Astronomical terms and constants

Units of length

1 AU $\approx 1.5 \times 10^{13}$cm = one astronomical unit, i.e. the earth–sun distance.

1 pc $= 2.06 \times 10^{5}$AU $= 3.1 \times 10^{18}$cm = one parsec, i.e. a distance to a star with a parallax equal to one second of arc. A parallax is an angle at which the radius of earth's orbit around the sun is seen from a distance of the star. Notice: 2.06×10^{5} is the number of seconds of arc in 1 radian.

1 kpc $= 10^{3}$ pc = one kilo-parsec,

1 Mpc $= 10^{6}$ pc = one mega-parsec,

1 Gpc $= 10^{9}$ pc = one giga-parsec,

$\mathrm{d_H} = \mathrm{c/H_0} \approx 1.4 \times 10^{28}$cm ≈ 4 Gpc = Hubble distance, where $\mathrm{H_0} \approx 70$ km s^{-1} Mpc^{-1} is the Hubble constant; c $= 3 \times 10^{10}$ cm s^{-1} is the speed of light. The Hubble distance is approximately the radius of the observable universe with us at the "center".

1 $\mathrm{R_\odot} \approx 7 \times 10^{10}$cm = solar radius

Most stars have radii between $10^{-2}\mathrm{R_\odot}$ (white dwarfs) and $10^{3}\mathrm{R_\odot}$ (red supergiants); neutron stars have radii of about 10^{6}cm = 10 km .

Units of time

1 year $= 3 \times 10^{7}$s

$\mathrm{H_0^{-1}} = \mathrm{d_H c^{-1}} \approx 1.4 \times 10^{10}$ years = Hubble time, approximate age of the universe.

Units of mass

$\mathrm{M_\odot} = 2 \times 10^{33}$ g = solar mass.

Known stars have masses in the range $0.08 - 100\ \mathrm{M_\odot}$. Below about $0.08\ \mathrm{M_\odot}$ the objects are *brown dwarfs.*

Units of luminosity, magnitudes

$\mathrm{L_\odot} = 4 \times 10^{33}$erg s^{-1} = solar luminosity.

Known stars have luminosity in the range $10^{-5} - 10^{6}\ \mathrm{L_\odot}$.

$\mathrm{M_{bol}} = 4.8 - 2.5 \log\ (\mathrm{L/L_\odot})$ = absolute bolometric magnitude of a star with a luminosity L . "Bolometric" means integrated over the entire stellar spectral energy distribution. $\mathrm{M_{bol,\odot}} = +4.74$.

$\mathrm{M_V} = \mathrm{M_{bol}} - \mathrm{BC}$ = absolute visual magnitude of a star; BC is a bolometric correction, and V indicates that we are referring to that part of the stellar radiation that is emitted in the "visual" part of the spectrum, i.e. at about 5×10^{-5} cm, 5000 Å . The BC depends on stellar temperature. $\mathrm{BC_\odot} = -0.08$.

$\mathrm{M_B}$ = absolute blue magnitude of a star; B indicates that we are referring to that part of stellar radiation that is emitted in the "blue" part of the spectrum, i.e. at about 4×10^{-5} cm, 4000 Å.

$\mathrm{m_{bol}} = \mathrm{M_{bol}} + 5 \log\ (\mathrm{d/10pc})$ = apparent bolometric magnitude of a star at a distance d .

$\mathrm{V} = \mathrm{M_V} + 5 \log\ (\mathrm{d/10pc})$ = apparent "visual" magnitude of a star as seen in the sky.

$\mathrm{B} = \mathrm{M_B} + 5 \log\ (\mathrm{d/10pc})$ = apparent "blue" magnitude of a star as seen in the sky.

$\mathrm{B - V} = \mathrm{M_B} - \mathrm{M_V}$ = a difference between "visual" and "blue" magnitudes; it is called a "color index", and it is a measure of the color. i.e. of the shape of the stellar spectrum between 4×10^{-5} and 5×10^{-5} cm (4000 to 5000 Å). Very hot stars are blue, with $\mathrm{B - V} \approx -0.3$, whereas very cool stars are red and have $\mathrm{B - V} \approx +1.5$. In general, color index is a good indicator of the temperature of the stellar "surface", or photosphere.

