Nuevas magnitudes ...

¿Y si el receptor que usáramos fuera integral?

Es decir, si empleáramos un **detector ideal** para el cual $S_{i\lambda} = 1$ para cualquier longitud de onda

Flujo total **efectivamente** medido

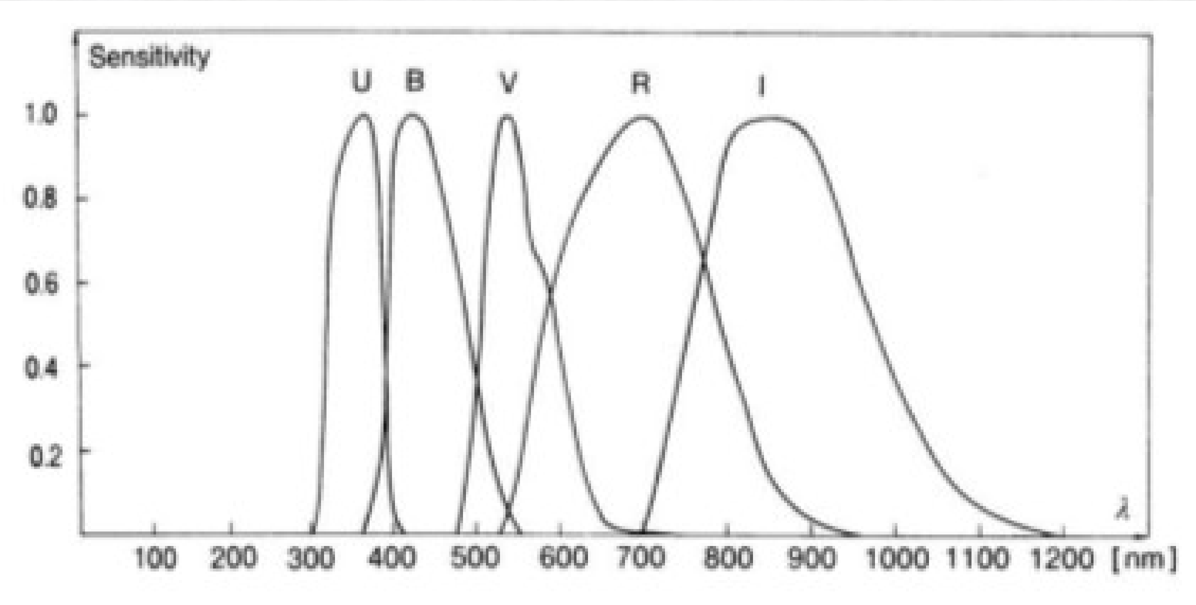
Transparencia de la atmósfera
Transmisión del instrumento
Sensibilidad del detector

$$\phi_{medido} = \pi A (R/r)^2 \int_0^\infty I_\lambda T_{A\lambda} T_{i\lambda} S_{i\lambda} \, d\lambda$$

Nuevas magnitudes ...

¿Y si el receptor que usáramos fuera integral?

Es decir, si empleáramos un **detector ideal** para el cual $S_{i\lambda} = 1$ para cualquier longitud de onda



($S_{i\lambda} < 1$ para cualquier longitud de onda)

Nuevas magnitudes ...

¿Y si el receptor que usáramos fuera integral?

Es decir, si empleáramos un **detector ideal** para el cual $S_{i\lambda} = 1$ para cualquier longitud de onda

La magnitud que mediríamos sería

magnitud radiométrica

(solo afectadas por la $T_{A\lambda}$ y $T_{i\lambda}$)

Flujo total **efectivamente** medido

Transparencia de la atmósfera
Transmisión del instrumento
~~***Sensibilidad del detector***~~

$$\phi_{medido} = \pi A\left(R/r\right)^2 \int_0^\infty I_\lambda T_{A\lambda} T_{i\lambda} \cancel{S_{i\lambda}} d\lambda$$

Magnitud radiométrica

$$m_r = Z_r^p - 2.5\log \frac{R^2 \int_0^\infty I(\lambda) T_{A\lambda} T_{i\lambda} d\lambda}{r^2}$$

Flujo total **efectivamente** medido

~~Transparencia de la atmósfera~~
~~Transmisión del instrumento~~
~~Sensibilidad del detector~~

$$\phi_{medido} = \pi A \left(R/r\right)^2 \int_0^\infty I_\lambda \cancel{T_{A\lambda} T_{i\lambda} S_{i\lambda}} \, d\lambda$$

Nuevas magnitudes ...

¿Y si el receptor que usáramos fuera integral $S_{i\lambda}=1$, midiéramos fuera de la atmósfera ($T_{A\lambda}=1$), y la transmisión del instrumento fuera ideal ($T_{i\lambda}=1$)?

Nuevas magnitudes ...

¿Y si el receptor que usáramos fuera integral $S_{i\lambda}$=1, midiéramos fuera de la atmósfera ($T_{A\lambda}$=1), y la transmisión del instrumento fuera ideal ($T_{i\lambda}$=1)?

$$m_b = Z_b^p - 2.5\log\frac{R^2\int_0^\infty I(\lambda)d\lambda}{r^2}$$

La magnitud **ideal** que mediríamos sería la **magnitud bolométrica**.

Nuevas magnitudes ...

¿Y si el receptor que usáramos fuera integral $S_{i\lambda}=1$, midiéramos fuera de la atmósfera ($T_{A\lambda}=1$), y la transmisión del instrumento fuera ideal ($T_{i\lambda}=1$)?

$$m_b = Z_b^p - 2.5\log\frac{R^2\boxed{\int_0^\infty I(\lambda)d\lambda}}{r^2}$$

La magnitud **ideal** que mediríamos sería la **magnitud bolométrica**.

Se relacionada con la **emisión total** de la estrella.

Magnitud bolométrica

Magnitud bolométrica (estrella ~ CN):

$$m_b = Z_b^p - 2.5\log \frac{R^2 \int_0^\infty B(\lambda,T)\,d\lambda}{r^2}$$

Función de Planck

Magnitud bolométrica

Magnitud bolométrica (estrella ~ CN):

$$m_b = Z_b^p - 2.5\log\frac{R^2\int_0^\infty B(\lambda,T)\,d\lambda}{r^2}$$

$$\int_0^\infty B(\lambda,T)\,d\lambda = \frac{\sigma}{\pi}T^4$$

$$m_b = C_b - 2.5\log\frac{R^2\sigma T^4}{r^2}$$

Temperatura efectiva (T_e)
Luminosidad (L)

“**T_e**: temperatura que tendría que tener un CN con un radio igual a la estrella, para irradiar la misma cantidad total de energía que irradia la estrella”.

$$L = 4\pi R^2 \sigma T_e^4$$

$$m_b = C_b - 2.5 \log \frac{L}{4\pi r^2}$$

Luminosidad y magnitud ...

$$m_b = C_b - 2.5\log\frac{L}{4\pi r^2}$$

$$m_b = C_b^{'} + 5\log r - 2.5\log L$$

Magnitud "aparente"depende de:
la luminosidad (L)
la distancia (r)

Magnitud aparente

$$m_b = C_b' + 5\log r - 2.5\log L$$

Magnitud absoluta (bolométrica): M

r = 10 pc

$$M_b = C_b' + 5 - 2.5\log L,$$

Magnitud aparente

$$m_b = C_b' + 5\log r - 2.5\log L$$

Magnitud absoluta (bolométrica): M

r = 10 pc

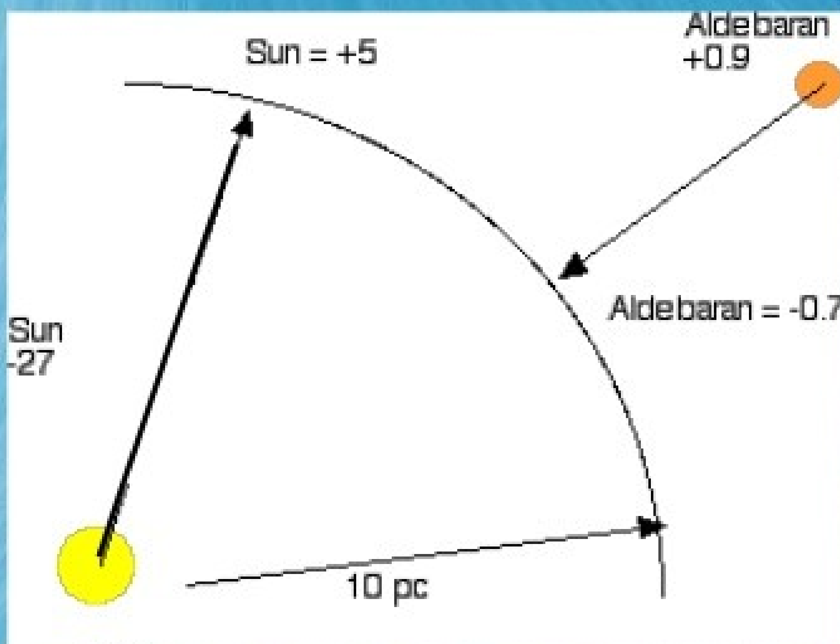
$$M_b = C_b' + 5 - 2.5\log L,$$

$$m_b - M_b = 5 \log r - 5$$

$$m_b - M_b = 5 \log r/10$$

Absolute Magnitude (M)

removes the effect of distance
and
puts stars on a common scale



- The Sun is -26.5 in apparent magnitude, but would be 4.4 if we moved it far away
- Aldebaran is farther than 10pc, so it's absolute magnitude is *brighter* than its apparent magnitude

Remember magnitude scale is "backwards"

Absolute Magnitude of our Sun

Our Sun would have a magnitude of 4.8 if it were at 10 pc, so its absolute magnitude is 4.8!

