ASTRONOMY 1102 – 1

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Study Guide for Second Test – Friday October 15, 1999

This test will be based on material we have covered in class. I have followed quite closely the content but not always the order in which this material is presented in "The Cosmic Perspective".

The Sections of the text included in the test: Chapter 7, all sections, with special emphasis on radiation laws (Wien's displacement law, Stefan-Boltzmann law for perfect emitters - blackbody emitters), the types of spectra, and the Doppler effect; Chapter S2, Figure S2.18, atmospheric transparency and the optical and radio "windows"; Chapter 14, all sections plus measuring the mass, size and luminosity of the sun (see Prof. Landolt's lectures or box 6.2 on p. 150 on using Newton's version of Kepler's Third Law), The "solar constant" is the flux from the sun received on earth. It is about $S = 1370$ W/m^2 and can be used to determine the solar luminosity $L_\odot = 4\pi d^2 S$; Chapter 15 all sections up to and including HR diagrams.

The test will consist of two parts: multiple choice questions: 20 at 3 pts each (for a total of 60 %), and 4 problems (for a total of 40 %). I give below some examples of the type and format of test questions and problems.

Review class notes: do not memorize first, understand first, and then commit to memory only a few basic definitions and laws. Review homework: this is especially important since the homework is considered test practice.

Chapter 7: Light the Cosmic Messenger

Properties of Wave Motion: Understand the meaning of wavelength (λ) and frequency ($f = 1/T$). Photons, the quanta of light, their energy. Relationships between wavelength, the photon energy $E = hf$, the frequency and the wave velocity c: $\lambda = c/f$ or $\lambda f = c$. Frequency and wavelength are *inversely proportional* to one another: if I double the frequency I am halving the wavelength. Units used: angstroms (Å) and nanometers (nm).

The electromagnetic spectrum: visible light (400 nm $< \lambda <$ 700 nm). Other wavebands of the EM spectrum: Study carefully Fig. 7.5. Recall what we said in class: note the scales of frequency, wavelength, and photon energy.

Sect. 7.4.6: Spectroscopy and Kirchhoff's Laws: Spectral lines, the continuum: identify in Fig 7.6 the continuum and the absorption/emission lines/bands. Fig 7.13 summarizes Kirchhoff's laws. When do you see lines in emission? When do you see lines in absorption? Which elements produce the lines?

The laws that govern blackbody radiation: Wien's displacement law $\lambda_{\rm max} \propto 1/T$ (see how the peak "displaces" to smaller wavelength as T increases in Fig 7.12), Stefan-Boltzmann Law: total power emitted per unit area $\propto T^4$ (see how the "area" below the blackbody curve increases as T increases in Fig 7.12).

The formation of spectral lines, basic concepts of atomic structure. Absorption and emission of a quantum of radiation (photon). The spectrum of hydrogen: Balmer lines.

Putting it all together: understanding Fig. 7.14.

Chapter 14: Our Star

The balance between gravity and pressure. Gravitational equilibrium. The internal structure of the sun: all the zones from the core to the wind. Nuclear reactions, the pp chain and the generation of the solar luminosity. Study fig. 14.7 showing the steps involved and the overall effect: the total reaction. Note the products of the reaction. The solar thermostat. Why do we need such high temperatures for fusion? Strong force vs electromagnetic force. Windows to the interior of the sun: neutrinos and helioseismology. The solar neutrino problem. How can we resolve it? Sunspots, why they form, why they migrate, why are they cooler, why are they darker. The solar differential rotation (faster at equator than at the poles). The stretching of field lines. Why do sunspots appear in pairs of opposite magnetic polarity? Effects of the solar wind hitting the terrestrial magnetosphere.

Chapter 15: Stars

Geometric parallax, distance and parallax angle $d(\mathrm{pc}) = 1/p(\mathrm{arcsec})$. Stellar luminosity and apparent brightness. Absolute and apparent magnitudes. The magnitude scale: $\Delta m = 5$ means a flux ratio of 100. The smaller the magnitude the brighter the star (example: a 0th magnitude star is 100 times brighter than a 5th magnitude star). Spectral classification. Effective temperature or surface temperature and color. The sequence of spectral classes OBAFGKM. Subclasses, ...A0,...,A9,F0,...F9, etc. The sun is G2. Meaning and origin. The Hertzsprung–Russell Diagram (HR diagram). Main sequence stars. giants, supergiants and white dwarfs. Luminosity classes. The luminosity given the stellar radius and surface temperature; $L = 4\pi R^2 \sigma T^4$. Luminosity classes I...III...V. The sun is G2V. Variation of stellar mass and radius along the main sequence and other parts of the HR diagram.

SAMPLE:

Part I – Multiple Choice questions (5 pts/question; total = 60 pts)
Identify the correct answers by placing a check between the brackets [ ]. Check **ALL** correct answers in the questions identified by a *.

1) The power emitted by every square inch of a star twice as hot as another is
   [ ] 2 times larger.
   [ ] 2 times smaller.
   [ ] 4 times larger.
   [ ] 8 times larger.
   [ ] 16 times larger.

2) The pp chain produces the following reaction products
   [ ] just pure Helium.
   [ ] Helium, protons and radiation.
   [ ] Helium, positrons, neutrinos and radiation.
   [ ] Helium and Oxygen.
   [ ] pure Hydrogen.

*3) Dubling the frequency of a photon
   [ ] doubles its energy.
   [ ] halves its energy.
   [ ] doubles the wavelength.
   [ ] halves the wavelength.
   [ ] doubles its speed.

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Part II – Problems (10 pts/problem; total = 40 pts) **NO CALCULATORS!**
Problem 1: Powers of Ten: Show your calculations. The lifetime of the sun is estimated to be around 10^{10} yr. What is the total mass of Helium produced by the pp chain in that time? The rate of Hydrogen burning is 600 billion kg/s, of which 4 billion kg/s appear as radiation. Obtain a result accurate to a level of a few percent.

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Problem 2: A star shows a well-known spectral line whose laboratory wavelength is 200nm shifted to an observed wavelength of 180nm. Is this a blueshift or a redshift? Is the star approaching or moving away? What is the speed of this motion in km/s?