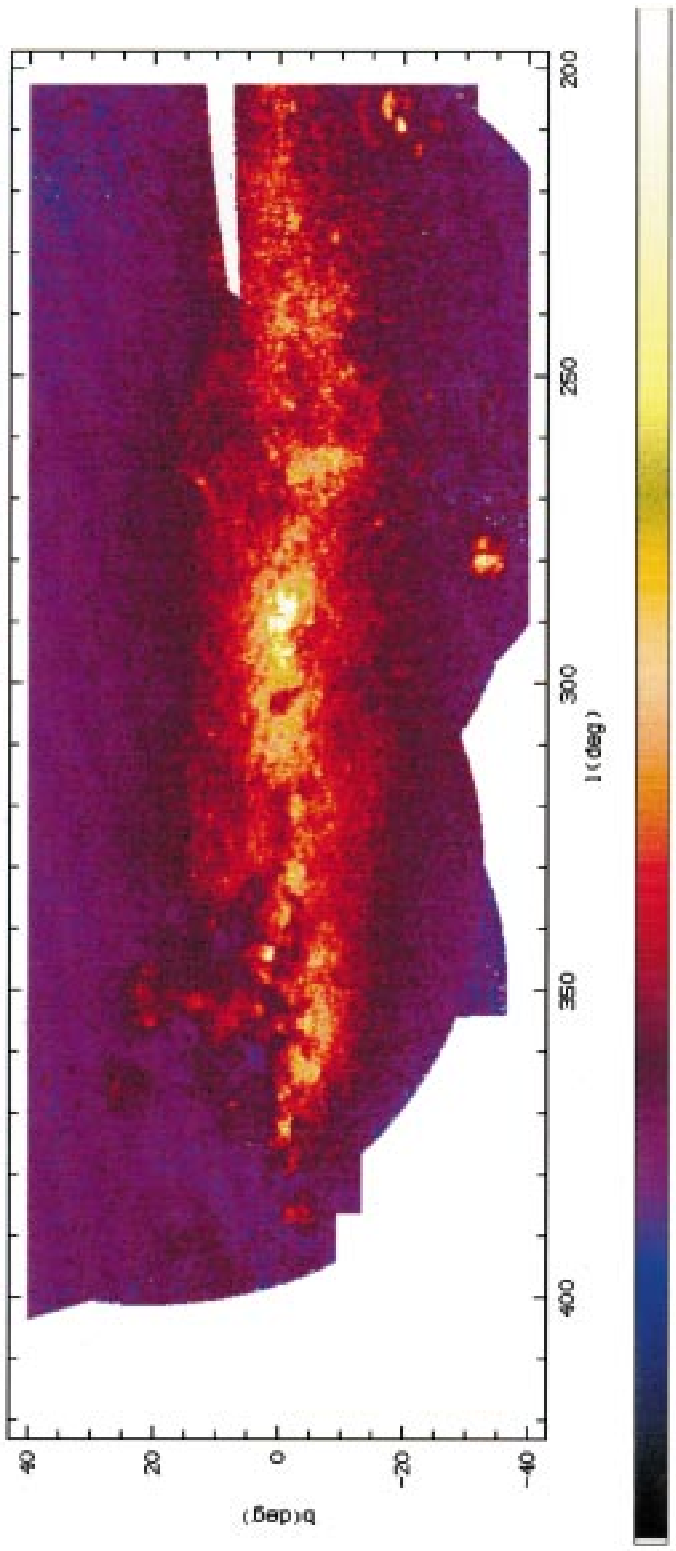

Fig. 2. The Southern Milky Way in the U passband. The colour code is from black ≤ -100 to white ≥ 450 S10U. The lower cut of the colour table has been chosen for technical reasons only. For all photometries, intensity ≥ 0 S10

