Study Guide for Exam 2, Ast 309N (47760), Fall 2012 (Dinerstein)

Exam 2 will be Thurs., Nov. 8. It will have the same format as Exam 1: 24 multiple choice questions plus 3 short essays chosen from 5 options. It will focus on material covered in class from Tues., Oct. 2 to Tues., Nov. 6. Relevant readings can be found in portions of chs. 3 – 7 in Kaler's "Extreme Stars," and chs. 2 –8 in Wheeler's "Cosmic Catastrophes." Detailed page listings by topic, as well as some recommended outside links can be found on the **Readings & Links** page of the class website. Below is a brief outline of the major topics covered in this part of the semester, with dates of the relevant lectures, cards, and quizzes. We also list **key terms and concepts** you ought to be familiar with, and some general study questions (on the back). You may also check the postings from the Wed. Help Sessions, which are posted on **Blackboard.**

Topic	Class Dates	Cards	Quizzes
I. Small Astronomical Objects	10/2, 9, 11, 16	10/9, 11	4, 5

Red Dwarfs (low mass Main Sequence Stars): very numerous; long lifetimes; starspots, flares, & other evidence for activity; minimum mass of a M.S. star

Brown Dwarfs: "failed stars," young brown dwarfs as protostars; electron degeneracy pressure; spectral types L, T, Y; cooling/fading "track" in HR diagram

Exoplanets: direct vs. indirect detection methods; gravitational tugs, position wobble (astrometry), Doppler wobble or radial velocity method (spectroscopy), transits (light curves); "hot Jupiters"; habitable zones; NASA's *Kepler* satellite.

Topic	Class Dates	Cards	Quizzes
II. Life Stories of Solo Stars	10/16, 18, 23, 25, 30	10/16, 18, 23, 25	5, 6, 7

Pre-Main Sequence or Protostar phase: contraction under gravity, conversion to thermal energy, beginning of core H fusion, path or "track" in the HR Diagram

Post-Main Sequence Evolution of Low and Intermediate Mass Stars (up to 8 $M_{\odot}$): core H exhaustion, up the red giant branch, core He-fusion, horizontal branch, double-shell burning stage = Asymptotic Giant Branch, Mira variables, mass loss, neutron-capture reactions, thermal pulses, dredge-up, planetary nebula, white dwarf

Post-Main Sequence Evolution of High Mass Stars (over 8 $M_{\odot}$): CNO cycle, triple-alpha and higher fusion reactions, "onion" structure of evolved star, core collapse, neutronization, neutrino burst, supernova explosion, more neutron-capture reactions (rapid or "r"-process), jets, Supernova 1987A, supernova remnants, Crab Nebula

Topic	Class Dates	Cards	Quizzes
III. Compact Stellar Remnants	10/23, 30, 11/1, 11/6	10/23, 30	7

White Dwarf, former cores of AGB stars: end-states of low & intermediate-mass stars; electron degeneracy pressure, mass-radius relation, cooling tracks and cooling ages

Neutron Stars, collapsed cores of high-mass star supernovae: neutron degeneracy pressure, pulsars, synchrotron radiation, lighthouse model, pulsar slowdowns and glitches, association of pulsars with supernova remnants (e.g. Crab Nebula), binary pulsars (pulsars in binary systems), pulsar planets, magnetars, millisecond pulsars

Study Questions (*not* guaranteed to cover all possible questions on the exam!)

1. What are the differences between a red dwarf, brown dwarf, and white dwarf? Where is each located in the HR diagram and how do their positions change with time?

2. Consider the CNO cycle of nuclear reactions and the “triple-alpha” process, both of which involve C and O. Describe what happens in each sets of reactions: what is the input (fuel), and what is the output (product)? In what stars, and where within these stars, do they take place?

3. Why is looking in the infrared part of the electromagnetic spectrum a good strategy for finding brown dwarfs? If you found an object that was brighter in the infrared than in the visible, how would you confirm/check on whether it is in fact a brown dwarf, rather than something else?

4. What are the maximum and minimum masses for brown dwarfs, Main Sequence stars, white dwarfs, and neutron stars? (Hint: In some cases there might not be a maximum and/or minimum value.) What are the physical reasons for these maximum/minimum values?

5. What are the three major “indirect” methods for finding exoplanets? In what way are they “indirect”? What kind of measurements do you need to make, to apply each method? Which of them have been more successful, and which less successful?

6. What are the properties of a “hot Jupiter”? What causes it to be hot?

7. Describe some of the discoveries of exoplanets that astronomers found surprising.

8. How does the Kepler satellite search for exoplanets? How successful has it been?

9. What are the observable properties of a protostar, and where does it lie in the HR diagram?

10. Describe the major energy-producing fusion reactions that occur in low to intermediate-mass stars. What are the inputs and the products? Where in the stars do the reactions occur?

11. Cite the (6 or so) major stages in the life cycle of the lower-mass stars (less than 8 $M_{\odot}$). Summarize the physical properties of the star at these stages, the energy production mechanisms, the kind of pressure that supports them, and the path in the HR diagram.

12. Cite the major stages in the life cycle of the higher-mass stars (more than 8 $M_{\odot}$). Summarize the physical properties of the star, the energy production mechanisms, and the path in the HR diagram. Which stages are in common with the lower-mass stars, and which are different?

13. What are the similarities and differences between the event that throws off the outer layers of lower vs. higher-mass stars at the ends of their lives? What are their expanding debris called?

14. Where and how in nature are the elements heavier than Fe (iron) made?

15. Once formed, how does a white dwarf’s properties change with time?

16. What is a pulsar? Once formed, how does its properties change with time?

17. Are there neutron stars that are not pulsars? What properties do or would they have, or lack?

18. Compare white dwarfs and neutron stars in terms of: mass, radius, density, composition.

19. What can be learned from a pulsar that is found to be in a binary system?

20. Why was Supernova 1987A an important event for astronomers, in terms of confirming theories about supernovae?