Mon. Not. R. astr. Soc. (1983) **204**, 347–353

Southern spectrophotometric standards for large telescopes

Remington P. S. Stone* *Lick Observatory, University of California, Santa Cruz, California 95064, USA*

J. A. Baldwin *Cerro Tololo Inter-American Observatory, Casilla 603, La Serena, Chile.*

Received 1982 October 20; in original form 1982 June 22

Summary. We present spectral energy distributions for 18 stars intended as flux standards for large southern hemisphere telescopes. The monochromatic magnitudes range between 10 and 14.5 and the wavelengths observed are from $\lambda\,3200$ to $\lambda\,8280$. We also present mean narrow-band extinction coefficents for Cerro Tololo over the wavelength range $\lambda\lambda\,3200$–8370.

1 Introduction

The proliferation of telescopes of large aperture in the southern hemisphere, coupled with the development of a variety of sensitive detectors, has led to considerable demand for well-calibrated spectrophotometric flux standards at southerly declinations. Although equatorial and northern flux standards of intermediate brightness exist (Oke 1974; Stone 1974, 1977), many are inaccessible from the south, the distribution with right ascension of those that remain is very poor and even on the meridian some of their zenith distances are large, which sometimes precludes an adequate determination of extinction.

We have attempted to provide a suitable network of southerly standards. Our 18 newly calibrated flux standards are spaced fairly evenly in right ascension, and are generally in the declination band between -20° and -40°. Their monochromatic magnitudes range from 10 to 14.5. For the particular convenience of observers of the Magellanic Clouds, we have provided a pair of standards in their vicinity.

2 Observations and reductions

Our program stars are generally white dwarfs of spectral type F or hotter, chosen from a variety of lists in the literature. In some cases (LTT 377, L745 – 46A, LTT 3864, LTT 6248, EG 274, LTT 7379) it is not entirely certain that we have been able to select the correct star

*Visiting Astronomer, Cerro Tololo Inter-American Observatory, supported by the National Science Foundation under Contract No. AST 78-27879.

due to the coarse coordinates and lack of finding charts in the original source. In fact, SIT-Vidicon spectra of LTT 6248 kindly obtained for us by Drs R. D. Cannon and J. Hesser show an F-type spectrum rather than the expected A spectrum, but for the other stars the spectral types are in reasonable agreement with those given in the original source. The finding charts provided show the stars we actually observed.

Our approach was to use the low-resolution dual channel ('Harvard') scanner to provide the basic flux calibration. Then, in order to calibrate a satisfactory number of wavelength points per standard in a reasonable amount of observing time, we used spectrographs with linear detectors to interpolate fluxes at wavelength points between those observed with the scanner.

2.1 SCANNER

The computer controlled scanner was used on the CTIO 1.5-m telescope with dry-ice cooled dual channel ITT FW-130 (S-20) photomultipliers and the usual CTIO pulse counting electronics and data-taking system. We used a 40 Å passband in the second order ($\lambda \leqslant 5000$) and 80 Å in the first order ($\lambda \geqslant 5556$). Ten wavelengths covering the range $\lambda\lambda$ 3200–7550 were chosen from Hayes (1970). We were usually able to observe each program star on three or more separate nights, but some of the brighter stars were observed only twice. The mean number of observations per star was 3.8.

We repeated observations of as many Hayes (1970) standards per night as we could in order to provide a flux calibration and to determine reliable nightly extinction coefficients. The mean was 6.9 standard observations per night. The standards we used were 29 Psc, ξ^2 Cet, η Hya, κ Aql, 58 Aql and θ Crt.

The scanner data reduction was accomplished with the standard CTIO reduction package in La Serena. Data for each channel were reduced separately and then averaged. We used Hayes (1970) and Hayes & Latham (1975) for the flux calibration. Our assumptions and procedures for implementing the Hayes standards are described in Stone (1974, 1977).

2.2 SPECTROSCOPIC INTERPOLATION

In order to interpolate fluxes at wavelengths between those observed with the scanner, the new standard stars were observed on several nights each, using principally the CTIO SIT-Vidicon spectrometers on the 4-m and 1.5-m telescopes. Observations to the redward of λ 5500 were made on two nights using the 1.5-m telescope and the MIT 'Mascot' travelling CCD spectrometer. The interpolated wavelength points were also from Hayes (1970) with some additional points added when finer spacing was desirable. The added points were chosen so as to avoid obvious spectral features in our new standards.

The spectroscopic observations of the new standards were flux-calibrated on each night relative to several equatorial standards from Stone (1977). The calibrated fluxes in 40 Å (for $\lambda \leqslant 5263$) and 80 Å (for $\lambda > 5263$) bandpasses were used to derive magnitudes at all of the calibration wavelengths, and then smoothly varying corrections were applied to fit the derived magnitudes to the Harvard scanner data.

