Astronomy 404

August 28, 2013

Review of last lecture:

- parallax $1'' \times 1\ pc = 1\ AU$
- apparent magnitude, absolute magnitude

  5 magnitude = a factor of 100

  $m_1 - m_2 = -2.5 \log_{10} (F_1 / F_2)$

  $F = L / (4 \pi r^2)$ Inverse Square Law

  $m - M = 5 \log_{10} (d / 10)$ Distance Modulus

This is how "photometric distance" is determined.
Complication: extinction!

$$m - M - A = 5 \log_{10} (d / 10)$$

Chapter 3.
The Continuous Spectrum of Light

Planck Function

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

$d\,B_\lambda / d\,\lambda = 0$
to get λ_{max} at peak

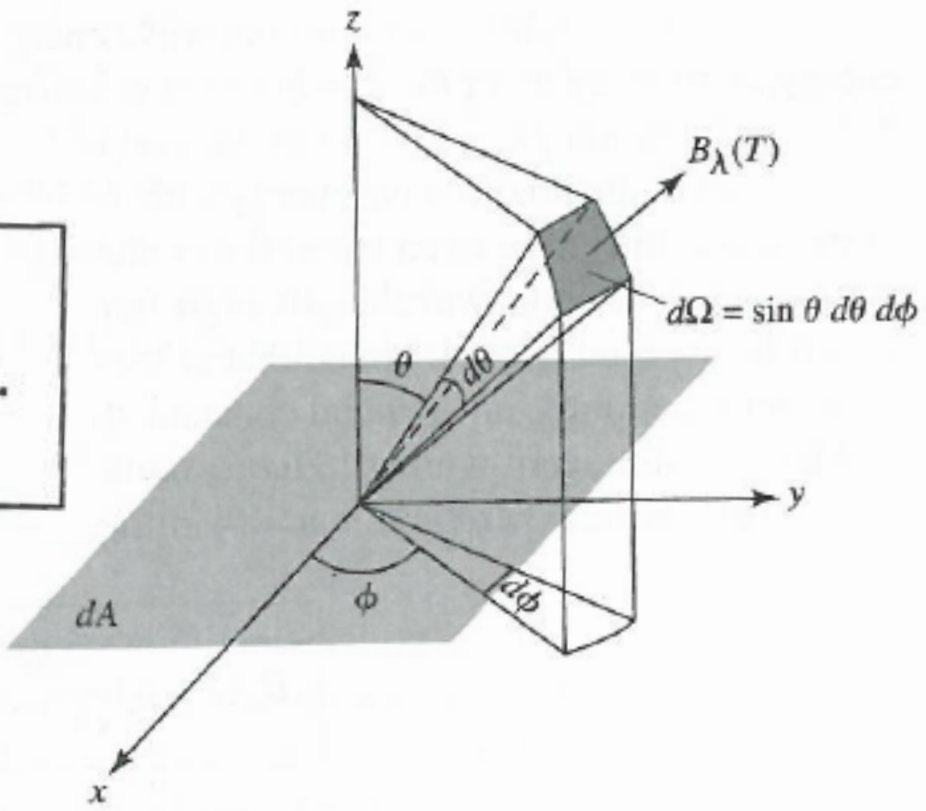
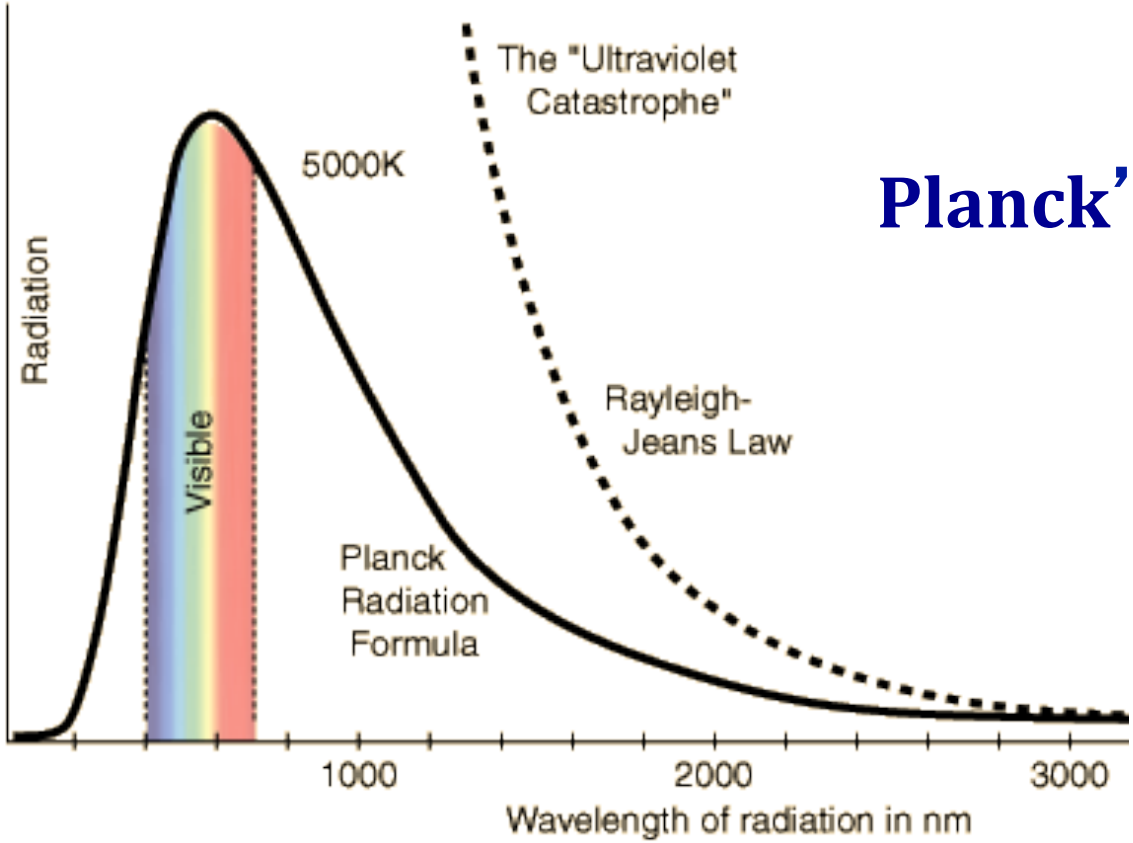


