Physics equations/Sheet/Astronomy

Astronomy college course

Astronomy dimensions

- Earth's Radius: $R_{\oplus} \approx 6.37\text{x}10^6$m
- Earth's Mass: $M_{\oplus} \approx 5.97\times10^{24}$kg
- Solar and Lunar radius and mass:
- Solar radius and mass: $R_{\odot} \approx 110R_{\oplus}$ and $M_{\odot} \approx 330{,}000M_{\oplus}$.
- Lunar radius and mass: $R_L \approx 0.273R_{\oplus}$ and $M_L \approx 0.0123M_{\oplus}$
- Earth-moon distance ≈ $60R_{\oplus}$
- Earth-Sun distance = 1AU ≈ $1.496\text{x}10^{11}$m ≈ $23481R_{\oplus}$
- One light-year ≈ 9.5×10^{15} m = 63240 AU
- One parsec ≈ 3.26 light-years

Kepler-Newton Mass,Period,Distance (normalized units)

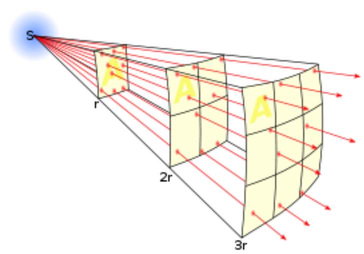
- $a_{\text{AU}}^3 = \tilde{M}_{\text{net}} P_{\text{year}}^2$, where *P* is the period of orbit in years, and *a* is the semi-major axis measured in AU. The net mass, $\tilde{M}_{\text{net}}$, is the sum of the mass of both bodies, and is normalized to the mass of the Sun. For a planet of mass, m, orbiting a star of much larger mass, $M >> m$, the normalized net mass is $\tilde{M}_{\text{net}} = (M+m)/M_{\odot} \approx M/M_{\odot}$. The mass of the Sun, $M_{\odot}$, is 1.99×10^{30} kilograms. If $M_{\odot} = 2$ for some object, then that object is twice as massive as the Sun. One year is 3.15×10^7 seconds.

Parallax

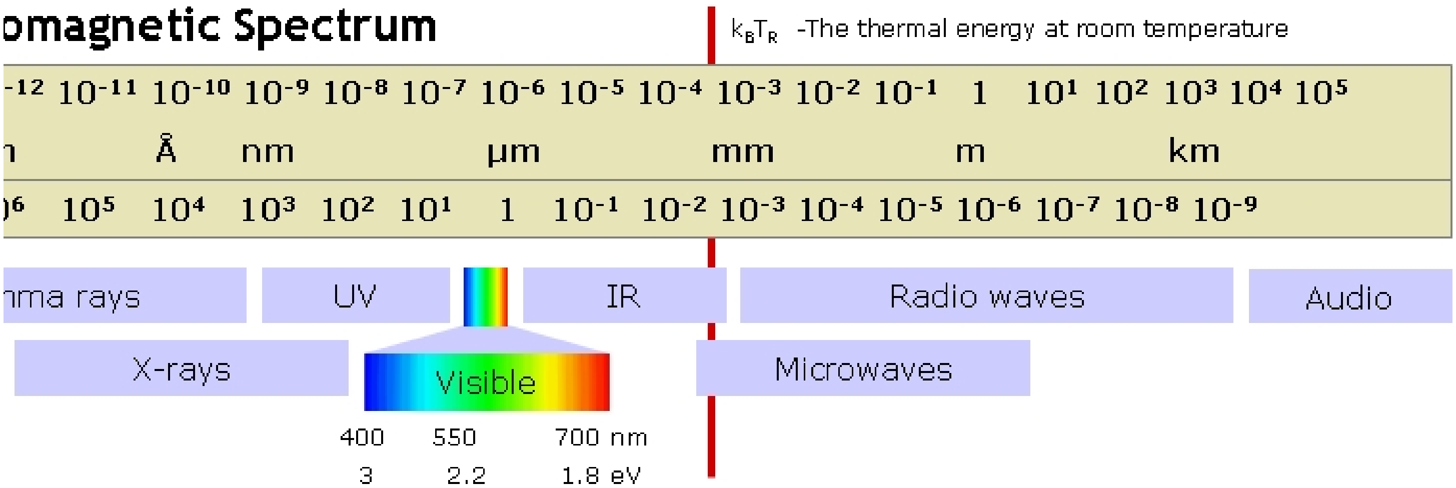
- $D_{\text{parsec}} = \dfrac{b_{\text{AU}}}{\theta_{\text{arcsec}}}$, where D is the distance to the object in parsecs, θ is the parallax angle in arcseconds, and b is the baseline in AU; b=1 for observations taken from Earth. One degree is 60 arcminutes and one arcminute is 60 arseconds. One AU ≈ $1.5\text{x}10^{11}$ meters, and one parsec ≈ 3.26 light-years, and one light-year ≈ 9.5×10^{15} meters.