For the present, we have provided data which we have extrapolated beyond the redmost scanner point at λ 7550. In a later paper, we hope to provide a more accurate and extensive infrared calibration.

Table 1. New spectrophotometric standard stars.

Star	α (1985.0)	δ	Type	m(5556)	μ(″/yr)	θ	μ_α(″/yr)	μ_δ(″/yr)	Source†
LTT 377	00 41 02.9	−33 44 06	f	11.2	0.45	237	−0.45	−0.25	1
LTT 1020	01 54 08.6	−27 32 53	g	11.5	0.36	125	0.33	−0.21	1
EG 21	03 10 22.1	−68 39 28	DA	11.4	0.30	180	0	−0.30	2
LTT 1788	03 47 49.8	−39 11 19	f	13.1	0.27	136	0.24	−0.19	1
LTT 2415	05 55 48.7	−27 51 31	–	12.2	0.32	124	0.30	−0.18	1
LTT 2511*	06 16 01.6	−59 12 02	a	13.9	0.34	190	−0.12	−0.33	1
L745 – 46A	07 39 39.2	−17 22 35	DF	13.0	1.26	117	1.18	−0.57	1
LTT 3218	08 40 57.4	−32 53 40	DA	11.8	1.69	321	−1.26	1.31	1, 2
LTT 3864	10 31 33.1	−35 33 03	f	12.1	0.28	267	−0.34	−0.01	1
LTT 4364	11 44 53.2	−64 45 24	C_2	11.5	2.68	97	6.19	−0.33	1, 2
LTT 4816	12 38 00.6	−49 43 02	DA	13.8	0.57	257	−0.86	−0.13	1, 2
CD – 32° 9927	14 10 53.1	−32 59 02	A0	10.4	0.02	162	0.01	−0.02	3
LTT 6248	15 38 04.8	−28 32 40	a	11.8	0.28	231	−0.25	−0.18	1
EG 274	16 22 32.7	−39 11 45	DA	11.0	0.08	96	0.10	−0.01	2
LTT 7379	18 35 20.7	−44 19 24	G0	10.2	0.22	225	−0.22	−0.16	1
LTT 7987	20 10 01.1	−30 15 45	DA	12.2	0.44	237	−0.43	−0.24	1, 2
LTT 9239	22 51 52.6	−20 40 15	f	12.0	0.34	164	0.10	−0.33	1
LTT 9491	23 18 48.0	−17 10 24	DC	14.1	0.26	80	0.27	0.05	1, 2

*Companion to LTT 2510 (mag 7.0) 302° 40.6 arcsec.

† Sources: 1, Luyten (1957); 2, McCook & Sion (1977); 3, Hoffleit (1967).

3 Results

Our new flux standards are listed in Table 1, along with relevant basic information, including the source from which each star was chosen. Since a few of our stars are high proper motion objects, we give μ and θ (for 1950). In this connection we call attention especially to LTT 3218, LTT 4364 and L745 – 46A, which have proper motions greater than one arcsec per year. Notice that the coordinates given in Table 1 are fairly accurate. Positions were measured with respect to nearby SAO stars with the CTIO Mann measuring engine and have been precessed and corrected for proper motion to 1985.0. We give approximate values for μ_α and μ_δ to facilitate corrections to the coordinates.

In Table 2, we present the results of the scanner observations in magnitudes per unit frequency interval (mag $= -2.5 \log f_\nu - 48.595$), where f_ν is the stellar flux in erg s^{-1} cm^{-2} Hz^{-1} and the constant is derived from the absolute flux of Vega (Hayes & Latham 1975). Notice that Table 2 combines all of our data, obtained in the quite distinct ways described above. We have used roman type to indicate the scanner data, and italics to denote interpolated and extrapolated data.

Table 2. Magnitudes per unit frequency interval. Numbers in roman type are spectrophotometric results with standard deviation of the mean in parentheses; italicized numbers are interpolated (or for $\lambda \geq 7780$, extrapolated) SIT and CCD data with standard deviations of single observations in parentheses. Standard deviations are in units of 0.01 mag. Bandpasses: 40 Å for ≤ 5263; 80 Å for $\lambda > 5263$.

