Advancing the Physics of Cosmic Distances
Proceedings IAU Symposium No. 289, 2012
Richard de Grijs, ed.

doi:10.1017/S1743921312021758

Revisiting the absolute-magnitude calibration of F-type supergiants and bright giants as a function of the equivalent width of the OIλ7774Å triplet

A. K. Dambis

Sternberg Astronomical Institute, M. V. Lomonosov Moscow State University,
Universitetskii pr. 13, Moscow, 119992 Russia
email: mirage@sai.msu.ru

Abstract. We reduce the published measurements of the equivalent width of the oxygen triplet (OIλ7774Å) to a single system and combine the resulting homogenized indices with revised *Hipparcos* parallaxes to derive the M_K versus log[W(OIλ7774Å)] absolute-magnitude calibration for bright F-type giants and supergiants and use the resulting calibration to estimate both the distance to the Large Magellanic Cloud and the parameters of the Galactic rotation curve.

Keywords. stars: distances, stars: luminosities, supergiants, stars: kinematics

1. Introduction

Merrill (1925, 1934) found that the strength of the OIλ7774Å feature was very different in stars of different luminosity classes and Keenan & Hynek (1950) proposed to use it as a luminosity indicator for A- and F-type stars. Since then, many authors have measured the strength of the OIλ7774Å feature in different stars and calibrated it in terms of absolute magnitude (Osmer 1972; Baker 1974; Sorvari 1974; Kameswara Rao & Mallik 1978; Hopkinson & Humrich 1981; Faraggiana *et al.* 1988; Arellano Ferro *et al.* 1989, 1991, 1993, 2003; Mendoza & Arellano Ferro 1993; Slowik & Peterson 1993, 1995; Kovtyukh *et al.* 2012). Our aim is to determine the parameters of the linear log[W(OIλ7774Å)] versus M_K relation for F0–G0 I–II stars. K-band absolute magnitudes (M_K) are adopted rather than V-band magnitudes (M_V) to minimize the effect of possible errors in the adopted interstellar extinction estimates by rendering these barely significant.

2. Sample and Calibration

Our working sample consists of 96 F0–G0 I–II-type stars with published OIλ7774Å strength measurements in different systems (equivalent widths and photometric indices), which we reduced to a single homogeneous system defined by the measurements of Kovtyukh *et al.* (2012).

We first use 14 F0–G0 I–II-type stars in 13 open clusters (see Table 1) with homogeneously determined (main-sequence fitting) photometric distances (Dambis 1999) to determine the slope of the log[W(OIλ7774Å)] versus M_K relation (see Fig. 1).

The resulting equivalent width–luminosity relation is

$$M_K = -5.33 - 10.81 \log\left[W(\text{OI}\lambda7774\text{Å})\right]; \sigma(M_K) = 0.48 \text{ mag}. \qquad (2.1)$$

We now adjust the zero point of this relation in two ways. First, we use the technique employed by Feast & Catchpole (1997), which consists of determining the correction

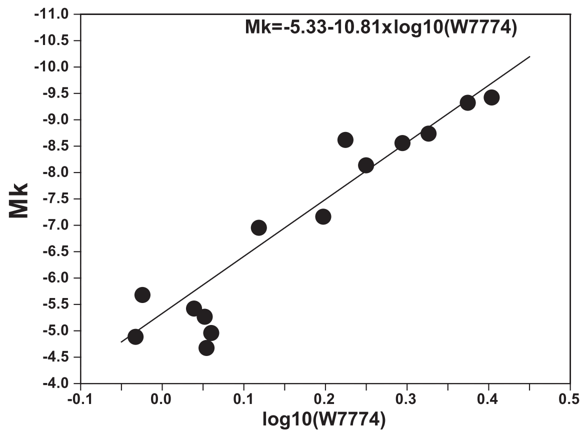

Figure 1. M_K as a function of $\log[W(\mathrm{O\,I}\lambda 7774\text{Å})]$ for stars from Table 1.

Table 1. Parameters of the cluster stars used for calibration.

Star	Spectral type	$W(7774)$ (Å)	$\sigma_{W\,(7774)}$ (Å)	K_s (mag)	$(m-M)_0$ (mag)	$E(B-V)$ (mag)	M_K (mag)	Cluster
HD 7927	F0Ia	2.36	0.02	2.750	11.92	0.505	−9.33	NGC 457
HD236433	F2Iab	1.15	0.05	6.165	10.97	0.508	−4.97	NGC 129
BD+59 65	F5Ib	1.13	0.23	5.857	10.97	0.508	−5.28	NGC 129
HD332843	F0Ib	1.13	0.13	7.225	11.66	0.777	−4.69	NGC 6834
HD 20902	F5Ib	1.09	0.02	0.540	5.94	0.099	−5.43	α Per
BD+60 2532	F7Ib	0.94	0.04	5.320	10.80	0.650	−5.69	NGC 7654
HD 10494	F5Ia	1.77	0.03	4.104	11.95	0.935	−8.15	NGC 654
HD 87283	F0II	0.93	0.09	5.030	9.90	0.080	−4.90	NGC 3114
HD 90772	F0Ia	2.12	0.05	3.070	11.68	0.428	−8.75	IC 2581
HD 54605	F8Ia	1.67	0.03	0.380	9.00	0.027	−8.63	Cr 121
HD 17971	F5Ia	1.57	0.03	4.428	11.39	0.657	−7.17	IC 1848
HD101947	G0Ia	1.97	0.04	3.180	11.67	0.245	−8.57	Stock 14
HD173638	F1II	1.31	0.05	3.840	10.61	0.601	−6.96	NGC 6694
HD 74180	F2Ia	2.53	0.03	1.890	11.18	0.444	−9.43	Pismis 6