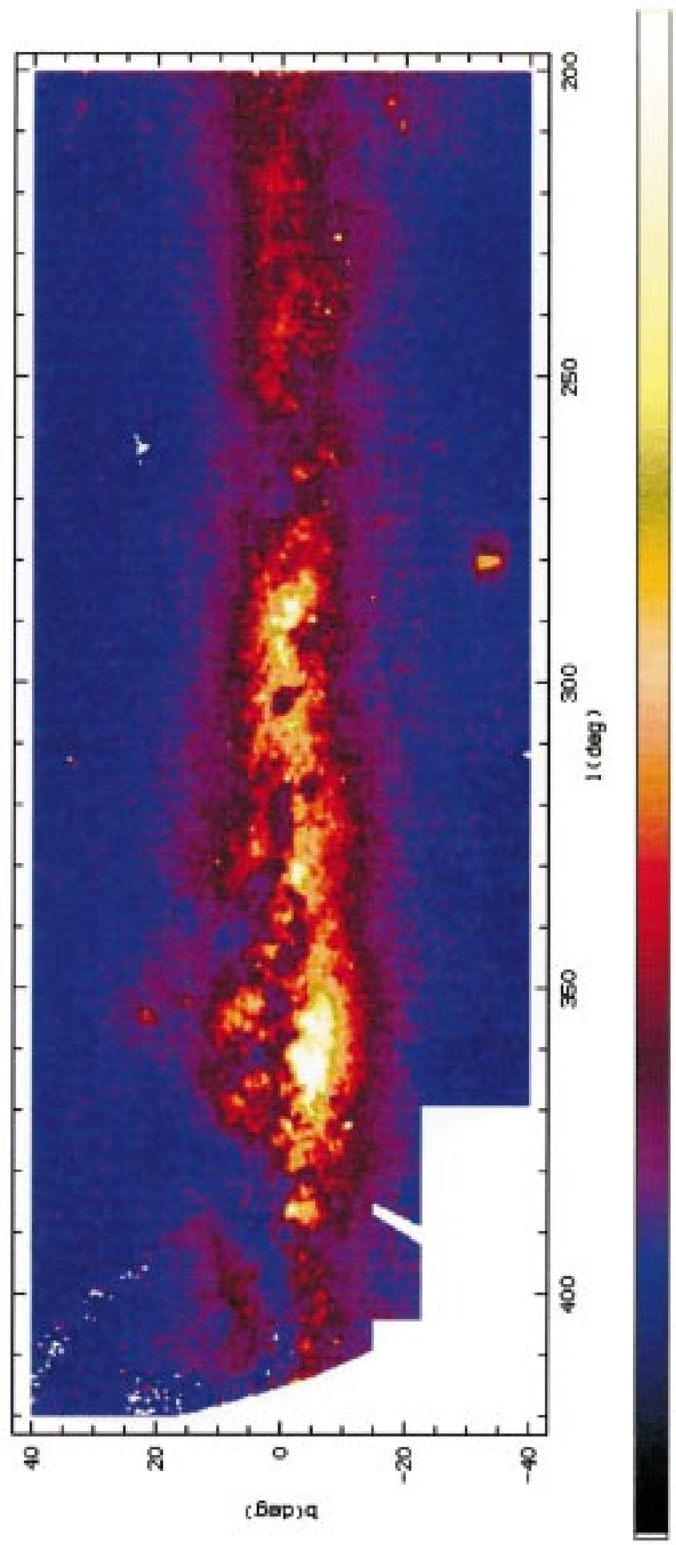

Fig. 3. The Southern Milky Way in the V passband. The colour code is from black ≤ -100 to white ≥ 900 S10V