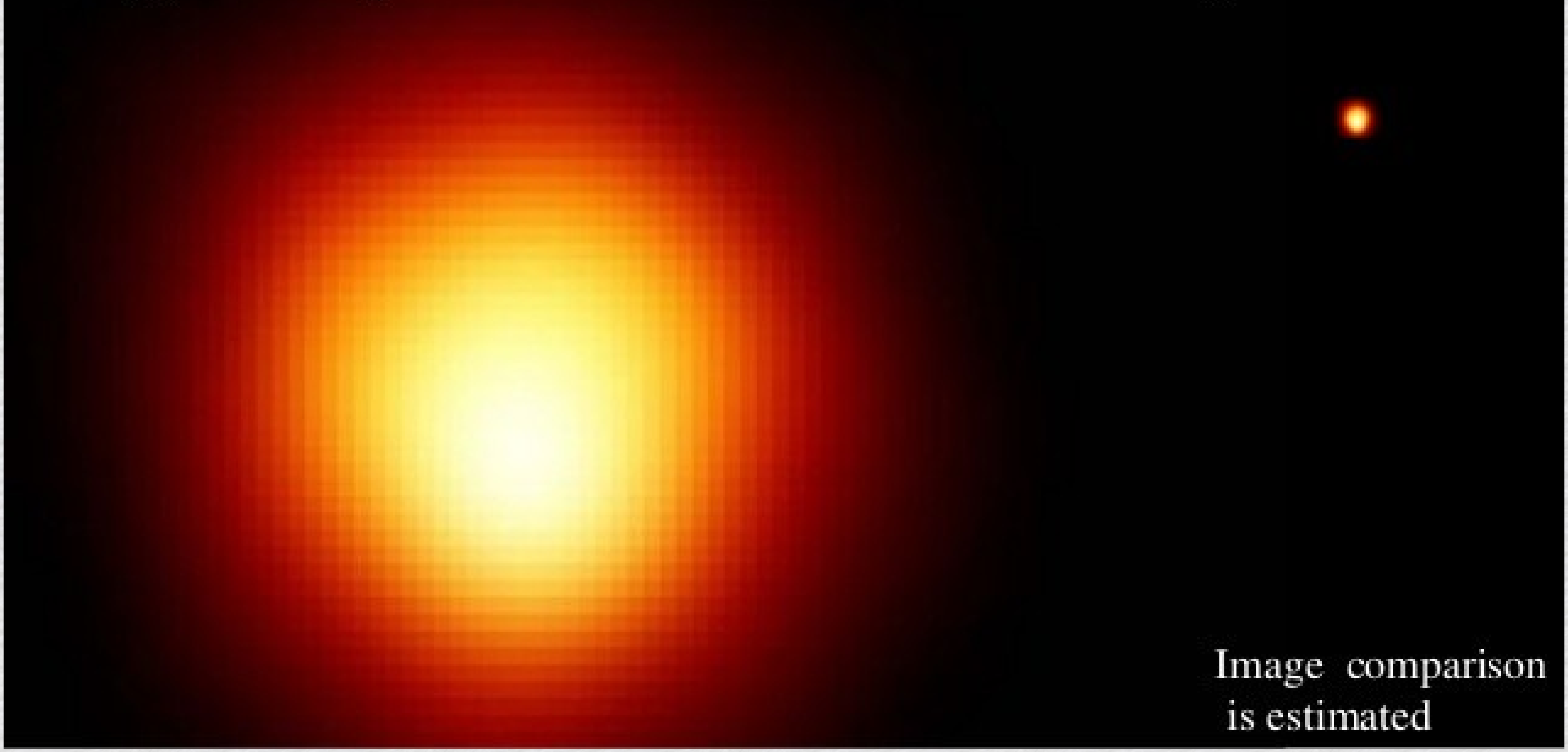


Image comparison is estimated

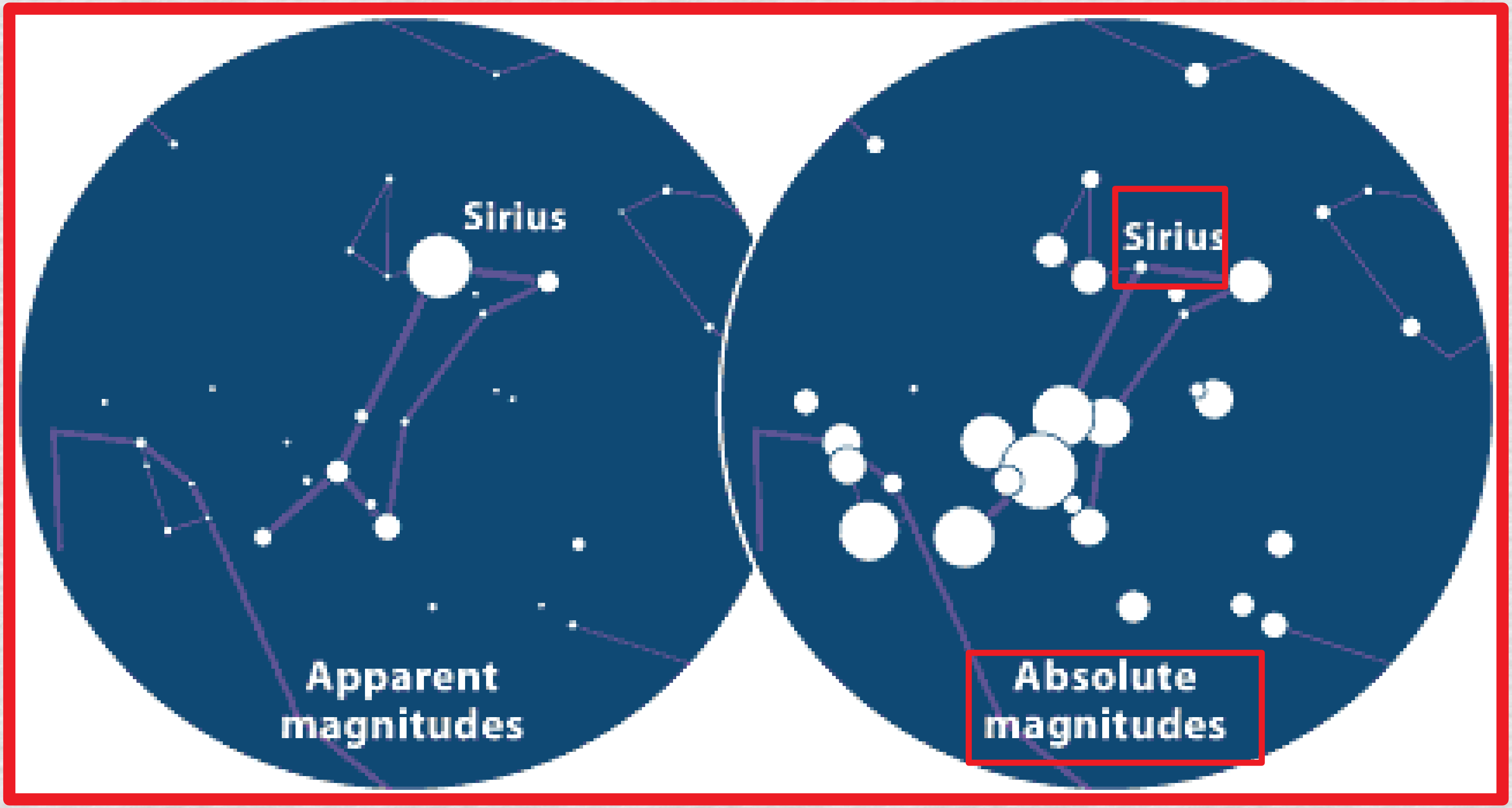
Sirio

v = -1.46

d = 2.6 pc

¿Mv?