Inverse square

- $4\pi\tilde{I} = \dfrac{\tilde{L}}{D^2}$ is a "normalized intensity", closely related to relative magnitude, that allows students to combine equations and solve problems without resorting to the logarithmic magnitude scale. If the distance to the stellar object, D, is measured in parsecs, it is the power per square parsec that enters a telescope on Earth. The luminosity, $\tilde{L}$, (in solar units) is a measure of the absolute magnitude. In general, $\text{Intensity} \propto \dfrac{1}{\text{distance}^2}$ is the inverse-square law.



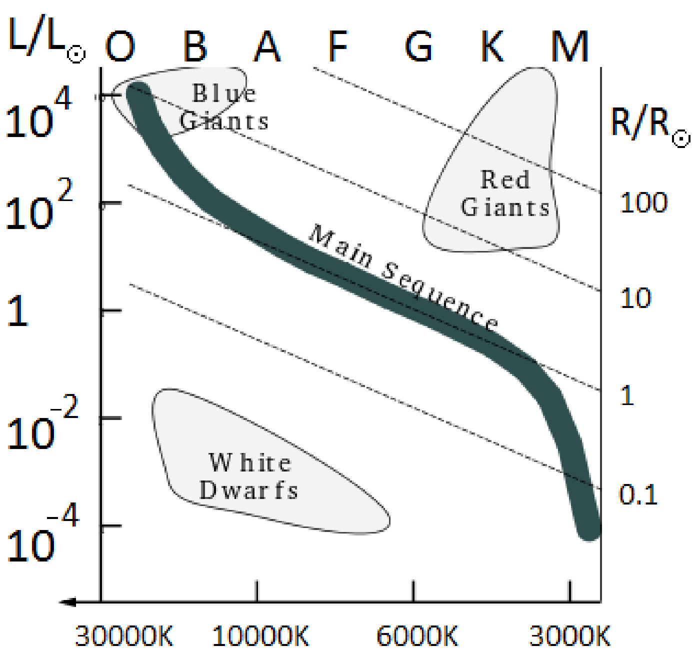
Photons, waves, and particles

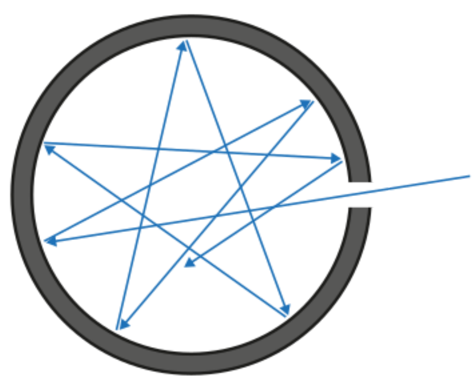


sured in electron volts: 1 eV=1.6×10^{-19}J. Also, hc=1240nm-eV.

- $E = hf = hc/\lambda$ is the energy of a photon, where *f* is frequency and h ≈6.6×10^{-34}m^{2}kg/s is Plank's constant, and c ≈3×10^{8}m/s is the speed of light. Also, E=$\hbar$ ω where $\hbar$ ≈1.05×10m^{2}kg/s and ω =2π f.
- $f\lambda = c$ relates frequency, wavelength, and the speed (or phase velocity). Using wavenumber, k =2π/λ, this can also be represented as ω =ck.

