PHY 474/374 **Spring 2021**

Review for In-class Examination

This review is meant as a guide, and *is not* a replacement for class summaries, worksheets and homework solutions.

All equation number references in this review are to the *Dalsgaard* text posted in D2L for this course.

Definitions and Ideas

- **Stellar Timescales:** You must know **Section 1.1** in *Dalsgaard* (**pages 2-4**) thoroughly. Of particular interest are the following timescales:
  - → **dynamical timescale**, t_{dyn}, in equation (1.2),
  - → **Kelvin-Helmholtz timescale**, t_{KH}, in equation (1.5), and
  - → **nuclear timescale**, t_{nuc}, in equation (1.7).

  See pages 1-3 of the **Worksheet** for Week 1—Mon, March 29 for examples, and Question 1 on Homework 1.

- **Distance Measures:** You must be familiar with the following frequently used distance measures: **Astronomical Unit (AU)**, **parsec (pc)**, and **Light Year (Ly)**. Read through **Sections 2.1-2.2** in *Dalsgaard* (**pages 13-15**). Also see page 4 of the **Worksheet** for Week 1—Mon, March 29, and the posted video for that day. Also see Question 2 on Homework 1.

- **Stellar Brightnesses:** The **magnitude scale** is used by optical astronomers, historically magnitude 0 to magnitude 6, with a drop of a factor of 2.5 in brightness for each successive level. Remember that magnitude drops as you go up in numbers, so zeroth magnitude is brighter than 1st magnitude, and a 1st magnitude object is brighter than a 2nd magnitude object, and so on; this can sometimes be confusing. Moreover, objects brighter than magnitude zero have negative magnitudes. This scale has been expanded to fainter objects in modern times, and the Hubble Space Telescope can spot objects as faint as about 30th magnitude. See **Section 2.3** in *Dalsgaard* (**pages 15-19**) for a host of useful relations; you used some of these on page 5 of the **Worksheet** for Week 1—Mon, March 29. Also see Question 3 on Homework 1.

- **Stellar Spectra:** You must be familiar with the idea of **interstellar absorption** discussed in **Section 2.4** in *Dalsgaard* (**page 20**). Also be familiar with spectra and its analysis, in particular:
  - → the existence of Continuum, Emission Line, Absorption Line spectra
  - → **Natural Broadening**
  - → **Lorentzian profile**
  - → **Collisional (or pressure) Broadening**
  - → **Doppler Broadening**

  See the **Class Summary** for Week 1—Wed, Mar 31 and the **worksheet** for that day. Also see Question 4 on undergrad Homework 2.

The Physics of Stars

- **Thermodynamic Equilibrium:** See page 1 of the **Class Summary** for Week 2—Mon, Apr 5, and page 1 of the **worksheet** for that day. In particular, you should be aware of:
  → **Maxwellian distribution** of speeds, and the **kinetic temperature**
  → **Boltzmann distribution** of energy levels, and the **excitation temperature**
  → **Planck distribution**, and the **radiation temperature**

  See also Question 1 on Homework 2.

- **Ideal Gas: Many important ideas and relations** here; see pages 2-4 of the **Class Summary** for Week 2—Mon, Apr 5, and pages 2-4 of the **worksheet** for that day. In particular, you must understand what is meant by **mass fraction** and the **mean molecular weight**.

- **Hydrostatic Equilibrium:** Read **Section 4.1** in *Dalsgaard* (**pages 53-55**); more concise information is also on pages 1-2 of the **Class Summary** for Week 2—Wed, Apr 7, and pages 1-2 of the **worksheet** for that day. See also Questions 2 and 3 on Homework 2.

- **The Virial Theorem:** Go over page 3 of the **Class Summary** for Week 2—Wed, Apr 7, and page 3 of the **worksheet** for that day.

- **Polytropic models, Lane-Emden equation:** See page 4 of the **Class Summary** for Week 2—Wed, Apr 7, and pages 4-5 of the **worksheet** for that day. You will also want to go over page 1 of the **Class Summary** for Week 3—Mon, Apr 12, and page 1 of the **worksheet** for that day. Also see Question 4 on Homework 2.

- **Energy Transport in Stellar Interiors:** See pages 2-5 of the **Class Summary** for Week 3—Mon, Apr 12, and pages 2-5 of the **worksheet** for that day.

- **Stellar Atmospheres:** See pages 1-3 of the **Class Summary** for Week 3—Wed, Apr 14, and pages 1-3 of the **worksheet** for that day. Also see Question 1 on Homework 3.

- **Energy Production:** See pages 4-5 of the **Class Summary** for Week 3—Wed, Apr 14, and pages 4-5 of the **worksheet** for that day.

- **Energy Transport by Convection:** See all pages of the **Class Summary** for Week 4—Mon, Apr 19, and the **worksheet** for that day. In particular, be aware of the adiabatic gradient, $\nabla_{\rm ad}$, and the **condition for instability** in which the radiative temperature gradient $\nabla_R > \nabla_{\rm ad}$, and which is also the condition for convection to take place. Also see Question 3 on Homework 3.

- **Mass-Luminosity Relations:** See all pages of the **Class Summary** for Week 4—Wed, Apr 21, and the **worksheet** for that day. In particular, you must be able to work with the mean free path, understand what is meant by **opacity**, know about the different contributions to opacity: electron scattering, bf, ff, bb, and be aware of what contributes to the opacity in different kinds of stars, e.g., opacity is dominated by electron scattering in high mass stars, and so on. Also see Questions 2 and 4 on Homework 3.

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Energy Generation in Stars

- **Nuclear Energy Generation:** See all pages of the **Class Summary** for Week 5—Mon, Apr 26. Be familiar with the Coulomb barrier, **cross sections**, be able to find the **binding energy**, and work with the **mass excess**. Also see all pages of the **Worksheet** for Week 5—Mon, Apr 26.

- **Hydrogen Fusion:** Understand hydrogen fusion in detail. In particular, you should know:
  - → Nuclear reactions: see page 1 of the **Worksheet** for Week 5—Wed, Apr 28.
  - → **PP chain:** see pages 1-3 of the **Class Summary** for Week 5—Wed, Apr 28, and pages 2-3 of the **worksheet** for that day. Also see Question 1 on Homework 4.
  - → **CNO cycle:** see pages 4-5 of the **Class Summary** for Week 5—Wed, Apr 28, and page 4 of the **worksheet** for that day. Also see Question 3 on Homework 4.

Stellar Evolution

Coming soon . . .