λ	LTT 377	LTT 1020	EG 21	LTT 1788	LTT 2415	LTT 2511	L745-46A	LTT 3218	LTT 3864
3200	12.96(1)	13.17(2)	11.45(1)	14.57(3)	13.57(0)	13.75(2)	13.67(1)	12.44(1)	13.73(3)
3350	12.69(1)	12.87(1)	11.39(1)	14.30(2)	13.36(2)	13.61(1)	13.49(2)	12.31(1)	13.49(2)
3400	*12.58*	*12.64*	*11.41*	*14.16(6)*	*13.33(2)*	-----	*13.44(4)*	*12.26(9)*	*13.37(6)*
3450	*12.61*	*12.79*	*11.47*	*14.26(5)*	*13.34(4)*	*13.62*	*13.45(4)*	*12.30(0)*	*13.39(11)*
3500	12.53(1)	12.67(1)	11.43(0)	14.19(3)	13.27(2)	13.62(1)	13.41(2)	12.27(1)	13.34(2)
3571	*12.60*	*12.74*	*11.54*	*14.16(4)*	*13.29(0)*	*13.65*	*13.43(5)*	*12.33(5)*	*13.42(6)*
3636	*12.46*	*12.58*	*11.50*	*14.06(4)*	*13.21(5)*	*13.68*	*13.31(5)*	*12.24(1)*	*13.23(4)*
3704	*12.33*	*12.51*	*11.50*	*14.04(4)*	*13.18(1)*	*13.68*	*13.35(5)*	*12.28(5)*	*13.23(6)*
3790	*12.18*	*12.43*	*11.53*	*13.87(3)*	*12.93(1)*	*13.68*	*13.33(1)*	*12.26(1)*	*12.98(8)*
3862	*12.02*	*12.32*	*11.48*	*13.73(3)*	*12.72(1)*	*13.64*	*13.19(4)*	*12.14(2)*	*12.85(2)*
4036	*11.75*	*12.12(3)*	*11.26*	*13.60(2)*	*12.55(1)*	*13.87*	*13.20(9)*	*11.98(2)*	*12.66(4)*
4167	11.66(1)	12.02(0)	11.15(1)	13.53(1)	12.48(2)	13.67(2)	13.16(2)	11.88(0)	12.57(3)
4255	*11.66*	*12.02(3)*	*11.18*	*13.53(1)*	*12.48(1)*	*13.69*	*13.16(7)*	*11.88(1)*	*12.57(2)*
4464	*11.53*	*11.82(2)*	*11.12*	*13.42(3)*	*12.40(2)*	*13.95*	*13.09(5)*	*11.82(1)*	*12.43(2)*
4566	11.49(1)	11.79(1)	11.12(1)	13.40(2)	12.36(2)	13.73(1)	13.09(2)	11.82(1)	12.40(1)
4675	*11.41*	*11.72(3)*	*11.12*	*13.36(4)*	*12.34(2)*	*13.72*	*13.07(10)*	*11.79(2)*	*12.36(1)*
4785	*11.38*	*11.69(1)*	*11.29*	*13.30(1)*	*12.31(5)*	*13.77*	*13.09(5)*	*11.82(4)*	*12.30(1)*
5000	11.36(2)	11.65(0)	11.28(2)	13.25(1)	12.28(1)	13.92(2)	13.07(1)	11.83(1)	12.27(1)
5130	*11.32*	*11.60(2)*	*11.25(3)*	*13.18(3)*	*12.23(6)*	*13.84(0)*	*13.07(5)*	*11.82(3)*	*12.24(2)*
5263	*11.28*	*11.56(3)*	*11.32(1)*	*13.15(1)*	*12.18(8)*	*13.86(3)*	*13.01(3)*	*11.80(4)*	*12.19(1)*
5420	*11.23*	*11.52(4)*	*11.36(0)*	*13.14(1)*	*12.18(3)*	*13.89(1)*	*13.04(4)*	*11.86(4)*	*12.20(2)*
5556	11.19(1)	11.48(1)	11.39(1)	13.10(1)	12.16(1)	13.91(2)	13.01(3)	11.83(1)	12.12(2)
5700	*11.19*	*11.44(3)*	*11.46(1)*	*13.08(3)*	*12.12(3)*	*14.02(5)*	*13.04(3)*	*11.86(1)*	*12.08(1)*
5840	*11.14*	*11.41(2)*	*11.44(2)*	*13.04(1)*	*12.10(1)*	*14.07(1)*	*12.97(6)*	*11.88(6)*	*12.12(1)*
5950	*11.18*	*11.41(3)*	*11.52(0)*	*13.04(2)*	*12.12(2)*	*14.08(7)*	*12.99(6)*	*11.89(3)*	*12.03(3)*
6056	11.13(0)	11.38(0)	11.53(0)	13.04(1)	12.11(1)	14.01(2)	13.02(2)	11.88(1)	12.04(1)
6180	-----	*11.37(5)*	*11.56(1)*	*12.99*	*12.10*	*13.99*	*13.01*	*11.92(6)*	*12.02(5)*
6310	-----	*11.36(4)*	*11.61(0)*	*12.96*	*12.07*	*14.02*	*13.02*	*11.85(8)*	*11.98(6)*
6436	-----	*11.33(6)*	*11.68(3)*	*12.98*	*12.06*	*14.08*	*13.05*	*11.94(9)*	*11.98(8)*
6640	-----	*11.27(7)*	*11.83(2)*	*13.03*	*12.13*	*14.20*	*13.09*	*12.14*	*11.98*
6790	11.06(1)	11.26(1)	11.71(1)	12.97(1)	12.06(1)	14.15(2)	13.03(2)	11.98(2)	11.98(1)
7100	-----	*11.23(2)*	*11.76(2)*	*12.92(1)*	*12.06*	*14.20*	*12.95*	*11.96(4)*	*11.95(2)*
7250	-----	*11.25(8)*	*11.83(6)*	*12.97(6)*	*12.13*	*14.28*	*13.08*	*12.05(11)*	*11.97(5)*
7400	-----	*11.22(6)*	*11.83(3)*	*12.93(2)*	*12.08*	*14.30*	*13.08*	*11.99(1)*	*11.94(4)*
7550	11.04(0)	11.21(1)	11.87(1)	12.92(2)	12.04(1)	14.28(4)	13.11(2)	12.03(2)	11.94(1)
7780	-----	*11.27*	*11.87(4)*	*12.87(2)*	*11.98*	*14.26*	*13.14*	*12.08*	*11.93(4)*
7890	-----	*11.27*	*11.95(4)*	*12.84(5)*	*11.98*	-----	*13.08*	*12.02*	*11.94(6)*
7990	-----	*11.25*	*11.99(2)*	-----	*12.14*	-----	*13.12*	*12.10*	*11.93(4)*
8090	-----	*11.21*	-----	-----	*11.94*	-----	*13.28*	*12.17*	*11.87(4)*
8180	-----	*11.38*	-----	-----	-----	-----	-----	-----	*11.91(6)*
8280	-----	*11.50*	-----	-----	-----	-----	-----	-----	-----