Blackbody radiation

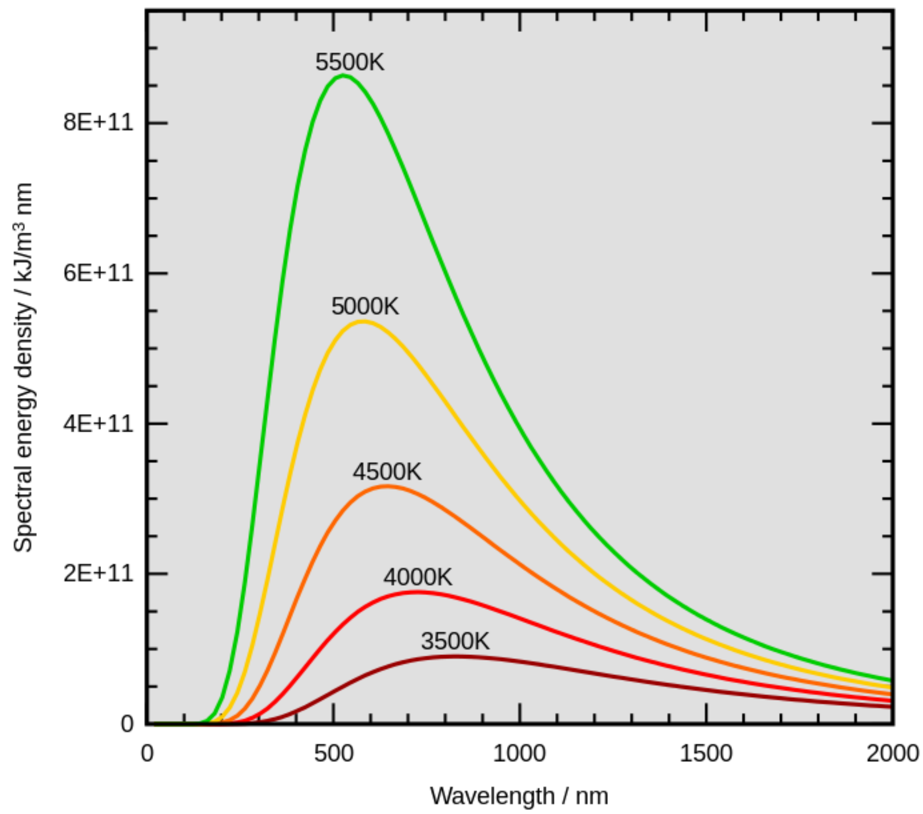




- $\lambda_{\max} T_K = .003\text{nm}$ is **Wein's law** that relates the peak emission wavelength, λ_{max}, of a black body to temperature, T measured in Kelvins. Peak wavelength, λ_{max}, is measured in nanometers (1nm=10^{-9}m). If temperature is measured in units normalized to the Sun's temperature, $T_\odot = 5778K$, then
- $\lambda_{\max}\tilde{T} = 502\text{nm}$ where $\tilde{T} = T/T_\odot$ is the temperature normalized to the Sun's temperature.

The **Stefan-Boltzmann law** is usually written as $P=\sigma AT^4$, where A is surface area, T is temperature (in Kelvins), and σ is the Stefan-Boltzmann constant. The power, P, can be written as normalized luminosity, $\tilde{L} = P/L_\odot$, where $L_\odot = 3.85\times 10^{26} W$ is the power output (or *luminosity*) of the Sun. In these normalized units, the Stefan-Boltzmann law is:

- $\tilde{L} = \tilde{R}^2\tilde{T}^4$, where $\tilde{R} = R/R_\odot$ is the radius and temperature normalized to the Sun's radius and $\tilde{T} = T/T_\odot$ is the temperature normalized to the Sun's temperature.


5500K
5000K
4500K
4000K
3500K
8E+11
6E+11
4E+11
2E+11
0
Spectral energy density / kJ/m³ nm
0
500
1000
1500
2000
Wavelength / nm