ASTRONOMY 1102 – 1

Instructor: Juhan Frank

Study Guide for First Test – Friday February 12, 1999

This test will be based on material we have covered in class, supported by the material in chapters 4, 21, 22, 23, 24 and 25 of ASTRONOMY: From the Earth to the Universe, 5th Edition. The test will consist of two parts: multiple choice questions (60 %) and problems (40 %). I give below an example of what the test will look like and a couple of examples of 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.

Chapter 4: Light and Telescopes

Why study the properties of radiation? Information from celestial objects is carried by the radiation they emit. Light is Electromagnetic Radiation (EMR). Electromagnetic Waves (EMW). Properties of Wave Motion: Understand the meaning of wavelength (λ), period (T), and frequency ($f = 1/T$). Material waves and electromagnetic waves: Distinguish what moves or changes (water, air, electric and magnetic fields). Relationships between wavelength, the period, the frequency and the wave velocity c: $\lambda = cT$ 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 Figs. 4-3 and 4-4. Recall what we said in class: note the scales of frequency and wavelength. Note the "windows" in the radio, optical and infrared bands.

Section 4.2: Telescopes, angular resolution (concept and Fig 4-5), dependence on wavelength. Sect. 4.3: Lenses and Telescopes, refraction, red bends less than violet: chromatic aberration (Fig 4-11). Sect 4.4: Reflecting Telescopes. Basic structure: primary mirror, secondary mirror, and eyepiece. Newtonian and Cassegrainian telescopes.

Sect. 4.5: Light gathering power (LGP) and seeing. LGP scales with the *square* of the diameter (it is a surface area!). The resolution is in practice limited by the seeing to > 0.5 arcsec.

Sects. 4.6 and 4.7: Spectroscopy and Kirchhoff's Laws: basic workings of a spectro scope/graph/meter. Spectral lines, the continuum: identify in Fig 4-23 the continuum and the absorption lines. Fraunhofer lines in the solar spectrum (see Figs. 4-24 AND 21-4). Fig 4-25 summarizes Kirchhoff's laws, see also homework 2. When do you see lines in emission? When do you see lines in absorption? Which elements produce the lines? Further discussion of this in Sect. 23.3 is based on atomic theory.

The Doppler Effect (See Section 4.8 AND 24.6): recall discussion in class source in motion (Figs. 4-26 and 4-27), observer in motion. The *relative speed* counts. Doppler formula: $\Delta\lambda/\lambda_{\rm emi} = (\lambda_{\rm obs} - \lambda_{\rm emi})/\lambda_{\rm emi} = v/c$. Meaning of the *sign* of v: negative when approaching, positive when receeding. Blueshift ($v < 0$) and Redshift ($v > 0$). See homework problem about train whistle. Most galaxies show redshifts.

Chapter 21: Our Star, the Sun

The main regions of the sun shown on p. 328: the solar "surface" or photosphere divides it into atmosphere and interior. The energy of the sun is generated in the core and is then carried out, first by radiation (EMW), then by convection. Solar seismology enables us to study the solar interior by observing oscillations on the solar surface. The atmosphere: chromosphere and corona. Mass is streaming out in the solar wind. How do we know that the corona is so hot? Spectral analysis: multiply ionized metal lines. Why is the corona so hot? See http://solar-center.stanford.edu/FAQ/Qcorona.html.

Chapter 22: The Sun and the Earth

Mostly Sect. 22.1: Sunspots, the magnetic field, Zeeman effect (splitting is proportional to magnetic field strength). Study Fig. 22-3. The average sunspot cycle of 11 years (Fig 22-7). The true cycle is twice as long: the magnetic field changes polarity from one cycle to the next. Sect. 22.5: the solar wind, what is it, what effect it has on Earth?. Sect. 22.6: is the "solar constant" constant?

