The second midterm exam for ASTR-1200 takes place in class on **Wednesday, March 13, 2019.** The exam covers the parts of Chapters 14, 15, 16, 17, and 18.1–18.2 in *The Cosmic Perspective* that were assigned as readings. The exam draws on the readings, lecture material, clicker questions, and concepts in the homework. Please come to office hours, the Astronomy Help Room, and/or the extra pre-exam HELP SESSIONS if you need assistance with this material.

The exam will consist mainly of multiple-choice questions, and a few (probably two) short-answer questions that require you to write a couple of sentences for each. The midterm exams are closed-book and closed-notes. You can bring a calculator, but you should not need one. Of course, no phones or laptops (or any device that connects to the outside world) are allowed.

Some of the questions will involve memorization, but these ought to be concepts that we have highlighted and/or repeated as being major topics. Other questions will involve you taking what you know and applying it in a slightly different way.

Below is a list of sources for study aids, followed by a "birds-eye-view" list of topics that we covered. If you review and understand every item in those lists (along with where they appear in the lecture-note PDFs), you should be in good shape for the exam.

SOURCES FOR STUDY ASSISTANCE

- **Textbook**
  - "Learning Goals" (start of every chapter)
  - "Big Picture" and "Summary of Key Concepts" (end of every chapter)
  - "Common Misconceptions" and "Think About It" boxes
- **Canvas**
  - All lectures notes are posted in PDF format
  - Review the clicker questions from lectures
  - Solutions to the homeworks will be posted
  - The first midterm exam (with answers) has been posted, too
  - Feel free to use the "Discussions" tab to chat online, post questions, find study partners, etc.
- **Study Groups**
  - You are encouraged to study with classmates, but be sure to take turns asking and answering questions. When done right, this can be one of the best ways to learn.
- **Office Hours & Help Sessions**
  - Please come with any questions you have about the material...
    Prof. office hours: Tues. & Fri., 10:00-11:00 (Duane D111)
    TA office hours: Mondays, 10:00-12:00 (Duane D232)
    TA EXAM REVIEW SESSION: Tues., March 12 only, 11:00-1:00 (Duane D142)
    Astronomy Help Room: Tues., Wed., & Thurs., 2:00-6:00 (Duane D142)

TOPICS/CONCEPTS FOR MIDTERM EXAM 2

Chapter 14 (sections 14.1, 14.2, 14.3)

- General properties of the Sun, and the wavelengths of light we see, as covered in class.
- Why does the Sun generate light? Review early (but wrong) ideas, as well as the correct idea.
- Nuclear fusion of H into He. How is $E = mc^2$ relevant? Why does the temperature have to be so high? Don't worry about detailed steps in the chain; just know the general inputs and outputs.
- How does the energy generated in the core get out? Know the layers up to the surface: core, radiative zone, convective zone, photosphere.
- Hydrostatic equilibrium: a balance betwen gravity (inward) and the pressure-gradient force (outward).
- The solar thermostat: an example of "negative feedback."
- How do we know what's going on inside the Sun? Neutrinos and helioseismology.
- Layers above the solar surface: photosphere, chromosphere, corona, and solar wind. Some of them can be observed only with total eclipses or from space (at UV/X-ray wavelengths).
- Know basic ideas about the 11-year sunspot activity cycle, and how magnetic fields are involved.
- Know some of the ways that variability in solar activity can cause dangerous "space weather" effects to human life, society, & technology.