factor, p, to reconcile photometric parallaxes based on the above $\log[W(\mathrm{O\,I}\lambda 7774\text{Å})]$–$M_K$ relation with the revised *Hipparcos* trigonometric parallaxes (van Leeuwen 2007) of 51 stars:

$$\pi_{\rm HIP} = p\pi_{\rm phot}. \tag{2.2}$$

We find $p = 0.90 \pm 0.07$, implying an absolute-magnitude correction of $\Delta M_K = -0.23 \pm 0.17$ mag. We next estimate an independent absolute-magnitude correction using the maximum-likelihood version of the method of statistical parallax determination as described by Murray (1983). The resulting kinematic plus distance-scale solution is summarized in Table 2.

We finally apply the weighted average of the two corrections to Eq. (1) to derive the final relation,

$$M_K = -5.66 - 10.81 \log\,[W(\mathrm{O\,I}\lambda 7774\text{Å})]. \tag{2.3}$$

When applied to 20 F0–G0 I–II-type stars in the Large Magellanic Cloud with published $W(\mathrm{O\,I}\lambda 7774\text{Å})$ data (Mantegazza 1991), this relation yields $(m-M)_0^{\rm LMC} = 18.53 \pm 0.28$ mag.

https://doi.org/10.1017/S1743921312021758 Published online by Cambridge University Press

Table 2. Rotation-curve plus distance-scale solution for local F0–G0 I–II-type stars (statistical parallax method).

U_0 (km s^{-1})	V_0 (km s^{-1})	W_0 (km s^{-1})	σ_U (km s^{-1})	σ_V (km s^{-1})	σ_W (km s^{-1})	Ω_0 (km s^{-1} kpc^{-1})	A (km s^{-1} kpc^{-1})	Ω'' (km s^{-1} kpc^{-3})	ΔM_K (mag)
−8.9 ± 2.2	−14.8 ± 1.9	−8.0 ± 1.3	16.8 ± 1.7	14.0 ± 1.4	8.3 ± 1.2	23.8 ± 2.4	13.5 ± 2.0	+0.84 ± 0.44	−0.29 ± 0.22

Acknowledgements

This work was supported by the Russian Foundation for Basic Research (grants 10-02-00489-a and 11-02-00608-a).

References

Arellano Ferro, A., Giridhar, S., Chavez, M., & Parrao, L. 1989, *A&A*, 214, 123
Arellano Ferro, A., Giridhar, S., & Goswamin, A. 1991, *MNRAS*, 250, 1
Arellano Ferro, A., Mendoza V., & Eugenio E. 1993, *AJ*, 106, 2516
Arellano Ferro, A., Giridhar, S., & Rojo Arellano, E. 2003, *Rev. Mex. Astron. Astrof.*, 39, 3
Baker, P. W. 1974, *PASP*, 86, 33
Dambis, A. K. 1999, *Astron. Lett.*, 25, 10
Faraggiana, R., Gerbaldi, M., van 't Veer, C., & Floquet, M. 1988, *A&A*, 201, 259
Feast, M. W. & Catchpole, R. M. 1997, *MNRAS*, 286, L1
Hopkinson, G. R. & Humrich, A. 1981, *MNRAS*, 195, 661
Kameswara Rao, N. & Mallik, S. G. V. 1978, *MNRAS*, 183, 147
Keenan, P. C. & Hynek, J. A. 1950, *AJ*, 111, 1
Kovtyukh, V. V., Gorlova, N. I., & Belik, S. I. 2012, *MNRAS*, 423, 3268
Mantegazza, L. 1991, *A&A*, 265, 527
Mendoza, E. E. & Arellano Ferro, A. 1993, *AJ*, 106, 2524
Merrill, P. 1925, *PASP*, 37, 272
Merrill, P. 1934, *ApJ*, 132, 68
Murray, C. A. 1983, *Vectorial Astrometry* (Bristol: A. Hilger)
Osmer, P. S. 1972, *ApJS*, 24, 247
Slowik, D. J. & Peterson, D. M. 1993, *AJ*, 105, 1997
Slowik, D. J. & Peterson, D. M. 1995, *AJ*, 109, 2193
Sorvari, J. M. 1974, *AJ*, 79, 1416
van Leeuwen, F. 2007, *A&A*, 474, 653