Astronomy 13 Equations (Spring 2010)

A.U. = 1.5×10^{11}m **pc**=206,000 A.U. = 3×10^{16}m **Solar mass**=2×10^{30}kg
Solar Radius = 7×10^{8}m **Solar Luminosity** = 4×10^{26} W **Proton mass** = 1.67×10^{-27}kg
Year: 3×10^{7}s **Earth mass** = 6×10^{24}kg **Earth radius=** 6.4×10^{6}m W= J/s =10^{7} ergs/s
Angles: 360 deg=2π radians 1 deg=60 arcmin 1 arcmin= 60arcsec
1 arcsec: transverse size = distance/206,000

Waves & Photons: Wavelength(λ) x Frequency(ν) = c(speed of light)
Energy = $h\nu = hc/\lambda$ where Planck's constant $h=6.6\times10^{-34}$J-s and $c=3\times10^{8}$m/s

Wien's Law: Peak Wavelength(m) = 0.0029/ T T=temperature in K=Kelvin

Stefan-Boltzman Law: Flux(W/m^2) = σT^4 where $\sigma=5.67\times10^{-8}$ W/m^{2}K^4 T(K)
For surface of sphere, Luminosity (W) = $4\pi R^2 \sigma T^4$ R=radius(m) of sphere

Redshift z: $z = \frac{\lambda(obs) - \lambda(rest)}{\lambda(rest)} \sim velocity/c$ (at low velocities)
Matter density (z) = matter density(at z=0) $*$ $(1+z)^3$
Radiation density (z) = radiation density(at z=0) $*$ $(1+z)^4$

Hubble Law: velocity= Ho $*$ Distance velocity(km/s), Ho($\frac{km}{s*Mpc}$), Distance(Mpc)

Brightness: $b(W/m^2) = \frac{\text{Luminosity}}{4\pi\text{Distance}^2}$ where for Sun at Earth b=1370 W/m^2

Magnitudes: apparent mag m = -2.5 log(brightness) + Constant
Absolute mag M = -2.5 log(brightness at 10pc) + Constant M(sun)=+5
Absolute mag M = -2.5 log (L/Lsun) + 5
Distance Modulus = m-M = 5 log(distance in pc) – 5
Log a=b ➔ 10^b = a =5 log(distance in Mpc) + 25

Proper Motion: μ(arcsec/yr) = $\frac{T}{4.74D}$ T=transverse motion(km/s) D=Distance(pc)

Luminosity of Stars: L $\propto$ Mass^4

Radiation Blackbody Energy Density: $U=aT^4$ $a=7.6\times10^{-16}\ \frac{W}{m^3K^4}$

Radiation Mass Density: $U/c^2 = 4.6\times10^{-31}$ kg/m^3 (from analogy of $E=mc^2$)

Law of Gravitation: Force = $\frac{GmM}{D^2}$ $G=6.7 * 10^{-11}\ \frac{m^3}{s^2kg}$ m, M are masses(kg)
D=distance(m)

Escape Velocity or Bending Angle: $v \propto \sqrt{\frac{\text{mass}}{\text{distance}}}$

EQUATIONS (continued)

Special Relativity Relations: $t(obs) = t(rest)/\sqrt{(1-\frac{v^2}{c^2})}$ Energy =mass c^2

$length(moving) = length(rest)\sqrt{(1-\frac{v^2}{c^2})}$ $mass(moving) = mass(rest)/\sqrt{(1-\frac{v^2}{c^2})}$

Schwarzschild Radius: R (m) = 2 G Mass/c^2 = 3km $*$ Mass(units of Sun)

Heisenberg Uncertainty Principle: $\Delta t * \Delta E > h/2\pi$

Where ΔE is the uncertainty in its measurement of energy when measurement is over an interval of time Δt.

$$\Delta d * \Delta p > h/2\pi$$

where Δd is the distance interval and Δp is the uncertainty in the momentum

Compton wavelength: λ(compton) = h/mc

Where h = Planck's constant = $6.63 * 10^{-34}$ J s = **$4.1 * 10^{-15}$** eV s
1eV = $1.6\text{x}10^{-19}$ J

Planck Mass: **=**$\sqrt{\frac{hc}{G}}$ = 5.5 x 10^{-8} kg

Planck Length: **=** $\sqrt{\frac{Gh}{c^3}}$ = $4.1\text{x}10^{-35}$ m

Planck Time: = (Planck length)/c = $1.4\text{x}10^{-43}$s

Energy Conservation: $\frac{v^2}{2} - \frac{Gm}{r} = constant$

Einstein's Eq. For U: $\frac{H^2}{2} - \frac{4\pi G}{3}D = -\frac{kC}{r^2} + \frac{\Lambda}{3}$

Critical Density: $Density(critical)$ = $3Ho^2/(8\pi G)$ ~ $1\text{x}10^{-26}$ kg/m^3

Density Parameter: Ωo = mass density/ critical density

Deceleration Parameter: **q_o =** $\frac{\Omega_o}{2} - \frac{\Lambda c^2}{3H_o^2}$ **= $\Omega o/2$** if cosmological constant Λ=0

Mass: mass = density x volume For spherical case = density $*$ $4\pi R^3/3$
$\propto rv^2$ r=size v=velocity

Temperature (K) of Universe = $\frac{10^{10}K}{\sqrt{t}}$ where t=age of Universe in seconds

Typical Energy of Photons = $\frac{2Mev}{\sqrt{t}}$ where t=age of Universe in seconds