ASTR367/702
Final Review Topics

Equations to memorize

$$F = \frac{L}{4\pi d^2} \tag{1}$$

$$d = \frac{1}{p['']}\,\mathrm{pc} \tag{2}$$

$$L = L_\odot \left(\frac{M}{M_\odot}\right)^\alpha (\alpha \simeq 4) \tag{3}$$

$$m_1 - m_0 = -2.5 \log_{10}(F_1/F_0) \tag{4}$$

$$\frac{F_1}{F_0} = 10^{0.4(m_0 - m_1)} \tag{5}$$

$$M_1 - M_0 = -2.5 \log_{10}(L_1/L_0) \tag{6}$$

$$\frac{L_1}{L_0} = 10^{0.4(M_0 - M_1)} \tag{7}$$

$$m - M = 5 \log d - 5 \tag{8}$$

$$\lambda_{\max} = \frac{0.2898}{T(\mathrm{K})}\,\mathrm{cm} \tag{9}$$

$$L = A\sigma T^4 \tag{10}$$

$$\tau_\nu = \int \kappa_\nu \rho ds \tag{11}$$

$$\frac{dP}{dr} = -G\frac{M_r \rho(r)}{r^2} = -\rho g \tag{12}$$

$$\frac{dM_r}{dr} = 4\pi r^2 \rho(r) \tag{13}$$

$$\tau_{ff} \propto (G\rho)^{-1/2} \tag{14}$$

$$\lambda = \frac{1}{n\sigma}, \tag{15}$$

$$t \simeq \frac{1}{n\sigma v}, \tag{16}$$

$$\Omega = \alpha\frac{GM^2}{R}. \tag{17}$$

$$P = nkT. \tag{18}$$

$$P_{\rm rad} = 1/3 a T^4 \,. \tag{19}$$

$$P = K_\alpha \rho^{(\phi+1)/\phi} = K_\alpha \rho^{\gamma_\alpha} \,, \tag{20}$$

$$\kappa = \kappa_0 \rho^a T^b \,, \tag{21}$$

$$P = K \rho^\gamma \,, \tag{22}$$

with $\gamma = 1 + 1/n$ and different values of K for different equations of state.

Lane-Emden is below, but I expect you to know

$$\rho = \rho_c \theta^n \tag{23}$$

$$\xi = r/\alpha \,. \tag{24}$$

$$\frac{m_1}{m_2} = \frac{a_2}{a_1} \,, \tag{25}$$

$$P^2 = \frac{4\pi^2}{G(M+m)} a^3 \,, \tag{26}$$

Equations I would give you

$$B_\nu = \frac{2h\nu^3}{c^2} \frac{1}{e^{h\nu/kT} - 1} \tag{27}$$

$$B_\lambda = \frac{2hc^2}{\lambda^5} \frac{1}{e^{hc/\lambda kT} - 1} \tag{28}$$

$$f(v) = \sqrt{\left(\frac{m}{2\pi kT}\right)^3} 4\pi v^2 e^{-\frac{mv^2}{2kT}} \tag{29}$$

$$\frac{n_i}{n_j} = \frac{g_i}{g_j} e^{-E_{\rm ij}/k\,T_{\rm ex}} \tag{30}$$

$$\frac{n_{i+1} n_e}{n_i} \simeq 2 \left(\frac{2\pi m_e kT}{h^2}\right)^{3/2} \frac{g_{i+1}}{g_i} \exp\left[-\frac{\Phi_r}{kT}\right] \tag{31}$$

$$\frac{dL_r}{dr} = 4\pi r^2 \rho \epsilon \tag{32}$$

$$\frac{dT}{dr}_{\rm rad} = -\frac{3}{4ac} \frac{\bar{\kappa}\rho}{T^3} \frac{L_r}{4\pi r^2} \tag{33}$$

$$P_{\rm e,deg} = K_1^{'} \left(\frac{\rho}{\mu_e}\right)^{5/3} \,, \tag{34}$$

$$P_{\mathrm{e,deg}} = K_2^{'} \left(\frac{\rho}{\mu_e} \right)^{4/3}, \tag{35}$$