Table 2 – *continued*

λ	LTT 4364	LTT 4816	CD-32°9927	LTT 6248	EG 274	LTT 7379	LTT 7987	LTT 9239	LTT 9491
3200	12.00(1)	14.09(2)	12.20(3)	13.31(3)	10.63(1)	12.17(3)	12.39(1)	13.96(1)	14.17(2)
3350	11.83(1)	14.00(2)	11.96(2)	13.09(0)	10.60(1)	11.79(1)	12.32(0)	13.57(3)	14.07(2)
3400	*11.78(1)*	*13.97(11)*	*11.85(8)*	*13.52*	*10.67*	*11.67*	*12.30(4)*	*13.43*	*14.07(1)*
3450	*11.80(1)*	*14.02(6)*	*11.91(6)*	*13.12*	*10.77*	*11.73*	*12.36(2)*	*13.38*	*14.11(1)*
3500	11.77(1)	14.02(0)	11.87(2)	12.94(2)	10.66(1)	11.58(0)	12.34(1)	13.36(1)	14.03(2)
3571	*11.83(0)*	*14.07(6)*	*11.80(1)*	*13.04*	*10.82*	*11.68*	*12.41(4)*	*13.39*	*14.09(4)*
3636	*11.75(2)*	*14.04(4)*	*11.72(1)*	*12.81*	*10.80*	*11.52*	*12.39(0)*	*13.25*	*14.07(6)*
3704	*11.76(1)*	*14.07(4)*	*11.52(1)*	*12.72*	*10.82*	*11.42*	*12.41(1)*	*13.25*	*14.05(2)*
3790	*11.70(2)*	*14.05(5)*	*11.30(5)*	*12.59*	*10.86*	*11.31*	*12.37(6)*	*13.09*	*14.02(4)*
3862	*11.60(1)*	*13.96(2)*	*10.96(5)*	*12.44*	*10.78*	*11.22*	*12.35(4)*	*13.00*	*13.97(3)*
4036	*11.63(1)*	*13.86(4)*	*10.65(4)*	*12.23*	*10.70*	*10.89*	*12.12(8)*	*12.77*	*14.04(7)*
4167	11.57(0)	13.77(1)	10.66(0)	12.21(1)	10.66(0)	10.77(1)	12.01(1)	12.66(0)	13.98(1)
4255	*11.57(1)*	*13.75(0)*	*10.61(2)*	*12.15*	*10.70*	*10.83*	*12.01(8)*	*12.69(1)*	*14.00(5)*
4464	*11.52(1)*	*13.66(0)*	*10.50(1)*	*12.07*	*10.74*	*10.56*	*11.95(3)*	*12.45(1)*	*14.02(6)*
4566	11.51(0)	13.66(0)	10.50(1)	12.03(4)	10.74(1)	10.49(1)	11.97(1)	12.37(0)	14.02(2)
4675	*11.58(1)*	*13.70(6)*	*10.45(4)*	*11.98*	*10.75*	*10.40*	*11.99(2)*	*12.29(2)*	*14.00(5)*
4785	*11.46(3)*	*13.81(4)*	*10.43(1)*	*11.99*	*10.90*	*10.37*	*12.18(3)*	*12.26(1)*	*14.01(1)*
5000	11.52(1)	13.73(2)	10.49(1)	11.93(1)	10.90(0)	10.35(2)	12.13(1)	12.22(1)	14.07(3)
5130	*11.57(1)*	*13.69(4)*	*10.49(2)*	*11.91(0)*	*10.92(1)*	*10.34(7)*	*12.13(4)*	*12.16(2)*	*14.08(4)*
5263	*11.48(3)*	*13.75(4)*	*10.46(3)*	*11.88(1)*	*10.97(1)*	*10.27(0)*	*12.15(2)*	*12.10(4)*	*14.09(2)*
5420	*11.48(2)*	*13.76(5)*	*10.43(2)*	*11.81(1)*	*10.98(2)*	*10.21(0)*	*12.16(6)*	*12.08(1)*	*14.11(0)*
5556	11.49(0)	13.80(5)	10.41(1)	11.77(2)	11.04(1)	10.18(1)	12.20(1)	12.01(1)	14.10(2)
5700	*11.48(1)*	*13.80(7)*	*10.42(3)*	*11.76(3)*	*11.09(2)*	*10.15(2)*	*12.25(2)*	*11.97(4)*	*14.13(5)*
5840	*11.47(5)*	*13.87(3)*	*10.45(5)*	*11.70(1)*	*11.14(4)*	*10.10(2)*	*12.28(3)*	*11.92(1)*	*14.17(6)*