FIGURE 3.9 Blackbody radiation from an element of surface area dA.

$$B_\lambda(T)\, d\lambda\, dA\, \cos\theta\, d\Omega = B_\lambda(T)\, d\lambda\, dA\, \cos\theta\, \sin\theta\, d\theta\, d\phi$$

Integrate over entire surface to get luminosity ***L***



Planck's Function

$$\lambda_{max}\, T = 0.00289775 \text{ m K}$$

Wien's law

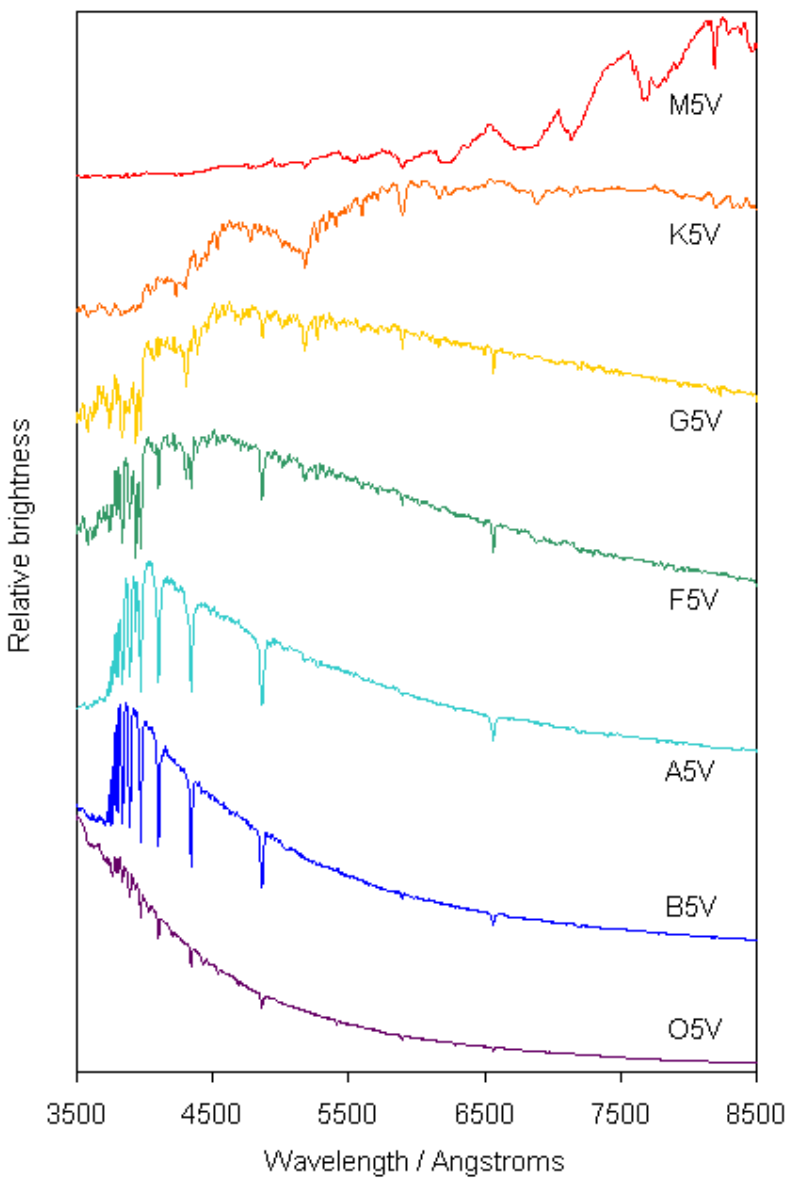
$$L = A\,\sigma\,T^4 = 4\,\pi\,R^2\,\sigma\,T^4$$