$$\frac{1}{\xi^2} \frac{d}{d\xi} \left(\xi^2 \frac{d\theta}{d\xi} \right) = -\theta^n . \tag{36}$$

$$\left| \frac{dT}{dr} \right|_* < \left(\frac{\gamma_a - 1}{\gamma_a} \right) \frac{T}{P} \left| \frac{dP}{dr} \right|_* \tag{37}$$

$$M_{\mathrm{Ch}} = \frac{M_3 \sqrt{1.5}}{4\pi} \left(\frac{hc}{G m_H^{4/3}} \right)^{3/2} \mu_e^{-2} = 5.83 \mu_e^{-2} M_\odot \tag{38}$$

$$L < \frac{4\pi c G M}{\kappa} \tag{39}$$

$$M_J = \left(\frac{5kT}{G\mu} \right)^{3/2} \left(\frac{3}{4\pi\rho} \right)^{1/2} \tag{40}$$

$$R_J = \sqrt{\frac{15kT}{4\pi G \mu \rho}} . \tag{41}$$

$$M_V = -2.81 \log_{10} P_d - 1.54 , \tag{42}$$

$$\Pi \approx 2 \int_0^R \frac{dr}{c_s} \approx 2 \int_0^R \frac{dr}{\sqrt{2/3 \gamma \pi G \rho (R^2 - r^2)}} \approx \sqrt{\frac{3\pi}{2\gamma G \rho}} \propto 1/\sqrt{\rho} . \tag{43}$$

$$T_c(t) = T_0 \left(1 + \frac{5}{2} \frac{t}{\tau_0} \right)^{-2/5}, \tag{44}$$

$$L(t) = L_0 \left(1 + \frac{5}{2} \frac{t}{\tau_0} \right)^{-7/5}, \tag{45}$$

$$v^2 = GM \left(\frac{2}{r} - \frac{1}{a} \right) . \tag{46}$$

$$T = \left(\frac{G M_1 \dot{M}}{8\pi\sigma R^3} \right)^{1/4} \left(\frac{R}{r} \right)^{3/4}, \tag{47}$$

Topics

Stars

Ranges for physical properties
Spectral types
Lifetimes
H-R diagram

Units

Parallax
Apparent and absolute magnitudes

Blackbodies

Radiative transfer
Colors and blackbodies

Stellar Equations

LTE
Mass conservation
Hydrostatic equilibrium
The Virial Theorem
Gravitational Potential
Timescales

Gas Physics

Equations of state
The pressure integral
Various pressures and when they are applicable
Ionization state (Saha)
Electronic state (Boltzmann)
The adiabatic exponent
Opacity
The temperature gradient

Fusion

Computing reaction rates
Proton-proton, CNO, triple alpha, with temperature scalings
r– and s–processes

Stellar Models

Polytropic models with values for γ and n
Lane-Emden relation
Chandrasekhar mass
Eddington luminosity

Stellar Stability

Dynamical Equilibrium
Thermal Equilibrium
When do we have instabilities?
Convection and when it dominates over radiation

Stellar Evolution

Star Formation process
Jeans radius and mass from hydrostatic equilibrium and Virial
Bonner-Ebert spheres
Hayashi tracks
The initial mass function
Main sequence evolution
Post-main sequence evolution for > 8 and $< 8\, M_{\odot}$ stars including elements produced and tracks on H-R diagram

Stellar Pulsations

Types of variable stars and characteristic pulsation periods
Cepheids and the period-luminosity relationship
κ and γ mechanisms

Compact Objects

White dwarfs: origin, composition, temperatures, luminosities, types, cooling
Nuetron stars: radii, rotation rates, magnetic field strengths

Pulsars: relationship between spin down rate and luminoty
Black holes: basic physics, Schwartschild radius, gravitational redshift and time dilation
Supernovae: types, core collapse vs WD, evolutionary phases
Rankin-Huginot conditions

Binaries

Types
What we can learn from visual, spectroscopic, and eclipsing binaries
Lagrangian points
Accretion disks
Novae and supernovae