

Unit 1 Energy Generation

1.1 Basics

- 1.1.1 Energy equilibrium
- 1.1.2 Nuclear interactions
- 1.1.3 Nuclear reaction rates
- 1.1.4 Energy release in nuclear reactions
- 1.1.5 Binding energy

1.2 Hydrogen burning

- 1.2.1 PP-I chain
- 1.2.2 PP-II and PP-III chain
- 1.2.3 CNO cycle

1.3 Things not discussed

Unit 2 Hydrostatics

2.1 Are stars approximately a one-fluid plasma?

2.2 Time scales of stars

- 2.2.1 Dynamical timescale
- 2.2.2 Thermal timescale
- 2.2.3 Nuclear timescale

2.3 Equation of state

- 2.3.1 Preliminaries
- 2.3.2 Mean molecular weight (μ)
- 2.3.3 Ideal monatomic gas
- 2.3.4 Completely degenerate gas
- 2.3.5 Partially degenerate gas
- 2.3.6 —
- 2.3.7 Radiation Pressure
- 2.3.8 Density-temperature equation of state landscape
- 2.3.9 Thermodynamics of an ideal gas
- 2.3.10 Mixture of ideal gas and radiation: pressure effects
- 2.3.11 Mixture of ideal gas and radiation: ionization effects

2.4 Hydrostatic equilibrium

- 2.4.1 Derivation

2.5 The Virial Theorem

2.6 Polytropes

- 2.6.1 Motivation and derivation
- 2.6.2 Lane-Emden equation
- 2.6.3 Polytrope solutions

Unit 3 Energy Transport

3.1 Radiation

3.1.1 Basics

3.1.2 Diffusion: Fick's Law, temperature gradient

3.1.3 Frequency dependence of radiation: Rosseland mean opacity

3.1.4 Opacity sources

3.1.5 Consequences

3.1.6 Eddington Luminosity

3.1.7 Final tools: introducing ' ∇ ', ' ∇_{rad} ', and ' ∇_{ad} '

3.2 Conduction

3.3 Convection

3.3.1 The convective instability: considering P and ρ as a blob is displaced, Schwarzschild criterion

3.3.2 Another useful formulation

3.3.3 Semiconvection

3.3.4 One more useful formulation

3.3.5 Physical conditions for convection onset

3.3.6 Mixing length theory

3.3.7 Convective overshoot

3.3.8 Depth of outer convection zones

Unit 4 The Main Sequence

4.1 Summary of stellar structure

4.2 Homology relations for stars in **radiative equilibrium**

4.2.1 Basic idea

4.2.2 Dependence on mass

4.2.3 Dependence on T_{eff}

4.2.4 Dependence on mean molecular weight (μ)

4.2.5 Dependence on heavy metal abundances

4.2.6 Contracting stars in radiative equilibrium

4.2.7 Convective stars

4.3 Evolution on the main sequence

4.3.1 Low-mass stars

4.3.2 High-mass stars

4.3.3 A note about *very* low mass stars

4.4 Summary of Main-Sequence properties

Unit 5 The Post Main Sequence

5.1 General considerations

5.1.1 Schonberg-Chandrasekhar Limit

5.1.2 The subgiant branch

5.2 Toward and up the RGB

5.2.1 High-mass stars

5.2.2 Low-mass stars

5.2.3 RGB properties

5.2.4 Summary

5.3 Helium burning

5.3.1 Quick tour of non-hydrogen nuclear reactions

5.3.2 Horizontal Branch

5.3.3 Location of the ZAHB

5.3.4 Horizontal branch evolution

5.3.5 Asymptotic giant branch

5.3.6 Thermal pulses

5.4 Last stages of evolution: low-mass stars

5.4.1 Production of s elements

5.4.2 Planetary nebula

5.4.3 White dwarfs

5.4.4 Further WD properties

5.4.5 Type Ia supernovae

5.5 Last stages of evolution: low-mass stars

5.5.1 Nuclear burning

5.5.2 Type II supernova – core collapse

5.5.3 Neutron star

5.5.4 Black hole