Stefan-Boltzmann Eq.

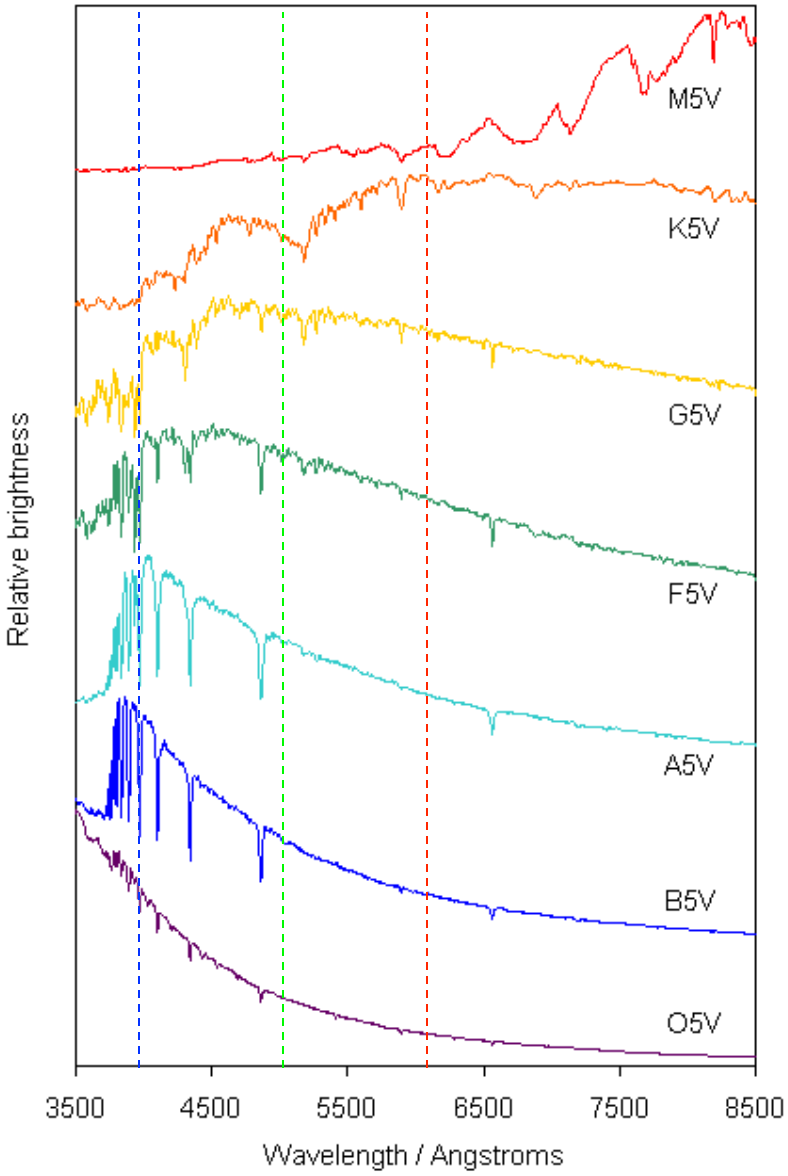
where A is the surface area, R the stellar radius, and