¿mayor o menor?


Sirius
Apparent magnitudes
Sirius
Absolute magnitudes

Módulo de distancia

$$m_b - M_b = 5 \log r - 5$$

$$m_b - M_b = 5 \log r/10$$

Módulo de distancia

$$m_b - M_b = 5 \log r - 5$$

$$m_b - M_b = 5 \log r/10$$

- **Absorción interestelar ausente!**

$$m_B - M_B = m_V - M_V = m_U - M_U = \ldots$$

Distancia aparente y real

$$m_b - M_b = 5 \log r/10$$

- **Absorción interestelar presente** →

$$V_0 = V - A_V$$

Módulo de distancia **real**

Distancia **real**

$$V_0 - M_V = 5 \log \frac{r_0}{10}$$

Distancia aparente y real

$$V_0 = V - A_V$$

$$V - M_V = 5\log\frac{r}{10}$$

$$V_0 - M_V = 5\log\frac{r_0}{10}$$

$$\log\frac{r}{r_0} = 0.2(V - V_0)$$

Distancia aparente y real

$$V_0 = V - A_V$$

$$V - M_V = 5\log\frac{r}{10}$$

$$V_0 - M_V = 5\log\frac{r_0}{10}$$

$$\log\frac{r}{r_0} = 0.2(V - V_0)$$

Distancia aparente

$$r = r_0 10^{0.2A_V}$$

Distancia real

Distancia aparente y real

Distancia aparente

$$r = r_0 10^{0.2 A_V}$$

Distancia real

Si la absorción Interestelar (A_V) = 1.5, ¿cuál sería la distancia aparente (r)?

Magnitud absoluta (bolométrica) y luminosidad (solar)

Ma

Vimos que la mag. absoluta ($r = 10\,pc$)

① $M_b = C_b' + 5 - 2.5 \log L$

Escribimos M_b para el sol:

② $M_b(sol) = C_b' + 5 - 2.5 \log L_{sol}$

Sabemos que: $M_b(sol) = +4.75$

(si $r = 10\,pc$ y $\underline{No} = 0.0000048\,pc$)

y restando ① y ② ⇒

$$M_b - M_b(sol) = \cancel{C_b'} + \cancel{5} - 2.5 \log L - \cancel{C_b'} - \cancel{5} + 2.5 \log L_\odot$$

$$= -2.5 \log \frac{L}{L_\odot}$$

$$\Rightarrow \quad M_b = 4.75 - 2.5 \log \frac{L}{L_\odot}$$

($L_\odot = 3.828 \times 10^{26}\,W$;

$= 4 \times 10^{33}\,erg/s$)

Luminosidades y magnitudes bolométricas

¿Obtención de magnitudes bolométricas a partir de magnitudes instrumentales?

Corrección bolométrica

M	= absolute magnitude = apparent magnitude standardized to 10 pc without absorption
$B-V$	= colour index; $(B-V)_0$ = intrinsic colour index. Various other colour indices (e.g. $U-B$) may be formed
BC	= bolometric correction = $m_{bol}-m_V$ (always negative)
A	= space absorption in magnitudes (usually visual)
m_0	= corrected magnitude = $m-A$

CHAPTER 10

NORMAL STARS

§ 94. Stellar Quantities and Inter-relations

Corrección bolométrica

M	= absolute magnitude = apparent magnitude standardized to 10 pc without absorption
$B-V$	= colour index; $(B-V)_0$ = intrinsic colour index. Various other colour indices (e.g. $U-B$) may be formed
BC	= bolometric correction = $m_{\mathrm{bol}}-m_{\mathrm{V}}$ (always negative)
A	= space absorption in magnitudes (usually visual)
m_0	= corrected magnitude = $m-A$

The luminosities or brightnesses of the stars integrated over all wavelengths are again measured in magnitudes, the so-called bolometric magnitudes. We can again distinguish apparent and absolute bolometric magnitudes, though generally only absolute bolometric magnitudes are in use. The difference between visual magnitudes m_{V} and bolometric magnitudes m_{bol} is called the bolometric correction BC. We then have

$$\boxed{m_{\mathrm{bol}} = m_{\mathrm{V}} - BC \quad \text{or} \quad M_{\mathrm{bol}} = M_{\mathrm{V}} - BC.} \tag{6.7}$$

Different authors disagree about the sign on the right-hand side of (6.7), which leads to different signs for the bolometric correction. This is of course only a matter of definition. Since the total radiation at all wavelengths is

Corrección bolométrica

Stellar colours, temperatures, and bolometric corrections

Sp	M_V	$(B-V)_0$	$(U-B)_0$	T_{eff}	BC	M_{bol}
		[1, 2, 5, 6, 8, 10,	12, 21, 25, 27, 28]		[1, 2, 2[illegible], 26]	
Main sequence, V						
O5	−5.8	−0.35	−1.15	40000	−4.0	−10
B0	−4.1	−0.31	−1.06	28000	−2.8	−6.8
B5	−1.1	−0.16	−0.55	15500	−1.5	−2.6
A0	+0.7	0.00	−0.02	9900	−0.40	+0.1
A5	+2.0	+0.13	+0.10	8500	−0.12	+1.7
F0	+2.6	+0.27	+0.07	7400	−0.06	+2.6
F5	+3.4	+0.42	+0.03	6580	0.00	+3.4
G0	+4.4	+0.58	+0.05	6030	−0.03	+[illegible]
G5	+5.1	+0.70	+0.19	5520	−0.07	+[illegible]
K0	+5.9	+0.89	+0.47	4900	−0.19	+[illegible]
K5	+7.3	+1.18	+1.10	4130	−0.60	+[illegible]
M0	+9.0	+1.45	+1.28	3480	−1.19	+[illegible]
M5	+11.8	+1.63	+1.2	2800	−2.3	+[illegible]
M8	+16	+1.8		2400		
Giants, III						
[illegible]	+1.1	+0.65	+0.3	5600	−0.03	+1

Table 6.1. *Effective temperatures* T^1_{eff} *and bolometric corrections BC for main sequence stars and supergiants* $M_{bol} = M_V - BC$.

B − V	T_{eff} Main sequence	*BC* Main sequence	T_{eff} Super giants	*BC* Super giants
−0.25	24500	2.30	26000	2.20
−0.23	21000	2.15	23500	2.05
−0.20	17700	1.80	19100	1.72
−0.15	14000	1.20	14500	1.12
−1.10	11800	0.61	12700	0.53
−0.05	10500	0.33	11000	0.14
0.00	9480	0.15	9800	−0.01
+0.10	8530	0.04	8500	−0.09
+0.2	7910	0.00	7440	−0.10
+0.3	7450	0.00	6800	−0.10
+0.4	6800	0.00	6370	−0.09
+0.5	6310	0.03	6020	−0.07
+0.6	5910	0.07	5800	−0.03
+0.7	5540	0.12	5460	+0.03
+0.8	5330	0.19	5200	+0.10

