

ASTR 221 Prob set 5 - solutions

Kutner P2.3

Sun has $M = -26.8$

Brightest star has $M = -1$.

(10)

$$\text{So } \Delta M = 25.8 = 2.5 \log_{10} \left(\frac{B_1}{B_2} \right)$$

Ratio of brightness is $10^{10.32}$ or 2.09×10^{10}

So the CCD images will take $\frac{9}{16} = 0.56$ times
as long. 3.

P 2.5

$$\begin{aligned}\text{magnitude difference } \Delta m &= 2.5 \log_{10} \left[\frac{f + \Delta f}{f} \right] \\ &= 2.5 \log_{10} (e) \ln \left[\frac{f + \Delta f}{f} \right] \\ &= 1.09 \ln \left(1 + \frac{\Delta f}{f} \right) \\ &\approx 1.09 \frac{\Delta f}{f}\end{aligned}$$

(20)

So, for example, a star that is 5% brighter
will have a magnitude difference of -0.05 mag.

P 2.13

Use Wien's law:

$$(10) \quad \lambda_{\max} = \frac{2.9 \times 10^{-3} \text{ cm K}^{-1}}{2.7 \text{ K}} = 1 \text{ mm}$$

P 2.14

Using Wien's law again

$$(a) \quad \cancel{\text{photospheric temperature}} \quad T = \frac{2.9 \times 10^{-3} \text{ cm K}}{400 \times 10^{-9} \text{ m}} = 7300 \text{ K}$$

(10)

$$(b) \quad " = 6400 \text{ K}$$

Kutner P2.19

$$L \propto R^2 T^4 \quad (4\pi R^2 \text{ is surface area})$$

If we double temp and keep surface area constant,
luminosity will go up by 2^4 or 16.

So we need to decrease the surface area
by a factor of 16.

C 2.2

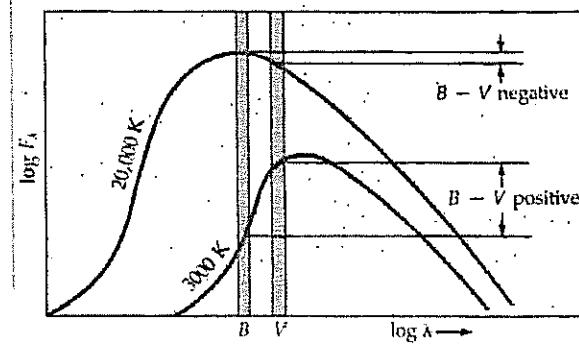


Figure 11-4 Color index in the BV system. Blackbody curves for 20,000 and 3000 K, along with their intensities at B and V wavelengths. Note that $B - V$ is negative for the hotter star and positive for the cooler one.

Blackbody eqn

$$I(\lambda, T) = \frac{2hc^2/\lambda^5}{e^{hc/2\lambda kT} - 1}$$

h Plank's constant 6.63×10^{-27} erg s

k is Boltzmann's const 1.38×10^{-16} erg/K.

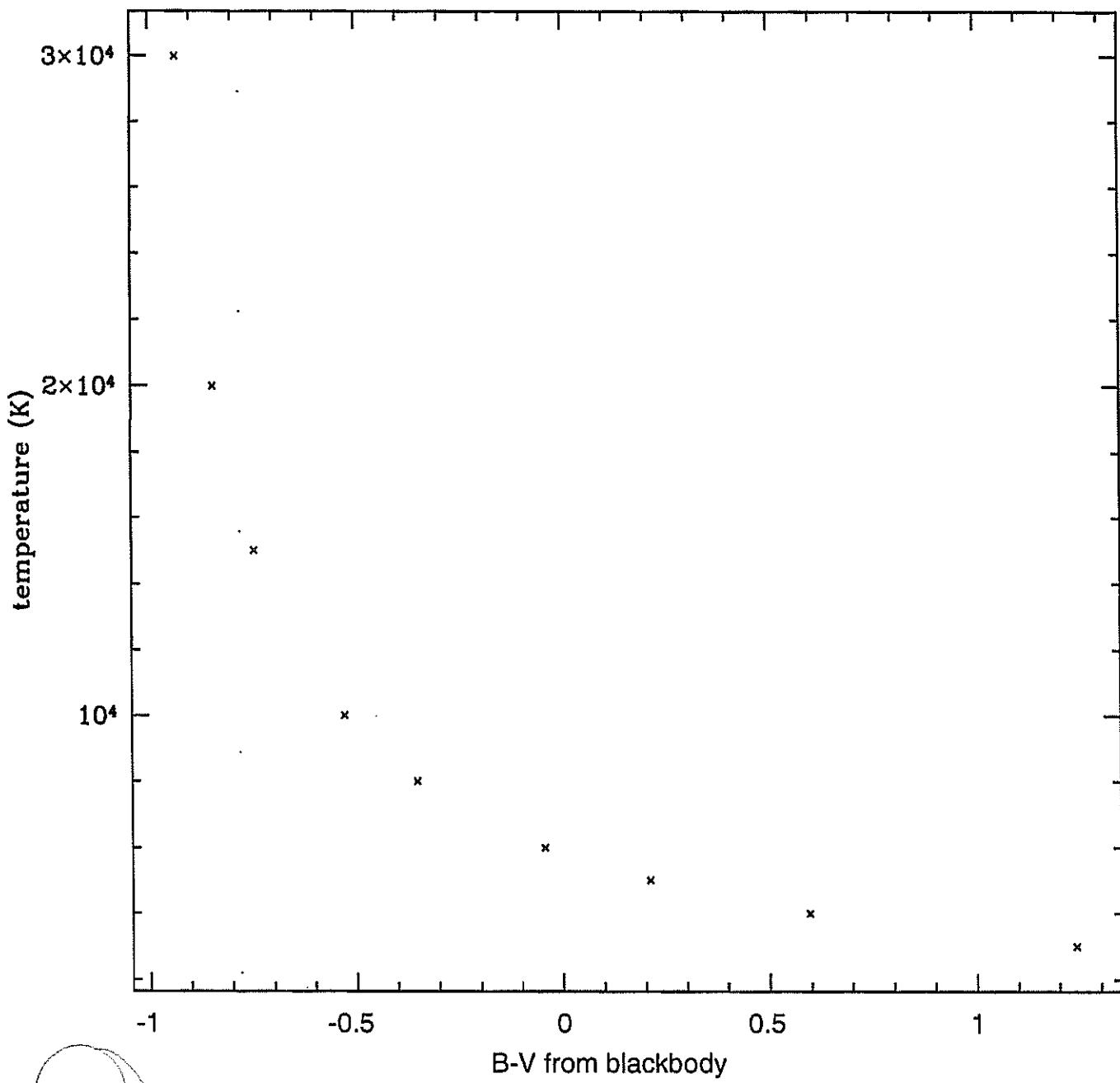
Need to evaluate the equation for 2 values of λ , the peak wavelengths in B & V filters