$\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}

Spectra of Stars



U B V



The Color Index

Radiant flux joules/s/m^2
=> **magnitude**

Apparent magnitudes:
***U, B, V, R, I, J, K*, etc**

Absolute Magnitudes:
M_U, M_B, M_V, M_R ,…

Bolometric magnitude: m_{bol}

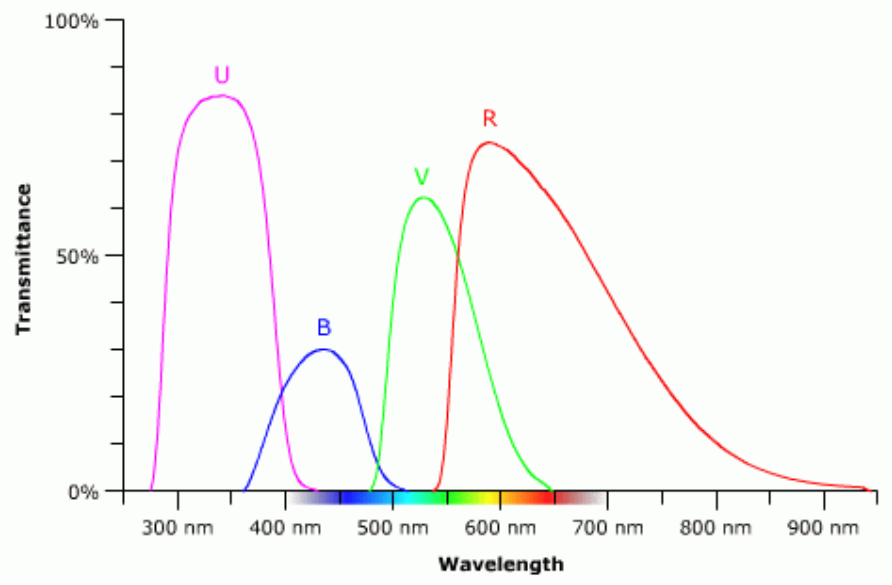
Absolute bolometric magnitude: M_{bol}

Color indexes:
***U-B, B-V, V-I, J-K*, etc.**

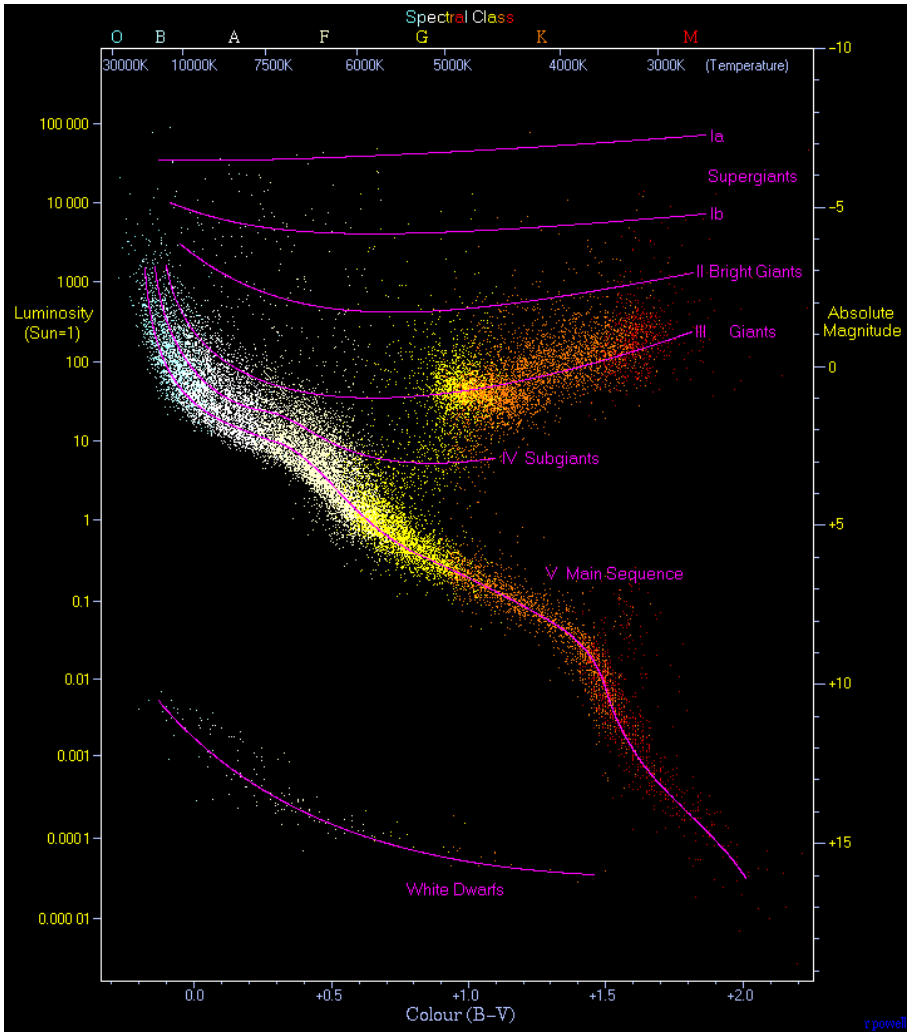
Bolometric correction:
$BC = m_{bol} - V = M_{bol} - M_V$