5950	*11.51(2)*	*13.84(6)*	*10.44(3)*	*11.70(2)*	*11.21(6)*	*10.11(1)*	*12.34(3)*	*11.95(3)*	*14.20(5)*
6056	11.50(0)	13.85(0)	10.41(1)	11.67(1)	11.21(1)	10.08(1)	12.37(0)	11.92(1)	14.19(1)
6180	*11.53(5)*	*13.89(2)*	*10.41(1)*	*11.65(4)*	*11.24(4)*	*10.07(4)*	*12.39(4)*	*11.92(2)*	*14.20(1)*
6310	*11.50(2)*	*13.97(5)*	*10.44(6)*	*11.64(4)*	*11.30(2)*	*10.04(4)*	*12.44(5)*	*11.89(7)*	*14.22(4)*
6436	*11.52(1)*	*13.98(4)*	*10.43(2)*	*11.62(1)*	*11.34(1)*	*10.01(1)*	*12.50(5)*	*11.83(2)*	*14.21(6)*
6640	*11.57(1)*	*14.12(0)*	*10.48(0)*	*11.65(3)*	*11.49(5)*	*10.02(4)*	*12.62(11)*	*11.81(5)*	*14.24(7)*
6790	11.53(0)	14.01(4)	10.45(1)	11.61(0)	11.40(1)	9.97(1)	12.53(1)	11.78(1)	14.29(3)
7100	*11.51(3)*	*14.06(1)*	*10.45(1)*	*11.59(3)*	*11.46(7)*	*9.95(2)*	*12.58(3)*	*11.75(4)*	*14.31*
7250	*11.59(8)*	*14.20(3)*	*10.51(6)*	*11.60(4)*	*11.57(4)*	*10.00(9)*	*12.63(3)*	*11.69(4)*	*14.41*
7400	*11.53(4)*	*14.20(6)*	*10.49(5)*	*11.59(2)*	*11.58(3)*	*9.95(5)*	*12.62(6)*	*11.66(1)*	*14.39*
7550	11.56(2)	14.23(2)	10.50(1)	11.56(0)	11.61(1)	9.94(1)	12.68(2)	11.70(1)	14.40(3)
7780	*11.56(3)*	*14.34(1)*	*10.52(1)*	*11.52*	*11.68*	*9.92(3)*	*12.62(3)*	-----	*14.38*
7890	*11.55(6)*	*14.35(1)*	*10.51(1)*	*11.51*	*11.54*	*9.89*	*12.66(5)*	-----	*14.42*
7990	*11.56(4)*	*14.39*	*10.56(2)*	*11.56*	*11.77*	*9.94*	*12.65(7)*	-----	*14.50*
8090	*11.56*	-----	*10.57(3)*	*11.62*	*11.79*	*9.96*	*12.70(11)*	-----	*14.56*
8180	*11.57(0)*	-----	*10.54*	-----	-----	*9.93*	*12.82(5)*	-----	*14.66*
8280	*11.56*	-----	-----	-----	-----	-----	-----	-----	*14.77*

Errors are quoted in parentheses in Table 2 for many of the observations, in hundredths of a magnitude. All of the errors are calculated from the internal agreement between nights. However, we emphasize that the scanner errors are the standard deviation of the mean, but errors for the interpolated/extrapolated data are the standard deviation of a single observation. For the scanner data, there is no significant relation between the standard deviations and wavelength, but there is a slight trend when the mean standard deviations are plotted against the magnitude interval of the observations. This is displayed in Fig. 1, which also indicates the mean standard deviation for all scanner observations, 0.013 mag.