These are 435 & 555 nm =
 (λ_B) (λ_V)

Then the $B-V$ color is $-2.5 \log_{10} \left(\frac{I(435 \text{ nm})}{I(555 \text{ nm})} \right)$

$$= -2.5 \log_{10} \left[\frac{\frac{2hc}{\lambda_B^5}}{e^{hc/2\lambda_B kT} - 1} \cdot \frac{e^{hc/2\lambda_V kT} - 1}{\frac{2hc}{\lambda_V^5}} \right]$$

$$= 12.5 \log_{10} \left[\frac{\lambda_B}{\lambda_V} \right] + 2.5 \log_{10} \left[\frac{e^{hc/2\lambda_B kT} - 1}{e^{hc/2\lambda_V kT} - 1} \right]$$



50

In fact, astronomers also define an AO star ($T_{\text{eff}} \sim 9500 \text{ K}$) to have $B-V = 0$. But these are not bad, nevertheless.
 (constant in equation)

P 3.17

M0 supergiant has $M_V \sim -5.5$ (from Fig 3.11)
^(1a)

M0 dwarf (V) has $M_V \sim 8.5$ (")

So the supergiant is 14 magnitudes brighter in V.

⑩ So $2.5 \log(B_2/B_1) = 14$

$$B_2/B_1 = 398,000.$$

P 3.18

Assume that this is a main sequence star.

Interpolate linearly in luminosity, not absolute magnitude
between A0 ($L/L_\odot = 79$) and A5 ($L/L_\odot = 20$)

This gives $L/L_\odot = 49.5$

The question does not specify which filter the
apparent magnitude is measured in, so let's assume

~~M_V~~ . $M_{V,\odot} = 4.83$

⑩

$$\cancel{M_{\text{star},\odot}} = \cancel{4.83}$$

$$M_{\text{star}} - M_\odot = -2.5 \log_{10}(L_*/L_\odot)$$

$$\begin{aligned} \text{So } M_{V,\text{star}} &= 4.83 - 2.5 \log_{10}(49.5) \\ &= 0.59 \end{aligned}$$

Then use $m - M = 5 \log d - 5$ (d in pc)

$$12 - 0.59 = 5 \log d - 5$$

So distance is 1,914 pc

P3.19

$$d = 500 \text{ pc}$$

$$m = 9$$

use $m - M = 5 \log d - 5$ to solve for M

So 'distance modulus' $m - M = 8.49$.

If $m = 9$, $M = 0.51$

- (15) Appendix E gives $M_V = 0.7$ for an A0 main sequence star — close enough (we will see soon that as stars evolve they become slightly ~~brighter~~ brighter)

So this star is a dwarf.

With $m = +4$, $M = -4.5$ which is a supergiant (look at figure 3.11)

Spectral type question

Look at notes for examples of spectra

- (a) F star : strong Balmer sequence plus CaII K line
(A stars have weaker K lines)
- (b) late K, early M (eg K7, M0) — overall red color in continuum
CaK line visible, molecular feature near 5170 \AA , but no TiO lines
- (c) O star : very blue continuum, so lot. Weak Balmer lines plus some weak K lines

(30)