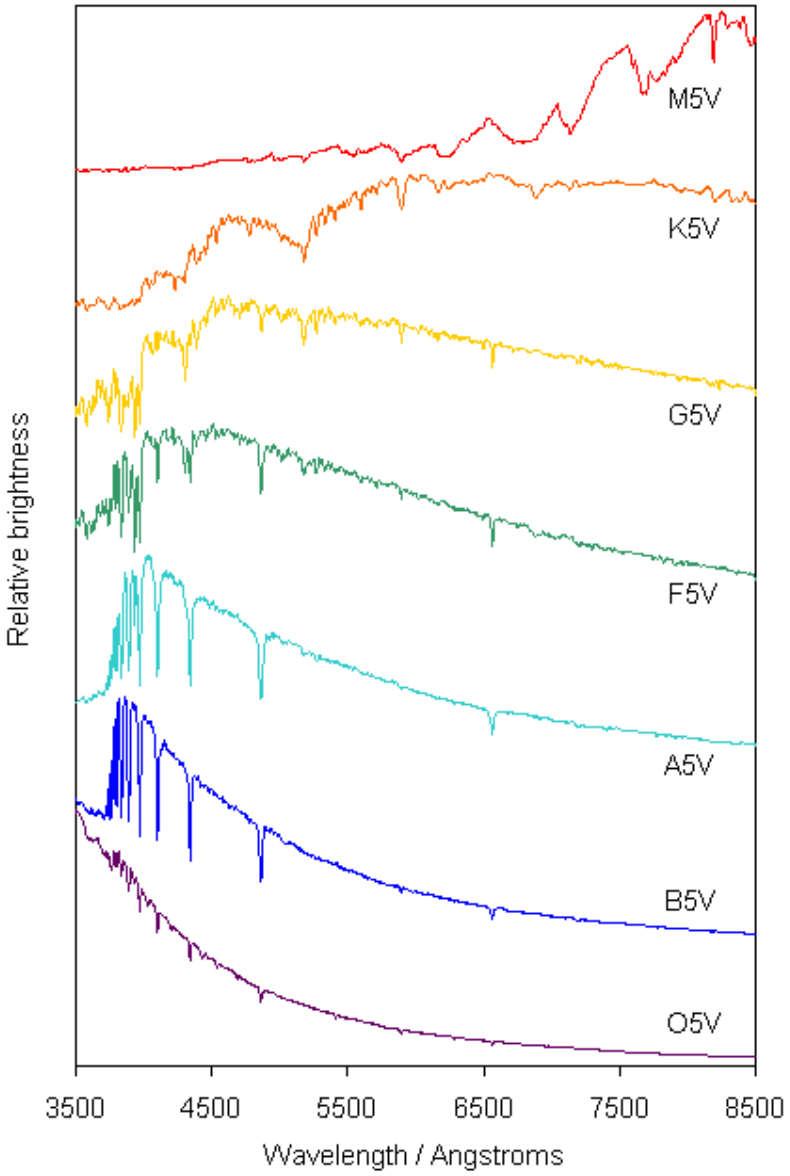
Flux calibration for A0 V star with $V = 0$

Band	Flux (erg/cm^2/s/Å)	λ (nm)	Δλ (nm)
U	4.22×10^{-9}	365	68
B	6.40×10^{-9}	440	98
V	3.74×10^{-9}	550	89