Chapter 23: Stars and their Spectra

Gravity and pressure in balance. Heat from the core is transported to the photosphere (as in the sun). Some photospheres are hot (50,000 K), others are realtively cool (3,000 K). The continuum (or continuous part of the spectrum) varies with temperature in a characteristic way (Fig 23-2). We call this the **blackbody** emission or the **Planck Curve** (Sect 23.2). Temperature, origin of the Kelvin scale. meaning of *absolute zero*. The laws that govern blackbody radiation: Wien's displacement law ($\lambda_{\rm max} \propto 1/T$, see dotted line on Fig 23-2), Stefan-Boltzmann Law (Total Energy Emitted $\propto T^4$) Sect 23.3: 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. Sect. 23.5 The spectral types OBAFGKM (and the new class L) are arranged from hottest to coolest. Subtypes within a class are also arranged from hottest to coolest: A0, A1, ...A9. Study Fig 23-14. Note that Balmer lines are strongest for A stars. Cool stars have lots of metal lines and molecular bands.

Chapter 24: Stellar distances and Motions

Sect 24.1: Apparent magnitude, historical origins. Scale: 1 magnitude **difference** is a **factor** of a 100 in brightness. Sect 24.2: Stellar Distances. **Parallax**, definition: it's a small angle (arcsec). Study Fig. 24-3. The *larger* the distance the *smaller* the parallax (Fig 24-4). Parsec (pc), definition. Comparison: 1pc = 3.26 LY. Sect 24.2b: $d(\mathrm{pc}) = 1/p(\mathrm{arcsec})$. Absolute Magnitude, definition. It is a measure of true brightness or **Luminosity**. Five magnitudes difference means a factor of 100 in brightness: the sun has an absolute magnitude of 5, while a star of type A0 has absolute magnitude of 0. Which is brighter and by how much? The inverse-square law for apparent brightness (Fig 24-7). Sect. 24.3: Photometry and filters, color index and its relation to surface temperature (Fig 24-9 compares a hot and a cool star). Basic Herzsprung-Russell Diagrams. The Main Sequence. Red Giants and White Dwarfs. (Study Figs 24-12 and 24-13).

Chapter 25: Doubles, Variables and Clusters

Sect. 25.1: Visual or astrometric binaries (Fig 25-1 Albireo), spectroscopic binaries (detected by Doppler effects, Fig. 25-2 and 25-3), and eclipsing binaries (they tell us something about stellar sizes, Fig 25-4). The mass of the sun can be calculated from Kepler's Third law as modified by Newton. The same can be used for binaries **if** we know the distance.

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 energy generated in the core of the sun is transported toward the photosphere
- [ ] mostly by heat conduction.
- [ ] by convection in the convection zone.
- [ ] by radiation just outside the core.
- [ ] by seismic waves.
- [ ] by the solar wind.

2) A star (it's surface temperature) of spectral type F7 is
- [ ] cooler than an A0 star .
- [ ] is hotter than a B9 star.
- [ ] is hotter than an A3 star .
- [ ] cooler than all K stars.
- [ ] hotter than all white dwarfs.

3) The spectral lines of a galaxy moving away from us at great speed are
- [ ] observed at the same wavelengths as measured in the lab.
- [ ] seen blueshifted to longer wavelengths than measured in the lab.
- [ ] seen blueshifted to shorter wavelengths than measured in the lab.
- [ ] seen redshifted to longer wavelengths than measured in the lab.
- [ ] seen redshifted to shorter wavelengths than measured in the lab.

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Part II – Problems (10 pts/problem; total = 40 pts)
Problem 1: The Earth is at a distance of 1 astronomical unit (AU) from the sun. How many times brighter or dimmer does the sun seem from a distance of 10 AU? Show your calculations and state which law of radiation you are using to get your result.

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Problem 2: Compare the spectra of two blackbodies of the same dimensions placed at the same distance from your spectroscope. One body is at 3000K and the other at 9000K. What do the spectra look like? Which is brighter and by how much? Compare the wavelengths of the peak. Can you sketch the spectra in arbitrary units?