Corrección bolométrica

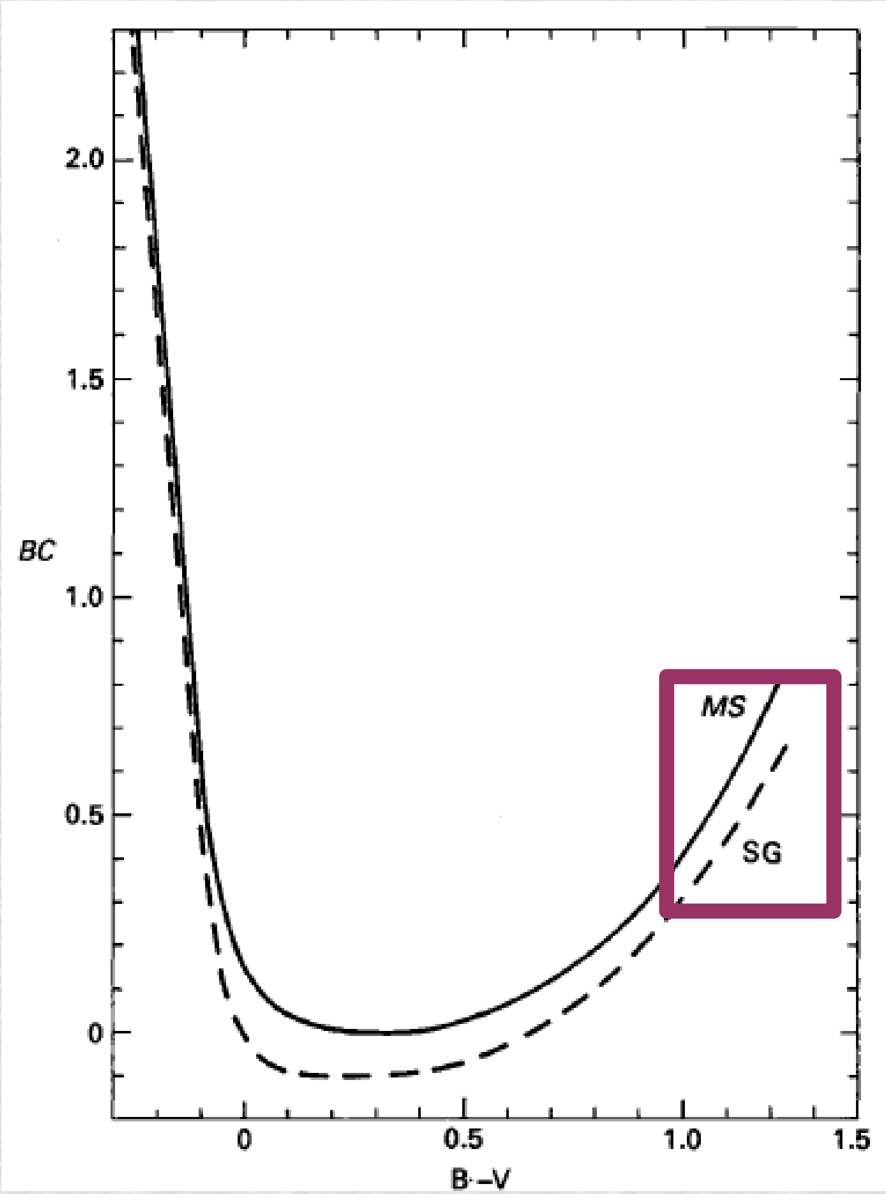


Fig. 6.3. The bolometric corrections, *BC*, are shown for main sequence stars with different B – V colors (solid line). These bolometric corrections have a minimum at B – V = 0.3. For main sequence stars the minimum bolometric correction was set equal to zero by definition. This now requires a change of sign of the *BC* for some supergiant stars as shown by the supergiant curve in this diagram (dashed curve).

Table 6.1. *Effective temperatures* T^1_{eff} *and bolometric corrections BC for main sequence stars and supergiants* $M_{\mathrm{bol}} = M_{\mathrm{V}} - BC$.

B – V	T_{eff} Main sequence	*BC* Main sequence	T_{eff} Super giants	*BC* Super giants
– 0.25	24500	2.30	26000	2.20
– 0.23	21000	2.15	23500	2.05
– 0.20	17700	1.80	19100	1.72
– 0.15	14000	1.20	14500	1.12
– 1.10	11800	0.61	12700	0.53
– 0.05	10500	0.33	11000	0.14
0.00	9480	0.15	9800	– 0.01
+ 0.10	8530	0.04	8500	– 0.09
+ 0.2	7910	0.00	7440	– 0.10
+ 0.3	7450	0.00	6800	– 0.10
+ 0.4	6800	0.00	6370	– 0.09
+ 0.5	6310	0.03	6020	– 0.07
+ 0.6	5910	0.07	5800	– 0.03
+ 0.7	5540	0.12	5460	+ 0.03
+ 0.8	5330	0.19	5200	+ 0.10

Corrección bolométrica

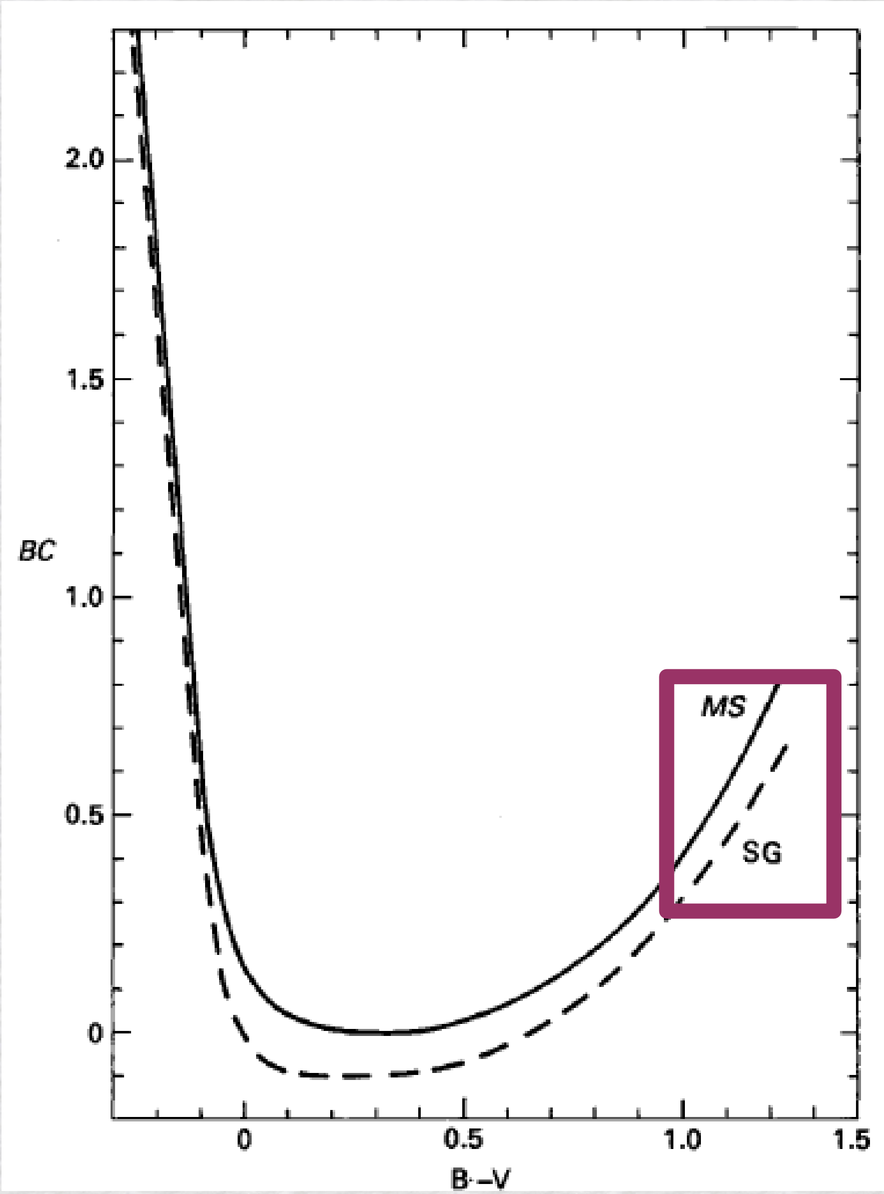


Table 6.1. *Effective temperatures $T_{\rm eff}^{1}$ and bolometric corrections BC for main sequence stars and supergiants $M_{\rm bol} = M_{\rm V} - BC$.*

B − V	$T_{\rm eff}$ Main sequence	*BC* Main sequence	$T_{\rm eff}$ Super giants	*BC* Super giants
−0.25	24500	2.30	26000	2.20
−0.23	21000	2.15	23500	2.05
−0.20	17700	1.80	19100	1.72
−0.15	14000	1.20	14500	1.12
−1.10	11800	0.61	12700	0.53
−0.05	10500	0.33	11000	0.14
0.00	9480	0.15	9800	−0.01
+0.10	8530	0.04	8500	−0.09
+0.2	7910	0.00	7440	−0.10
+0.3	7450	0.00	6800	−0.10
+0.4	6800	0.00	6370	−0.09
+0.5	6310	0.03	6020	−0.07
+0.6	5910	0.07	5800	−0.03
+0.7	5540	0.12	5460	+0.03
+0.8	5330	0.19	5200	+0.10

Fig
wit
mi

Por convención se acepta que CB=0 para T = 6000 K (F0)

correction was set equal to zero by definition. This now requires a change of sign of the *BC* for some supergiant stars as shown by the supergiant curve in this diagram (dashed curve).