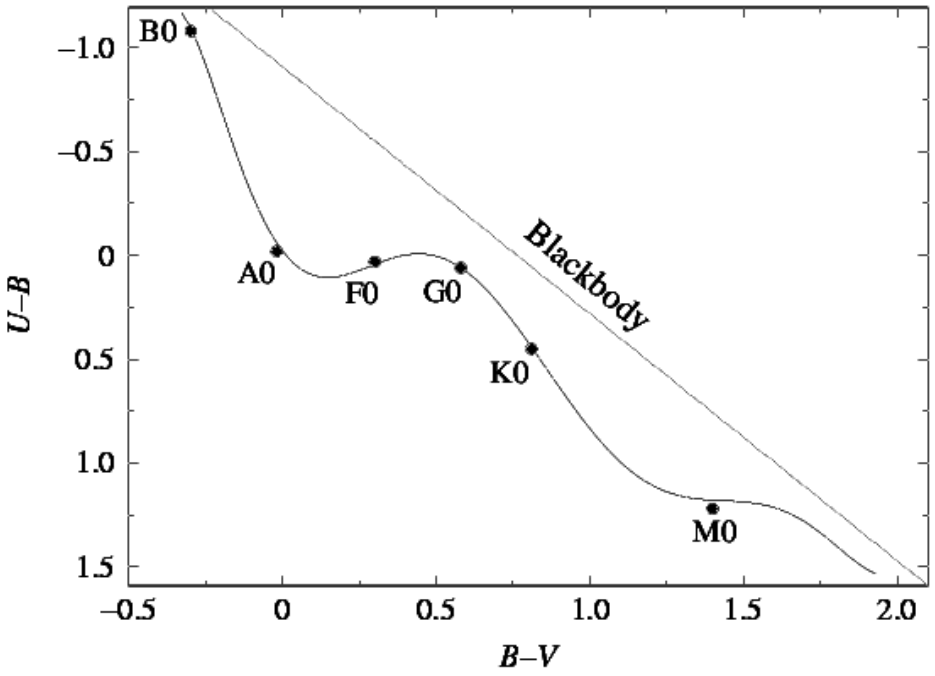


Hertzsprung-Russell Diagram
Color-Magnitude Diagram (CMD)
V vs (*B-V*)





Color-color Diagram
main sequence stars



Star	M_{bol}	BC	M_V	U-B	B-V
O5	-9.51	-4.40	-5.1	-1.19	-0.33
O8	-8.18	-3.54	-4.6	-1.14	-0.32
B1	-5.26	-2.70	-2.6	-0.95	-0.26
A0	+0.75	-0.30	+1.1	-0.02	-0.02
G0	+4.50	-0.18	+4.7	+0.06	+0.58
M0	+7.52	-1.38	+8.9	+1.22	+1.40