Chapter 15 (sections 15.1, 15.2, 15.3)

- Understand how parallax (p) is used to measure distances (d) to stars, and know that $p \propto 1/d$.
- A star's luminosity (L) is a fixed constant, but its apparent brightness (B) is smaller as you get further away. They're linked by the inverse-square law, $B = L/(4\pi d^2)$.
- Stellar surface temperatures can be measured from colors and spectral lines. The spectral types go from hottest to coldest as OBAFGKM.
- Stellar masses can be measured (for binary stars or stars with planets) with Newton's laws. If we know any 2 out of 3 for an orbit's {size, speed, period}, we can compute the mass of the orbiting objects.
- The Hertzsprung-Russell (H-R) Diagram is a useful way to organize stars by surface temperature T and luminosity L.
  - Stars are thermal blackbodies, so $L \propto R^2 T^4$. This lets us compute radius R for any point in the H-R Diagram.
  - The main sequence is where most "adult" stars live. Giants/supergiants live in the upper-right (largest R), and white dwarfs live in the lower-left (smallest R).
- Stellar lifetimes: More massive stars have more hydrogen fuel, but they burn it up *MUCH* faster, so they have the shortest lifetimes. For O→G→M types, the lifetimes are Myr→Gyr→Tyr.
- Stellar ages: star clusters are useful because we can see their "main-sequence turnoff" and measure their ages.

Chapter 16 (sections 16.1, 16.2, 16.3)

- Molecular clouds and their role in star formation.
- As a cloud collapses, its core heats up, so it goes from its initial stage (big & cold) with gravity "winning," to its final stage (dense & hot) with a balance between gravity and pressure.
- What are likely ways for the collapse to be triggered?
- Know the role of angular momentum conservation in creating a flat "accretion disk" of gas around the newly-born star. This disk eventually condenses into rings of dust, rocky bits, and (possibly) planets.
- Mass range for newly-born stars:
  - Low end ($M < 0.08\,M_{\rm sun}$): brown dwarfs; cores are too cold to fuse H $\rightarrow$ He.
  - High end ($M > 150\,M_{\rm sun}$): so luminous that "radiation pressure" is stronger than gravity.
  - Distribution of masses: many more at the low end. 200 M-stars for every O-star.

Chapter 17 (sections 17.1, 17.2, 17.3, 17.4)

- Evolution of a star after it runs out of hydrogen in the core:
  - Low-mass (0.08–3 $M_{\rm sun}$): H-main-sequence $\rightarrow$ red giant $\rightarrow$ helium flash $\rightarrow$ horizontal branch (He-main-sequence) $\rightarrow$ double-shell red giant $\rightarrow$ planetary nebula & white dwarf.
  - High-mass (3–150 $M_{\rm sun}$): H-main-sequence $\rightarrow$ red supergiant $\rightarrow$ core-burning for He, C, O, and higher-mass elements up to iron $\rightarrow$ core-collapse supernova $\rightarrow$ neutron star or black hole.
- Know which stages are "in balance" and which are "out of balance" (regarding pressure vs. gravity).
- Why are low-mass and high-mass stars different? Each type of fusion "switches on" only above a critical core temperature. Low-mass stars sometimes don't reach it; high-mass stars do.
- Know why iron is important as the end-stage for energy-generation by nuclear fusion in stars.
- Know that *you* are made of the elements fused in the cores of an older generation of massive stars.
- Evolution in close binaries: sometimes they look wrong! Low-mass red giant with a high-mass main-sequence star? The low-mass star started out with more mass, evolved more quickly, and donated mass to its companion!

Chapter 18 (sections 18.1, 18.2 only)

- What are the formation scenarios that lead to white dwarfs, neutron stars, or black holes?
- White dwarf (WD): gravity vs. electron-degeneracy pressure
  - Single WD's just cool down into "black diamonds."
  - The Chandrasekhar limit: WD mass must be $< 1.4\,M_{\rm sun}$
  - In binaries, an accreting WD may become a *nova* (explosion of thin layer of accreted hydrogen) or a *supernova* (mass exceeds 1.4 $M_{\rm sun}$ and the whole thing explodes)
- Neutron star (NS): gravity vs. neutron-degeneracy pressure
  - Single NS's cannot exceed approx. 3 $M_{\rm sun}$
  - Core collapse speeds up NS rotation and intensifies its magnetic field. Both of these effects mean that some NS's appear to us as *pulsars* (emitting narrow beams of radio waves).
  - Two NS's in a binary may merge together, creating a *kilonova* and associated gravitational waves.