Where no error is quoted for the interpolated/extrapolated data, the value given represents our only observation. In this case, the errors are probably worse than errors given in the

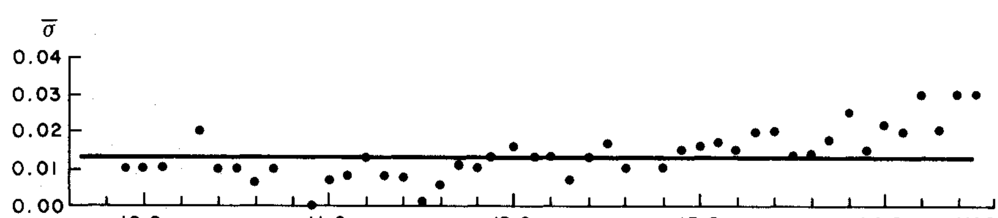

Figure 1. Standard deviation of the mean versus magnitude interval for the Harvard scanner observations. The solid line represents the mean value, 0.013 mag.

same row of the table. The mean standard deviation for all the SIT/CCD points for which we had more than one observation is 0.03 mag, although as may be seen in Table 2, some errors are much larger. The user is particularly cautioned to use the extrapolated values ($\lambda \geqslant 7780$) with appropriate discretion.

Our estimates of the external errors and the reasons for them are as given in Stone (1974).

The only program star for which we know comparable observations is L745 – 46A which was observed by Oke (1974). After linearly interpolating Oke's data to the wavelengths we observed and adjusting it to the same calibration of Vega (Hayes & Latham 1975) as ours, comparison of the two scanner data sets is quite unsatisfactory. The discrepancy is systematic with wavelength and exceeds 0.1 mag for $\lambda \geqslant 5000$. It is perhaps significant that the star in question is a difficult object to observe from Palomar where it *culminates* at greater than 1.5 airmasses, whereas from Tololo the airmass at mid-observation on each of the four nights we observed the object was 1.03. Although the errors quoted by Oke (his table 9) are only 0.01 mag in this wavelength range, they are estimated from photon statistics. In contrast, our errors are calculated from agreement between independent observations on separate nights. Finally, it is worth noting that Oke expressed some dissatisfaction in his paper with the tertiary standards on which his observations were based, and of course he did not intend his observations to be used as flux standards!

We have provided finding charts for all objects in Plate 1. The reproductions are from the Palomar Sky Survey red prints and ESO (B) films.

Table 3. Mean extinction at Cerro Tololo.

λ	Mag per unit airmass
3200	1.05
3250	0.91
3300	0.82
3350	0.75
3400	0.70
3450	0.66
3500	0.62
3571	0.57
3636	0.55
3704	0.50
3862	0.42
4036	0.38
4167	0.34
4255	0.31
4464	0.27
4566	0.27
4785	0.22
5000	0.19
5263	0.17
5556	0.14
5840	0.16
6065	0.15
6436	0.11
6790	0.07
7100	0.08
7550	0.06
7780	0.04
8090	0.04
8370	0.04