U B V

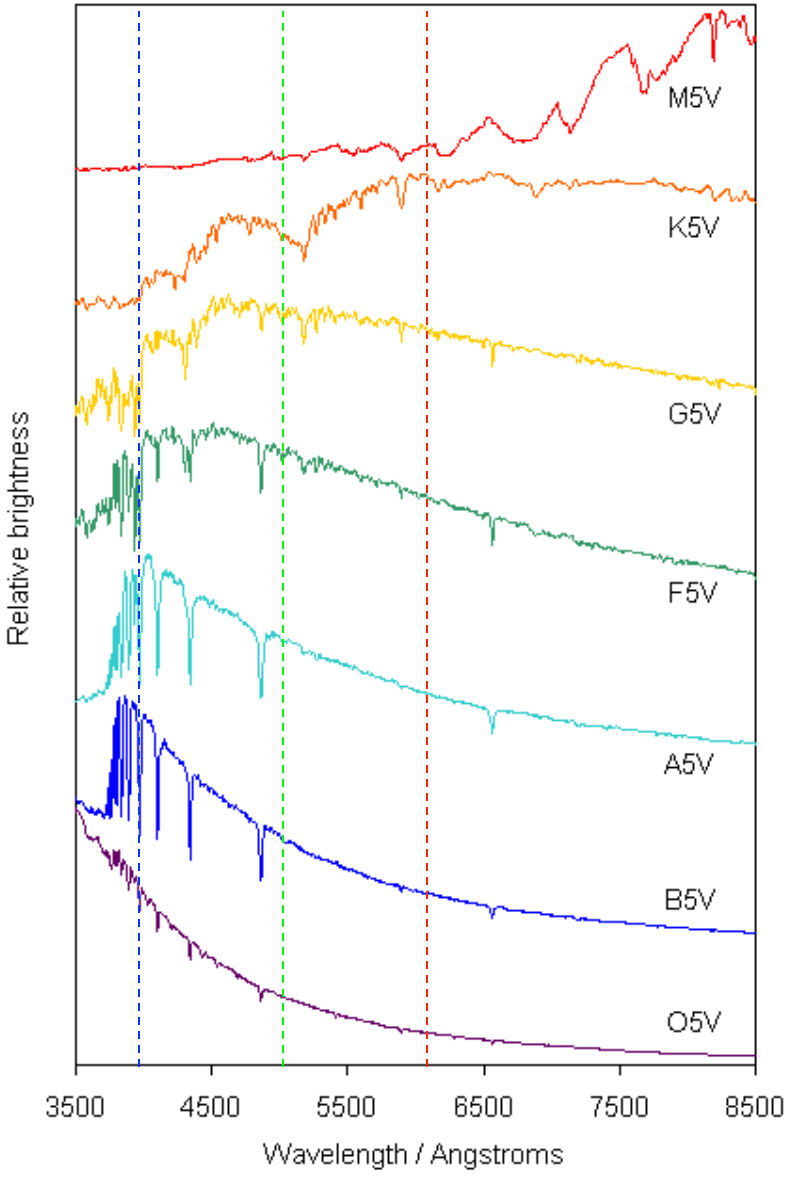
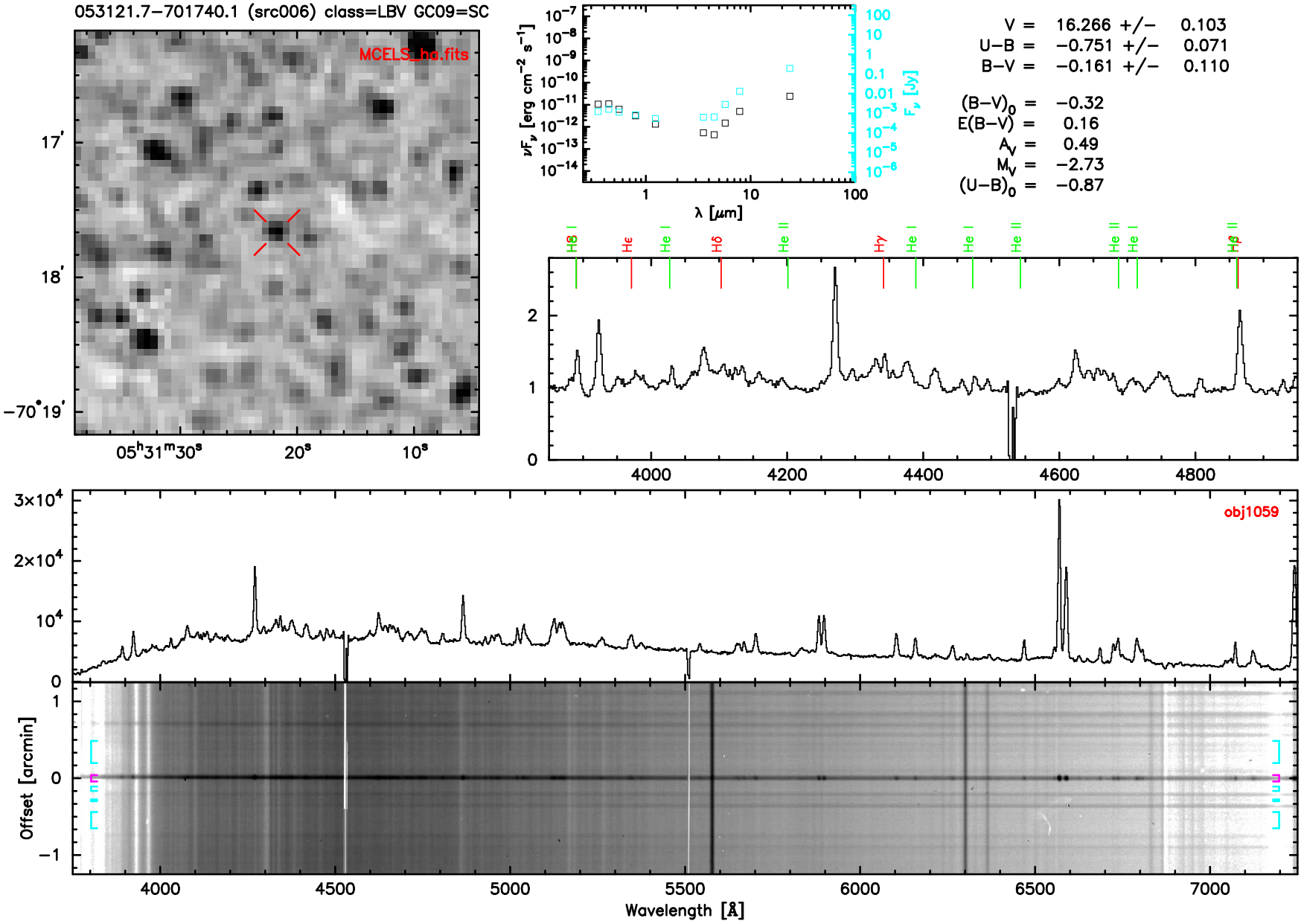