Corrección bolométrica

$$CB = m_b - m_V = M_b - M_V$$

$\boxed{\mathbf{b}}$ → magnitud bolométrica

~~magnitud "blue"~~

Corrección bolométrica

$$CB = m_b - m_V = M_b - M_V$$

$$m_b = Z_b^p - 2.5\log \frac{R^2 \int_0^\infty B(\lambda,T)d\lambda}{r^2}$$

$$m_v = Z_v^p - 2.5\log \frac{R^2 \int_0^\infty B(\lambda,T)\Phi_v(\lambda)d\lambda}{r^2}$$

Corrección bolométrica

CB = $m_b - m_V = M_b - M_V$

$$m_b = Z_b^p - 2.5\log \frac{R^2 \int_0^\infty B(\lambda,T)d\lambda}{r^2}$$

$$m_v = Z_v^p - 2.5\log \frac{R^2 \int_0^\infty B(\lambda,T)\Phi_v(\lambda)d\lambda}{r^2}$$

$$C.B. = \left(Z_b^p - Z_v^p\right) - 2.5\log \boxed{\frac{\int_0^\infty B(\lambda,T)d\lambda}{\int_0^\infty B(\lambda,T)\Phi_v(\lambda)d\lambda}}$$

CB=0 para T = 6000 K (F0)

Corrección bolométrica

$$CB = m_b - m_V = M_b - M_V$$

$$m_b = Z_b^p - 2.5\log\frac{R^2\int_0^\infty B(\lambda,T)d\lambda}{r^2}$$

$$m_v = Z_v^p - 2.5\log\frac{R^2\int_0^\infty B(\lambda,T)\Phi_v(\lambda)d\lambda}{r^2}$$

$$C.B. = \left(Z_b^p - Z_v^p\right) - 2.5\log\boxed{\frac{\int_0^\infty B(\lambda,T)d\lambda}{\int_0^\infty B(\lambda,T)\Phi_v(\lambda)d\lambda}}$$

Para diferentes temperatura → CB

…

…

¡conocer temperaturas!

¿Temperaturas efectivas a partir de magnitudes instrumentales (I.C.)?

(Ojo: magnitudes ya corregidas por absorción interestelar)

¿Temperaturas efectivas a partir de magnitudes instrumentales (I.C.)?

(Ojo: magnitudes ya corregidas por absorción interestelar)

¡Sí!

$$(B-V) = -0.64 + \frac{7200}{T}$$

I.C. versus temperatura

$$(B-V) = -0.64 + \frac{7200}{T}$$

Magnitudes heterocromáticas:

$$m_U = U = \alpha_U^p - 2.5\log\left(R/r\right)^2 \int_0^\infty I_\lambda(z)\Phi_u(\lambda)d\lambda\,,$$

$$m_B = B = \alpha_B^p - 2.5\log\left(R/r\right)^2 \int_0^\infty I_\lambda(z)\Phi_b(\lambda)d\lambda\,,$$

$$m_V = V = \alpha_V^p - 2.5\log\left(R/r\right)^2 \int_0^\infty I_\lambda(z)\Phi_v(\lambda)d\lambda\,,$$

Magnitudes monocromáticas

$$m(\lambda_U, z) = \alpha_p(\lambda_U) - 2.5\log\left(R/r\right)^2 I(\lambda_U, z),$$

$$m(\lambda_B, z) = \alpha_p(\lambda_B) - 2.5\log\left(R/r\right)^2 I(\lambda_B, z),$$

$$m(\lambda_V, z) = \alpha_p(\lambda_V) - 2.5\log\left(R/r\right)^2 I(\lambda_V, z),$$

$\lambda_U, \lambda_B, \lambda_V$ son las longitudes de onda equivalentes en los filtros del sistemas UBV

Magnitudes monocromáticas y magnitudes heterocromáticas

$$U = m(\lambda_U, Z) + \alpha$$

$$B = m(\lambda_B, Z) + \beta$$

$$V = m(\lambda_V, Z) + Y$$

$\lambda_U, \lambda_B, \lambda_V$ *son las longitudes de onda equivalentes en los filtros del sistemas UBV*

$$B = Z_B - 2.5\log\frac{R^2 I(\lambda_B)}{r^2}$$

$$V = Z_V - 2.5\frac{R^2 I(\lambda_V)}{r^2}$$

$$\boxed{B - V = C_{BV} - 2.5\log\frac{B(\lambda_B, T)}{B(\lambda_V, T)}}$$

$$C_{BV} = Z_B - Z_V$$

$$B(\lambda, T) = \frac{C_1}{\lambda^5(e^{C_2/\lambda T} - 1)} = \frac{C_1}{\lambda^5 e^{C_2/\lambda T}(1 - e^{-C_2/\lambda T})}$$

$$X = 1 - e^{-C_2/\lambda T}$$

$$B - V = C_{BV} - 2.5\log\left(\frac{\lambda_V}{\lambda_B}\right)^5 \frac{e^{C_2/\lambda T} X_V}{e^{C_2/\lambda_B T} X_B}$$

$$B - V = C_{BV} - 12.5\log\frac{\lambda_V}{\lambda_B} - 2.5\frac{C_2}{T}\left(\frac{1}{\lambda_V} - \frac{1}{\lambda_B}\right)\log e - 2.5\log\frac{X_V}{X_B}$$

$$B - V = A_1 + \frac{A_2}{T},$$

$$A_1 = -12.5\log\frac{\lambda_V}{\lambda_B} + C_{BV},$$

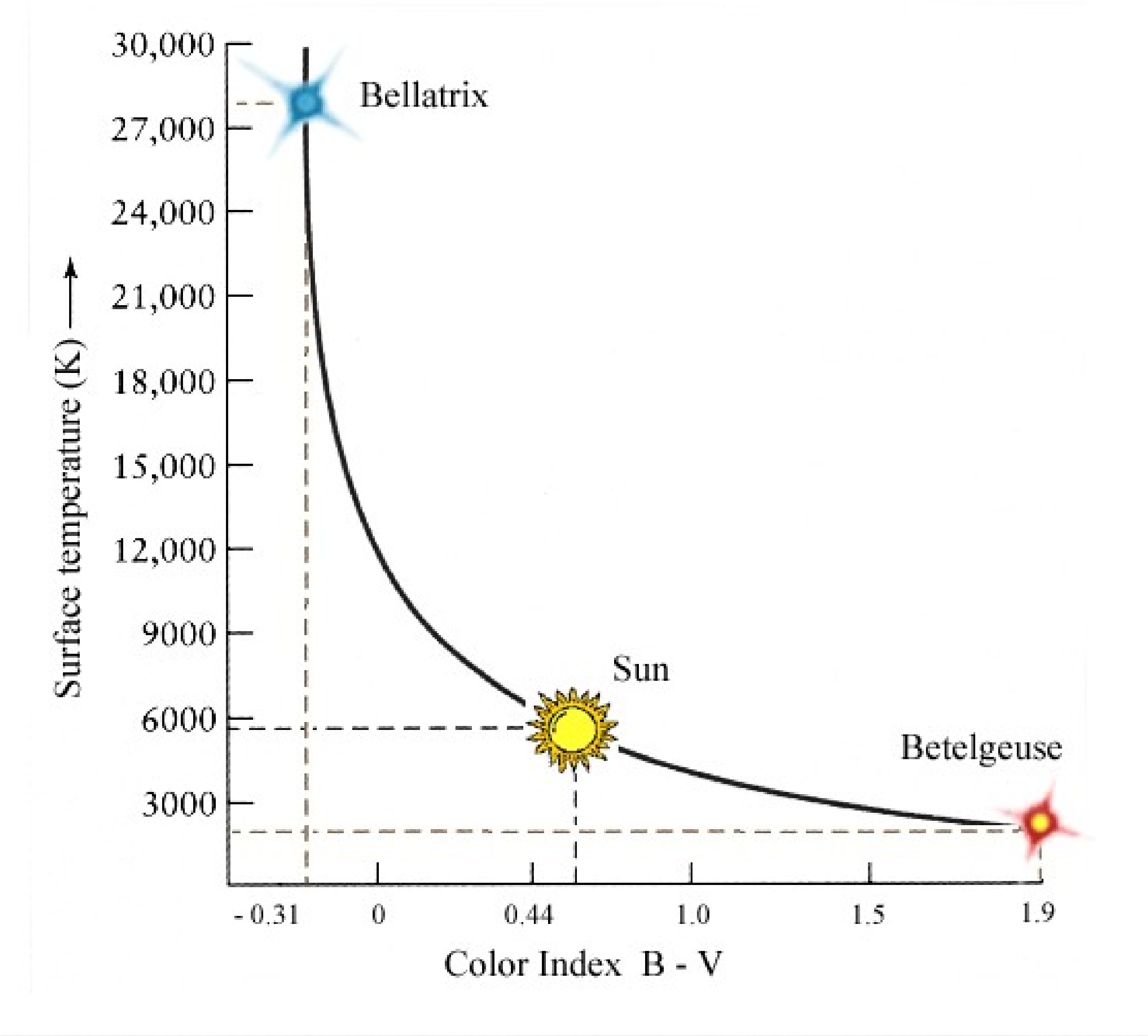
$$A_2 = -2.5\,C_2\left(\frac{1}{\lambda_V} - \frac{1}{\lambda_B}\right)\log e$$