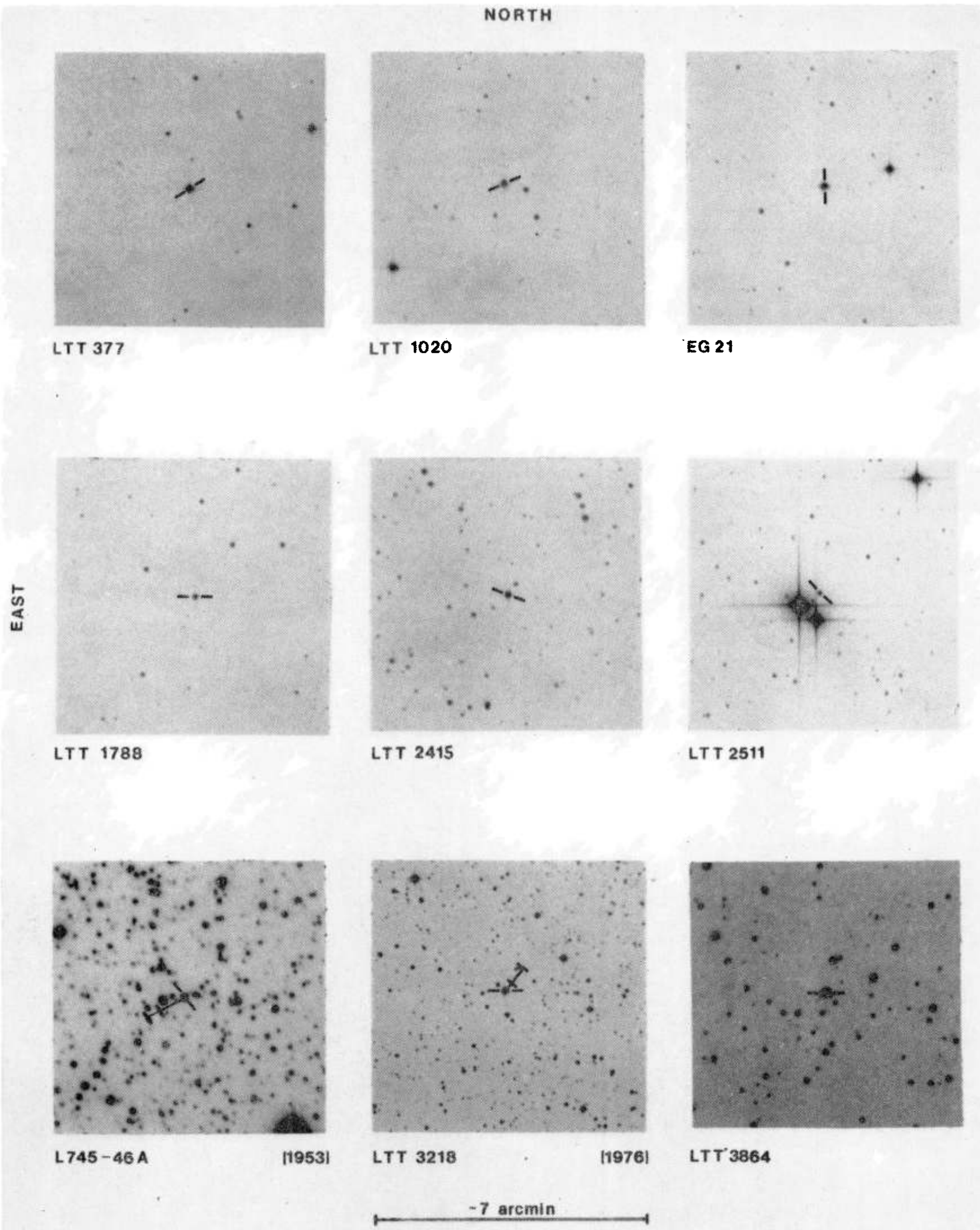

Plate 1. North is at the top, east to the left, and the fields shown are ~7 arcmin square. For the three objects with proper motions in excess of one arcsec per year, the epoch of the plate is given and tick marks indicate the expected positions in 1985 and 2000.

[*facing page* 352]