Table 1.3 Average magnitudes and colors for main-sequence stars: class V (dwarfs)

	M_V	BC	$15-V$	$U-B$	$B-V$	$V-R$	$V-I$	$J-K$	$V-K$	T_{eff}
O3	−6	4.5	—	−1.22	−0.32	—	—	—	—	50 000
O5	−5.6	4.0	—	−1.19	−0.32	−0.14	−0.32	−0.25	−0.99	43 000
O8	−4.8	3.3	−4.1	−1.14	−0.32	−0.14	−0.32	−0.24	−0.96	35 000
B0	−4.0	2.9	−4.0	−1.07	−0.30	−0.13	−0.30	−0.23	−0.91	29 800
B3	−1.4	1.6	−2.9	−0.75	−0.18	−0.08	−0.20	−0.15	−0.54	18 750
B6	−1.0	1.2	−2.3	−0.50	−0.14	−0.06	−0.13	−0.09	−0.39	14 000
B8	−0.25	0.8	−1.7	−0.30	−0.11	−0.04	−0.09	−0.06	−0.26	11 600
A0	0.8	0.3	−0.4	0.0	0.0	0.0	0.0	0.0	0.0	9400
A5	1.8	0.1	3.3	0.08	0.19	0.13	0.27	0.08	0.38	7800
F0	2.4	0.1	6.0	0.06	0.32	0.16	0.33	0.16	0.70	7300
F5	3.3	0.1	—	−0.03	0.41	0.27	0.53	0.27	1.10	6500
G0	4.2	0.2	—	0.05	0.59	0.33	0.66	0.36	1.41	6000
Sun	4.83	0.07	—	0.14	0.65	0.36	0.72	0.37	1.52	5780
G5	4.93	0.2	—	0.13	0.69	0.37	0.73	0.41	1.59	5700
K0	5.9	0.4	—	0.46	0.84	0.48	0.88	0.53	1.89	5250
K5	7.5	0.6	—	0.91	1.08	0.66	1.33	0.72	2.85	4350
K7	8.3	1.0	—	—	1.32	0.83	1.6	0.81	3.16	4000
M0	8.9	1.2	—	—	1.41	0.89	1.80	0.84	3.65	3800
M2	10.2	1.6	—	—	1.52	1.00	2.16	0.86	4.11	3500
M4	12.7	2.6	—	—	1.60	1.23	2.86	0.89	5.28	3150
M6	16.6	4.4	—	—	2.06	1.91	4.13	1.04	7.37	2800
M7	18.6	5.5	—	—	—	2.18	4.50	1.22	8.55	2600

We have a 300 ks Chandra X-ray observation of a region in the Large Magellanic Cloud (DM = 18.5). Many point sources are detected, and some have optical counterparts as stars. Are these stars in the LMC or the Galaxy?

Star 54	Star 145	Star109
U=20.959	U=17.78	U=20.11
B=22.031	B=18.23	B=19.77
V=21.023	V=18.30	V=19.30
I=18.075	I=18.35	I=18.42
J=16.61	J=18.50	J=17.66
H=16.07	H=18.22	H=17.15
K=15.86		K=17.09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MCELS_ha.fits
17′
18′
−70°19′
05h31m30s
20s
10s
νFν [erg cm−2 s−1]
Fν [Jy]
λ [μm]
V = 16.266 +/− 0.103
U−B = −0.751 +/− 0.071
B−V = −0.161 +/− 0.110
(B−V)0 = −0.32
E(B−V) = 0.16
AV = 0.49
MV = −2.73
(U−B)0 = −0.87
Hδ
Hε
He I
Hδ
He II
Hγ
He I
He I
He II
He II
He I
Hβ
He II
obj1059
Offset [arcmin]
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