$$\boxed{(B - V) = -0.64 + \frac{7200}{T}}$$

$$(B-V)=-0.64+\frac{7200}{T}$$

En rigor, la (125) resulta de considerar $\lambda_B = 4250$ Å y $\lambda_V = 5290$ Å. Estos valores corresponden a las longitudes de onda equivalentes de los antiguos sistemas fotográfico y visual, respectivamente. Evidentemente, las pequeñas diferencias entre las longitudes de onda y las correspondientes a los rangos B y V del sistema UBV, no modificarán sino ligeramente la ecuación (125). Sin embargo, debe tenerse presente que la (125) sería estrictamente respetada por las estrellas, sólo si éstas irradiaran como cuerpos negros. En consecuencia, estas conclusiones son válidas sólo en primera aproximación. Si la temperatura de color de una estrella coincidiese con su temperatura efectiva, ésta sería rigurosamente un cuerpo negro. Entendemos por temperatura de color de una estrella en un cierto invervalo espectral, la temperatura que tendría que tener un cuerpo negro para que la curva de Planck correspondiente se aproxime, tanto como sea posible, a la curva de emisión de energía de la estrella.

$$(B-V) = -0.64 + \frac{7200}{T}$$



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A STUDY OF THE $B-V$ COLOR-TEMPERATURE RELATION

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ABSTRACT

We derive a $B-V$ color-temperature relation for stars in the least model-dependent way employing the best modern data. The fit we obtained with the form $T_{\rm eff} = T_{\rm eff}\{(B-V)_0, [{\rm Fe/H}], \log g\}$ covers stars in the range F0–K5 with metallicity [Fe/H] = −1.5 to +0.3 for both dwarfs and giants. The fit is well constrained, and the residual temperature of the fit is 62 K, which is consistent with what is expected from the quality of the input data. Metallicity and surface gravity effects are well separated from the color dependence. Dwarfs and giants match in a single family of the fit, differing only in $\log g$. The fit also detects the interstellar extinction for nearby stars with the amount $E(B-V) = 0.235 \pm 0.03$ mag kpc^{-1}. Taking our newly obtained relation as a reference, we examine a number of $B-V$ color-temperature relations and atmosphere models available in the literature. We find with the Kurucz atmosphere a systematic error of 0.07 mag in $B-V$ in the color-temperature relation across G–K5 dwarfs. On the other hand, the Bell-Gustafsson atmosphere gives colors in agreement with our empirical relation from F to G stars; for late-K stars, however, it gives colors that are too blue by 0.05 mag. We also argue for errors in the temperature scale adopted in popularly used stellar population synthesis models; synthetic colors from these models, based on the temperature calibration of Ridgway et al., may be too blue for aged elliptical galaxies. Finally, we derive the color index of the Sun to be $(B-V)_\odot = 0.626 \pm 0.018$ and discuss that redder colors (e.g., 0.65–0.67) often quoted in the literature are incompatible with the color-temperature relation for normal stars.

Key words: color-magnitude diagrams — stars: atmospheres — stars: chromospheres

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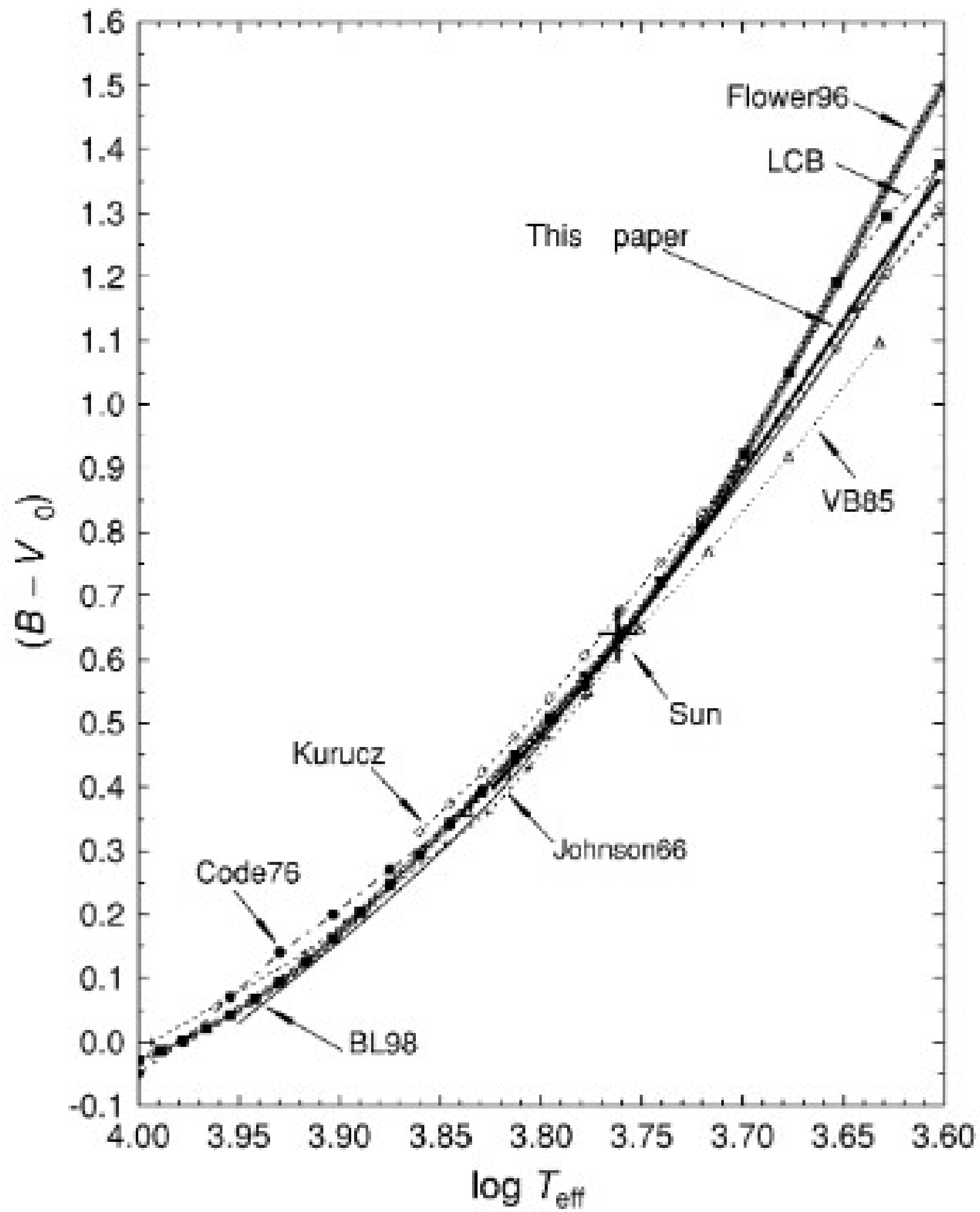

FIG. 9.—Compilation of $B - V$ color-temperature relations for dwarfs available in the literature, as compared with the one obtained in this paper. The relations are given for the solar abundance.