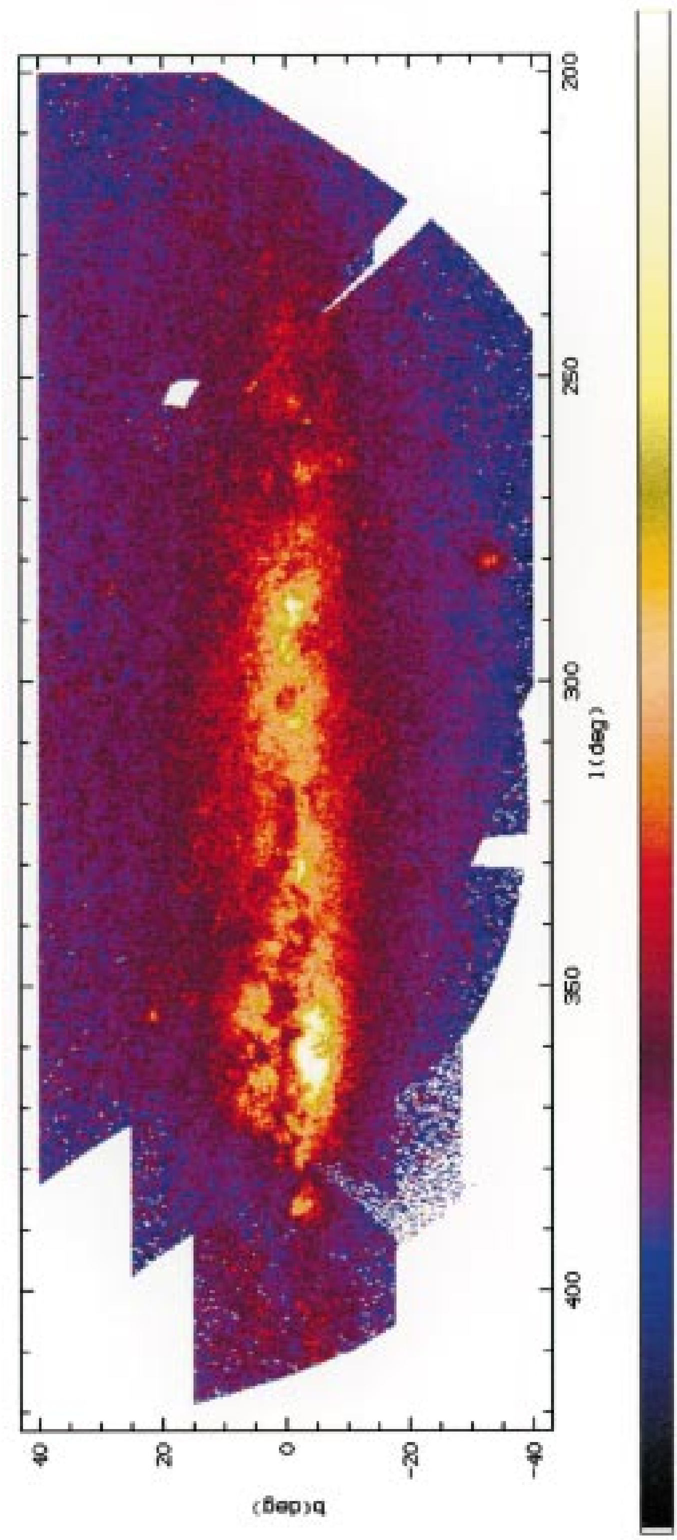

Fig. 4. The Southern Milky Way in the R passband. The colour code is from black ≤ -100 to white ≥ 2600 S10R

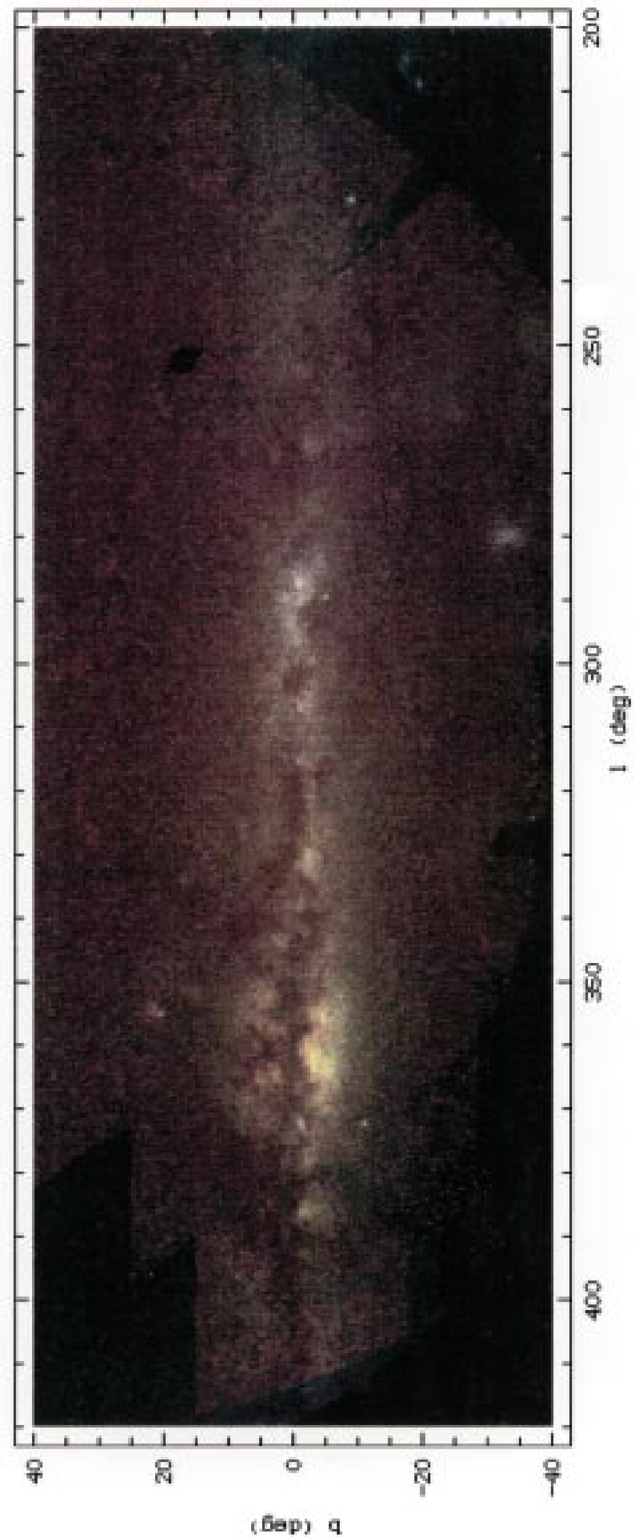

Fig. 5. Synopsis of the three B, V, R photometries