UBVRI photometric system

	U	B	V	R	I
Effective wavelength [$\mathring{A}$]	3600	4400	5500	7100	9700
Flux for m= 0 [10^{-9}erg cm^{-2} s^{-1}Å^{-1}]	4.22	6.40	3.75	1.75	0.84

Temperature, spectra, and related concepts

Temperature is measured in Kelvins (K) . A unit area of a black body radiates a "flux" of energy given as:

$$\mathrm{F} = \sigma \mathrm{T}^4,$$

where $\sigma = 5.67 \times 10^{-5}$ erg s^{-1} cm^{-2} deg^{-4} is the Stefan-Boltzman constant. The flux of energy is measured in [erg s^{-1} cm^{-2}],

A star with a radius R and luminosity L has an "effective" temperature $\mathrm{T_{eff}}$ defined with the relation:

$$\mathrm{L} = 4\pi \mathrm{R}^2 \sigma \mathrm{T}_{\mathrm{eff}}^4.$$

The sun has $\mathrm{T}_{\mathrm{eff},\odot} = 5.8 \times 10^3$K .

The coolest hydrogen-burning stars have $\mathrm{T_{eff}} \approx 2 \times 10^3$K .

The hottest main sequence stars have $\mathrm{T_{eff}} \approx 5 \times 10^4$K .

The hottest white dwarfs have $\mathrm{T_{eff}} \approx 3 \times 10^5$K .

The hottest neutron stars have $\mathrm{T_{eff}} \approx 3 \times 10^7$K .

The properties of stellar spectra gave rise to spectral classification, with spectra classified as O, B, A, F, G, K, M, with subclasses A0-A9 etc, e.g. A8, A9, F0, F1, F2. The exception is K stars, whose spectral subtypes are K0-K7. The following table gives approximate values of effective temperatures, bolometric corrections, and color indices of stars of various spectral types:

Spectral type	T_{eff}	BC	$B - V = M_B - M_V$
O5	40,000	-4.0	-0.35
B0	28,000	-2.8	-0.31
B5	15,500	-1.5	-0.16
A0	9,900	-0.4	0.00
A5	8,500	-0.12	+0.13
F0	7,400	-0.06	+0.27
F5	6,600	0.00	+0.42
G0	6,000	-0.03	+0.58
G5	5,500	-0.07	+0.70
K0	4,900	-0.2	+0.89
K5	4,100	-0.6	+1.18
M0	3,500	-1.2	+1.45
M5	2,800	-2.3	+1.63

Hertzsprung - Russell diagram

The original **Hertzsprung - Russell diagram** had spectral type of stars along the horizontal axis and absolute visual magnitude along the vertical axis, arranged so that bright stars were at the top, faint at the bottom, hot (blue) to the left, and cool (red) to the right.

It is more common now to use instead a **color - magnitude** diagram, with the $B - V$ color index along the horizontal axis, and either V or M_V along the vertical axis. This is the observer's diagram.

Theoreticians prefer to use a $\log T_{eff} - \log L$ diagram, with the logarithm of effective temperature plotted horizontally, and the logarithm of luminosity plotted vertically. In all these diagrams temperature increases to the left and the luminosity increases upwards.

Physical and Astronomical Constants

c $=2.99792\times10^{10}$ cm s^{-1}
G $=6.673\times10^{-8}$ dyne cm^2 gm^{-2}
h $=6.626\times10^{-27}$ erg s
e $=4.803\times10^{-10}$ esu
$m_e = 9.109\times10^{-28}$ gm
$m_p = 1.67\times10^{-24}$ gm
k $=1.3806\times10^{-16}$erg K^{-1}
$\sigma = 5.67\times10^{-5}$ erg cm^{-2} K^{-4} s^{-1}
1 eV $=1.602\times10^{-12}$ erg
1 A.U. $=1.496\times10^{13}$ cm
1 pc $=3.086\times10^{18}$ cm
1 $M_\odot = 1.989\times10^{33}$ gm
1 $R_\odot = 6.96\times10^{10}$ cm
1 $L_\odot = 3.826\times10^{33}$ erg s^{-1}
1 Jy(Jansky) $= 10^{-23}$ erg s^{-1} cm^{-2} Hz^{-1}
1 D(Debye) $= 10^{-18}$esu.cm(statcoulomb)