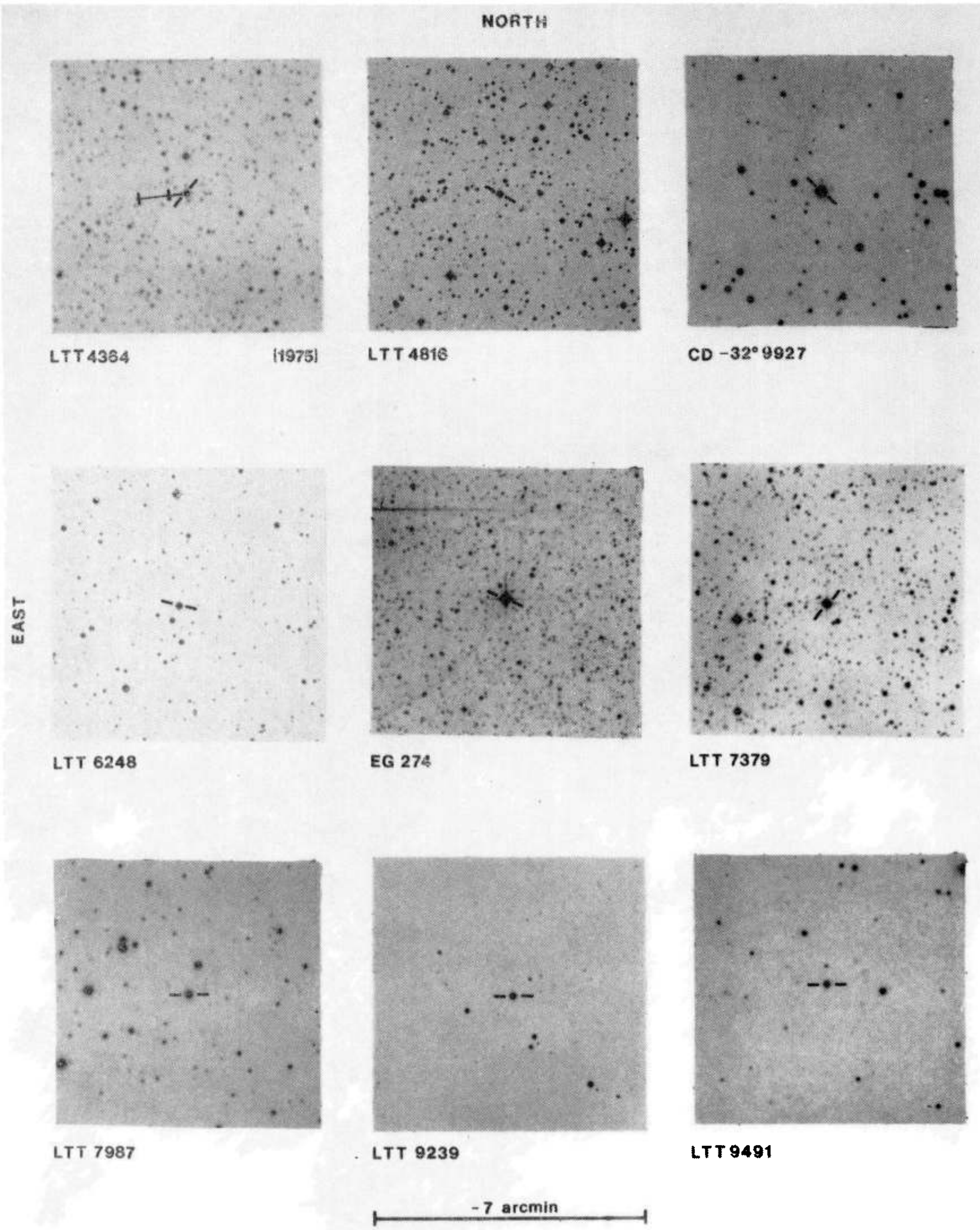

Plate 1 – *continued*

4 Extinction

As a byproduct of our work we have redetermined the mean extinction at Cerro Tololo. The values we found from observations on 11 excellent, stable nights are presented in Table 3 as magnitudes per unit airmass. The standard deviations of the means for the extinction coefficients are 0.02 for $\lambda \leqslant 3450$ and 0.01 for $\lambda \geqslant 3500$. These observations indicate a non-grey increase in the extinction at Cerro Tololo, compared to values in use half a decade ago (Osmer, P. 1975, private communication), averaging about 0.04 mag per airmass in the red and about 0.08 mag per airmass in the UV. We cannot readily explain the slight bump in the vicinity of 6000 Å, but it was often (but not always) present in the data for individual nights.

Acknowledgments

We wish particularly to acknowledge Drs G. Ricker and M. Bautz for their aid with the CCD spectrometer; the very able assistance of Srs Patricio Ugarte and Manuel Hernandez at the telescope; Dr Olin Eggen for helpful advice on sources of objects; Directors of Lick Observatory D. E. Osterbrock and R. P. Kraft for encouraging this research; Dr J. S. Miller for useful comments on the manuscript; and Dr Mark Phillips who was instrumental in initiating this project. We also thank Drs R. Cannon, J. Elias, J. Hesser and P. Osmer for obtaining spectra to check the identifications of the stars; and Gerri McLellan, Marilyn Oreck and Sue Robinson for their careful preparation of the manuscript.

This paper is Contribution from the Lick Observatory No. 429.

References

Hayes, D. S., 1970. *Astrophys. J.*, **159**, 165.
Hayes, D. S. & Latham, D. W., 1975. *Astrophys. J.*, **197**, 593.
Hoffleit, D., 1967. *Trans. Astr. Obs. Yale Univ.*, Vol. 28, New Haven, Connecticut.
Luyten, W. J., 1957. *A Catalogue of 9867 Stars in the Southern Hemisphere with Proper Motions Exceeding 0".2 Annually*, Lund Press, Minneapolis, Minnesota.
McCook, G. P. & Sion, E. M., 1977. *A Catalogue of Spectroscopically Identified White Dwarfs*, Villanova University Observatory Contributions No. 2, Villanova, Pennsylvania.
Oke, J. B., 1974. *Astrophys. J. Suppl.*, **27**, 21.
Stone, R. P. S., 1974. *Astrophys. J.*, **193**, 135.
Stone, R. P. S., 1977. *Astrophys. J.*, **218**, 767.