We deriv employing
the best mo overs stars
in the range fit is well
constrained s expected
from the q from the
color depen g. The fit
also detects 0.03 mag
kpc^{-1}. Tak $-V$ color-
temperature ucz atmo-
sphere a sy K5 dwarfs.
On the othe al relation
from F to C also argue
for errors i odels; syn-
thetic color e too blue
for aged ell 26 ± 0.018
and discuss e with the
color-tempe

Key words:

Stellar colours, temperatures, and bolometric corrections

Sp	M_V	$(B-V)_0$	$(U-B)_0$	T_{eff}	BC	M_{bol}
		[1, 2, 5, 6, 8, 10, 12, 21, 25, 27, 28]			[1, 2, 25, 26]	
Main sequence, v						
O5	−5.8	−0.35	−1.15	40000	−4.0	−10
B0	−4.1	−0.31	−1.06	28000	−2.8	−6.8
B5	−1.1	−0.16	−0.55	15500	−1.5	−2.6
A0	+0.7	0.00	−0.02	9900	−0.40	+0.1
A5	+2.0	+0.13	+0.10	8500	−0.12	+1.7
F0	+2.6	+0.27	+0.07	7400	−0.06	+2.6
F5	+3.4	+0.42	+0.03	6580	0.00	+3.4
G0	+4.4	+0.58	+0.05	6030	−0.03	+4.3
G5	+5.1	+0.70	+0.19	5520	−0.07	+5.0
K0	+5.9	+0.89	+0.47	4900	−0.19	+5.8
K5	+7.3	+1.18	+1.10	4130	−0.60	+6.7
M0	+9.0	+1.45	+1.28	3480	−1.19	+7.8
M5	+11.8	+1.63	+1.2	2800	−2.3	+9.8
M8	+16	+1.8		2400		
Giants, III						
G0	+1.1	+0.65	+0.3	5600	−0.03	+1.1
G5	+0.7	+0.85	+0.53	5000	−0.2	+0.5
K0	+0.5	+1.07	+0.90	4500	−0.5	+0.2
K5	−0.2	+1.41	+1.5	3800	−0.9	−1.0
M0	−0.4	+1.60	+1.8	3200	−1.6	−1.8

On the zero point constant of the bolometric correction scale

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Monthly Notices of the Royal Astronomical Society, Volume 503, Issue 3, May 2021, Pages 4231–4241, https://doi.org/10.1093/mnras/stab684

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ABSTRACT

Arbitrariness attributed to the zero point constant of the V band bolometric corrections (BC_V) and its relation to "bolometric magnitude of a star ought to be brighter than its visual magnitude" and "bolometric corrections must always be negative" was investigated. The falsehood of the second assertion became noticeable to us after IAU 2015 General Assembly Resolution B2, where the zero point constant of bolometric magnitude scale was decided to have a definite value $C_{Bol}(W) = 71.197\ 425\ ...$. Since the zero point constant of the BC_V scale could be written as $C_2 = C_{Bol} - C_V$, where C_V is the zero point constant of the visual magnitudes in the basic definition $BC_V = M_{Bol} - M_V = m_{bol} - m_V$, and $C_{Bol} > C_V$, the zero point constant (C_2) of the BC_V scale cannot be arbitrary anymore; rather, it must be a definite positive number obtained from the two definite positive numbers. The two conditions $C_2 > 0$ and $0 < BC_V < C_2$ are also sufficient for $L_V < L$, a similar case to negative BC_V numbers, which means that "bolometric corrections are not always negative". In sum it becomes apparent that the first assertion is misleading causing one to understand bolometric corrections must always be negative, which is not necessarily true.

THE ASTROPHYSICAL JOURNAL, 469:355–365, 1996 September 20

TRANSFORMATIONS FROM THEORETICAL HERTZSPRUNG-RUSSELL DIAGRAMS TO COLOR-MAGNITUDE DIAGRAMS: EFFECTIVE TEMPERATURES, $B-V$ COLORS, AND BOLOMETRIC CORRECTIONS

PHILLIP J. FLOWER[1]

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PHILLIP J. FLOWER[1]

ABSTRACT

This paper provides improved numerical relations between effective temperatures of stars, their $B-V$ colors, and their bolometric corrections (BCs) for the purpose of comparing theoretical stellar evolutionary calculations to color-magnitude diagrams of star clusters. Temperatures and bolometric correction measurements for 335 stars from the literature form the observational basis for the transformations. Measured temperatures range from 2900 to 52,500 K. Polynomial fits to the observations give relations between effective temperatures and $B-V$ colors and between temperatures and bolometric corrections. Hot supergiants appear to have a $T_{\rm eff}:B-V$ relation slightly different from those of main-sequence stars, subgiants, and giants. All luminosity classes appear to follow a unique $T_{\rm eff}$:BC relation. The $T_{\rm eff}$:BC relation for stars with temperatures less than $\sim$5000 K, however, is uncertain because temperatures of the coolest stars are determined from uncertain angular diameters.

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PHILLIP J. FLOWER[1]

Many observational tests of stellar evolutionary theory rely on the ability to compare theoretical parameters (log L and log $T_{\rm eff}$) of theoretical evolutionary tracks to observed parameters (V and $B-V$, for instance) of stars in star clusters. It is of primary importance, therefore, to establish accurate empirical scales of bolometric corrections (BCs), colors, and effective temperatures to convert the theoretically derived parameters to observational parameters. Since the publication of the comprehensive scales by Flower (1977), observers and theoreticians have made improved empirical scales possible by determining temperatures, bolometric corrections, and colors for several hundred stars.

This paper collects temperature and bolometric correction measurements for 335 stars for the purpose of establishing refined numerical relations between effective temperature and bolometric correction and between effective temperature and $B-V$ color. The stars span luminosity classes from main-sequence stars (V) to supergiants (I) and temperatures from 2900 to 52,500 K.

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PHILLIP J. FLOWER[1]

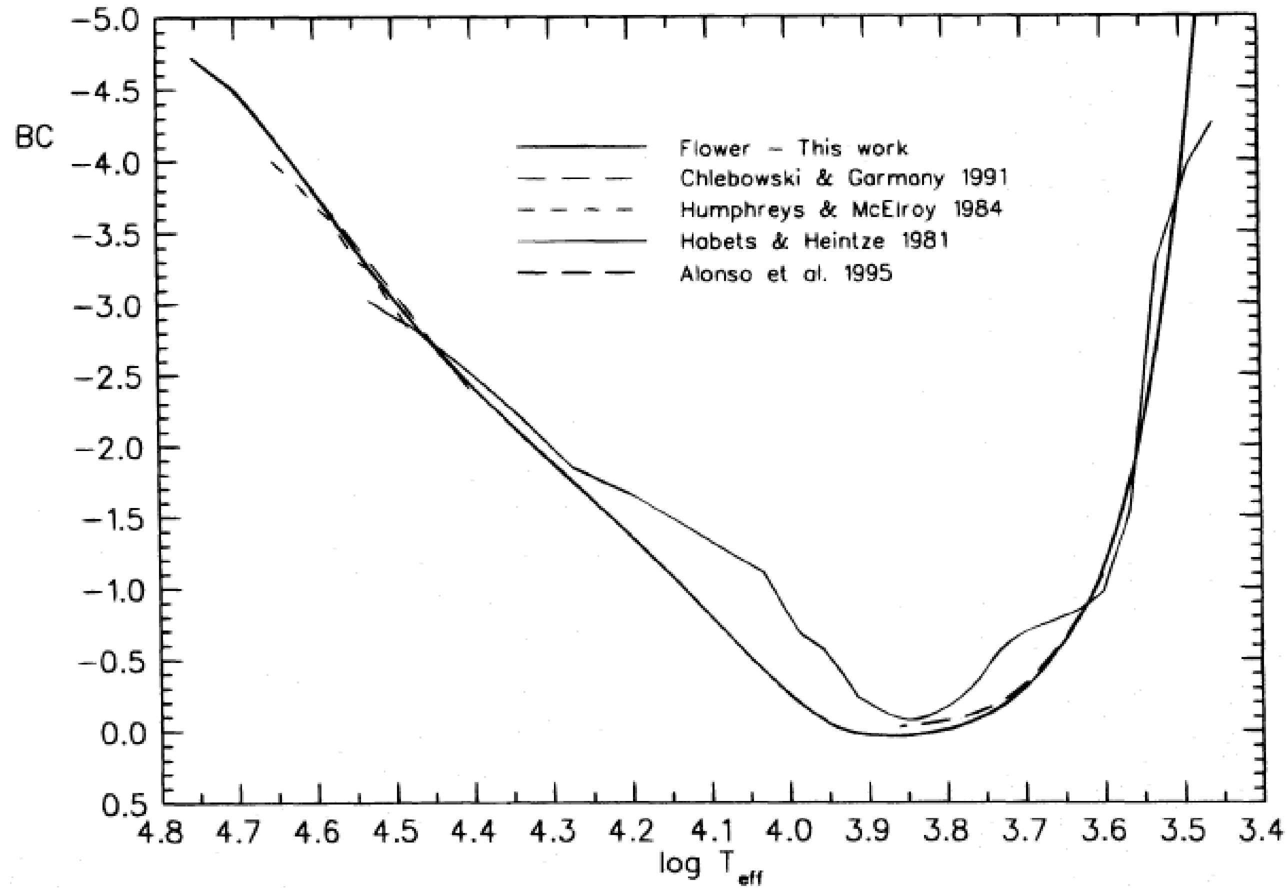

FIG. 9*b*

FIG. 9.—(*a*) The new bolometric correction scale compared with the scales of Flower (1977, 1975). (*b*) Comparison with other T_{eff} :BC scales. The models of Alonso et al. (1995) are for solar composition and log $g = 4$.

