Ay 20 / Winter Term 2013-2014

Midterm Exam Format and Questions to Prepare

This is an oral exam that is limited to 30 minutes in duration. Five questions from the set below will be asked. Your instructions are:

- Sign up for a 30-minute slot on Tuesday (18'th) or Thursday (20'th) using the link on the Ay20 web page. This is first-come, first-serve scheduling.
- Come to SRK office at the appointed time.
- You will be given a Chinese cookie with five magic numbers.
- Proceed to answer them, with encouragement to use the board.
- Please speak loudly (even – especially – if you are not sure of the answer)

You are expected to know the numerical values of the following constants:
G (gravitation), k or k_B or σ_B (Boltzmann constant), h (Planck constant), eV, NA (Avogadro's number), m_e/m_p (particle masses), σ_T (Thompson cross section for electron scattering)

The questions are:
1. SOLAR UNITS. Demonstrate your familiarity with: Mass of Sun, Radius of Sun, Luminosity of Sun, Astronomical Unit

2. KEPLER'S LAWS. Given the semi-major axis of Jupiter's orbit is 5 AU compute the time taken by Jupiter to go around the Sun once.

3. INVERSE SQUARE LAW. Compute the solar constant (solar flux at Earth).

4. PLANCK FORMULA. Consider the 3-K background. What is the typical energy of a CMB photon. Compute the number of photons per cubic centimeter (or cubic meter).

5. MORE PLANCK APPLICATIONS. Astronomers have discovered a "hot" Jupiter. Assuming that the effective temperature is 1000 K compute the wavelength at which the radiation from the planet will peak.

6. SOLAR SAIL. Consider a solar sail which has a size of 1 square meter. It is oriented perpendicular to the Sun. Compute the radial force for two cases: the sail is black in color (and absorbs all photons) and the sail is a perfect mirror.

7. EDDINGTON LUMINOSITY. Consider a star of radius R, mass M and luminosity L. At radius r, galance the gravitational force on a proton with the radiation force acting on an electron the radiation force. (the Eddington Luminosity). Plug in values for the Sun.

8. BOHR RADIUS. We know from the virial theorem that the kinetic energy is equal to half the (absolute value) of the potential energy. Now we apply Planck's requirement that

the orbital angular momentum is quantized with first level having the value h. Derive the radius of the first orbit (Bohr radius).

9. HYDROGEN LINES. Given that one Rydberg is 13.6 eV compute the wavelengths of the first few members of the Balmer series (for hydrogen).

10. DARKNESS. What can you deduce by noting that the sky is dark at optical wavelengths?

11. WHAT'S UP? At the vernal equinox, 0h is on the meridian at noon. The galactic pole at 12h49m is on the meridian at midnight in which month? The galactic center at 17h42m -29d is on the merdian at midnight in which month? Palomar is located on Earth at latitude +33d and Keck is at +19d; which is a better location for observing the galactic center? And the galactic pole?

12. DISTANCE MODULUS. Based on your observations of the spectral type and color of a particular star, and on the assumption that it is a main sequence star, you calculate a negative distance modulus. What does this imply? For another star, $M_{absolute} = -2$ and $m_{apparent} = 8$, what is the distance of the source?

13. OBSERVED SPECTRA. Describe how the spectrum of a star, as observed using a telescope on Earth, differs from the blackbody spectrum emitted at the bottom of the stellar photosphere I am looking for at least three major effects.

14. EMITTED SPECTRA. Give a qualitative description of the color and important spectral lines seen in: O stars; A stars; G stars; M stars. What is the main physics that determines which spectral lines are exhibited?

15. RADIATIVE TRANSFER. Define the terms "optically thick" and "optically thin". Where is the $\tau = 1$ surface in a stellar atmosphere? What is significant about $\tau = 2/3$? If the Sun's corona has very high temp (T = 2e6 K), why don't we see the Sun as a blackbody at this temperature?

16. MORE RADIATIVE TRANSFER. A gas cloud has large optical depth. If the amount of gas is somehow doubled, how does this affect a) the optical depth b) the amount of background starlight that gets through the cloud?

17. STELLAR PHYSICS. Describe the four equations of stellar structure and the equilibrium conditions they are related to.

18. STELLAR STRUCTURE. Draw a cut-away diagram of the Sun and label as many of its surface and interior features as you can. Discuss the predominant trends with increasing solar radius of temperature, pressure, luminosity, and mass.

19. IS MORE BETTER? Why do astronomers want telescopes as large as possible? What are the practical limitations on telescope size? What size aperture gives 1" resolution at 5000 A (optical) and 21 cm (radio).

20. INTERSTELLAR MEDIUM. Describe the various constituents of the interstellar medium and how we know they exist.