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Phillip J. Flower[1]

$B-V$ Colors

$$\boxed{B-V = a + b \log T_{\text{eff}} + c (\log T_{\text{eff}})^2 + \cdots}$$

Coefficient	Supergiants	Main-Sequence Stars, Subgiants, Giants
a	4.0125597	3.979145
b	−1.055043	−0.654499
c	2.133395	1.740690
d	−2.459770	−4.608815
e	1.349424	6.792600
f	−0.283943	−5.396910
g	...	2.192970
h	...	−0.359496

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PHILLIP J. FLOWER[1]

BOLOMETRIC CORRECTIONS

$$\boxed{\mathrm{BC} = a + b \log T_{\mathrm{eff}} + c\,(\log T_{\mathrm{eff}})^2 + \cdots}$$

Coefficient	$\log T_{\mathrm{eff}} > 3.90$	$3.90 < \log T_{\mathrm{eff}} > 3.70$	$\log T_{\mathrm{eff}} < 3.70$
a	−0.188115	−0.370510	−0.190537
b	0.137146	0.385673	0.155145
c	−0.636234	−0.150651	−0.421279
d	0.147413	0.261725	0.381476
e	−0.179587	−0.170624	...
f	0.788732	...	...

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ON THE USE OF EMPIRICAL BOLOMETRIC CORRECTIONS FOR STARS

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Received 2010 July 19; accepted 2010 August 21; published 2010 September 28

ABSTRACT

When making use of tabulations of empirical bolometric corrections for stars (BC_V), a commonly overlooked fact is that while the zero point is arbitrary, the bolometric magnitude of the Sun ($M_{bol,\odot}$) that is used in combination with such tables cannot be chosen arbitrarily. It must be consistent with the zero point of BC_V so that the apparent brightness of the Sun is reproduced. The latter is a measured quantity, for which we adopt the value $V_\odot = -26.76 \pm 0.03$. Inconsistent values of $M_{bol,\odot}$ are listed in many of the most popular sources of BC_V. We quantify errors that are introduced by failure to pay attention to this detail. We also take the opportunity to reprint the BC_V coefficients of the often used polynomial fits by Flower, which were misprinted in the original publication.

The Astronomical Journal, 140:1158–1162, 2010 November
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ON THE USE OF EMPIRICAL BOLOMETRIC CORRECTIONS FOR STARS

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Table 3
Empirical BC_V Scales and $M_{bol,\odot}$ Values from the Literature

Source	Advocated $BC_{V,\odot}$ (mag)[a]	Actual $BC_{V,\odot}$ (mag)[b]	Adopted $M_{bol,\odot}$ (mag)[c]	Recommended $M_{bol,\odot}$ (mag)[d]	Error (mag)[e]
Cox (2000)	−0.08	−0.20	4.74	4.61	+0.13
Allen (1976)	−0.08	−0.05	4.75	4.76	−0.01
Schmidt-Kaler (1982)	−0.19	−0.21	4.64	4.60	+0.04
Lang (1992)	−0.07	−0.20	4.75	4.61	+0.14
Popper (1980)	−0.14	−0.14	4.69	4.67	+0.02
Gray (2005)	...	−0.09	4.73	4.72	+0.01
Straižys & Kuriliene (1980)	...	−0.07	4.72	4.74	−0.02
Kenyon & Hartmann (1995)	...	−0.21	...	4.60	...
Flower (1996)	...	−0.08	...	4.73	...

Notes.
[a] Value that each source states to have adopted as the zero point of their BC_V scale.
[b] Value read off from the relevant BC_V table for each source.
[c] Bolometric correction for the Sun said to be adopted by each source.
[d] $M_{bol,\odot}$ value required for consistency with $V_\odot = -26.76$ (Section 3), when using the BC_V table as published.
[e] Error incurred when using the published BC_V table combined with $M_{bol,\odot}$ from the source, instead of the recommended $M_{bol,\odot}$ value in the previous column.

Allen's Astrophysical Quantities

Fourth Edition

Arthur N. Cox
Editor

Chapter 15

Normal Stars

John S. Drilling and Arlo U. Landolt

15.1 STELLAR QUANTITIES AND INTERRELATIONS

$\mathcal{M}$ = mass ($\mathcal{M}_\odot$ = Sun's mass).

R = radius ($R_\odot$ = Sun's radius).

L = luminosity ($L_\odot$ = Sun's luminosity) = total outflow of radiation (ergs s^{-1}).

$\bar{\rho}$ = mean density = $\mathcal{M}/(\frac{4}{3}\pi R^3)$.

Sp = spectral classification, which may be combined with a luminosity class.

m = apparent magnitude = −2.5 log apparent brightness. Typical subscripts: V = visual, B = blue, U = ultraviolet, pg = photographic, pv = photovisual, bol = bolometric (total radiation); in general, m_λ = apparent magnitude of spectral region λ.

$U, B, V = m_U, m_B, m_V$ = apparent magnitudes in the UBV system.

M = absolute magnitude = apparent magnitude standardized to 10 pc without interstellar absorption.

$B - V$ = color index; $(B - V)_0$ = intrinsic color index (i.e., no interstellar absorption); or, in general a color index is the difference in the apparent magnitude as measured at two different wavelengths.

BC = bolometric correction = $m_{\text{bol}} - V$ (always negative).

A = space absorption in magnitudes (usually visual).

15.3.1 Calibration of MK Spectral Types [2, 21, 22]

Table 15.7 presents the absolute magnitude, color, effective surface temperature, and bolometric correction calibrations for the MK spectral classes. Table 15.8 gives the calibrated physical parameters for stars of the various spectral classes.

Table 15.7. *Calibration of MK spectral types.*

Sp	$M(V)$	$B-V$	$U-B$	$V-R$	$R-I$	T_{eff}	BC
MAIN SEQUENCE, V							
O5	−5.7	−0.33	−1.19	−0.15	−0.32	42 000	−4.40
O9	−4.5	−0.31	−1.12	−0.15	−0.32	34 000	−3.33
B0	−4.0	−0.30	−1.08	−0.13	−0.29	30 000	−3.16
B2	−2.45	−0.24	−0.84	−0.10	−0.22	20 900	−2.35
B5	−1.2	−0.17	−0.58	−0.06	−0.16	15 200	−1.46
B8	−0.25	−0.11	−0.34	−0.02	−0.10	11 400	−0.80
A0	+0.65	−0.02	−0.02	0.02	−0.02	9 790	−0.30
A2	+1.3	+0.05	+0.05	0.08	0.01	9 000	−0.20
A5	+1.95	+0.15	+0.10	0.16	0.06	8 180	−0.15
F0	+2.7	+0.30	+0.03	0.30	0.17	7 300	−0.09
F2	+3.6	+0.35	0.00	0.35	0.20	7 000	−0.11
F5	+3.5	+0.44	−0.02	0.40	0.24	6 650	−0.14
F8	+4.0	+0.52	+0.02	0.47	0.29	6 250	−0.16
G0	+4.4	+0.58	+0.06	0.50	0.31	5 940	−0.18
G2	+4.7	+0.63	+0.12	0.53	0.33	5 790	−0.20
G5	+5.1	+0.68	+0.20	0.54	0.35	5 560	−0.21
G8	+5.5	+0.74	+0.30	0.58	0.38	5 310	−0.40
K0	+5.9	+0.81	+0.45	0.64	0.42	5 150	−0.31
K2	+6.4	+0.91	+0.64	0.74	0.48	4 830	−0.42
K5	+7.35	+1.15	+1.08	0.99	0.63	4 410	−0.72
M0	+8.8	+1.40	+1.22	1.28	0.91	3 840	−1.38
M2	+9.9	+1.49	+1.18	1.50	1.19	3 520	−1.89
M5	+12.3	+1.64	+1.24	1.80	1.67	3 170	−2.73
GIANTS, III							
G5	+0.9	+0.86	+0.56	0.69	0.48	5 050	−0.34
G8	+0.8	+0.94	+0.70	0.70	0.48	4 800	−0.42
K0	+0.7	+1.00	+0.84	0.77	0.53	4 660	−0.50
K2	+0.5	+1.16	+1.16	0.84	0.58	4 390	−0.61
K5	−0.2	+1.50	+1.81	1.20	0.90	4 050	−1.02
M0	−0.4	+1.56	+1.87	1.23	0.94	3 690	−1.25
M2	−0.6	+1.60	+1.89	1.34	1.10	3 540	−1.62
M5	−0.3	+1.63	+1.58	2.18	1.96	3 380	−2.48