

Astronomy 2115

Fall 2023

Homework #2

Due Thursday, Sept 7 at beginning of class

For full credit you must write your solutions neatly and include all work. Do not forget the units on every quantity that has them.

- 1) Describe the Sun's interior. Include references to the main physical processes that occur at various depths within the sun.
- 2) Assuming that the current rate of hydrogen fusion in the Sun remains constant, (a) what fraction of the Sun's mass will be converted into helium over the next 5 billion years? (b) How will this affect the overall chemical composition of the Sun?
- 3) (a) A positron has the same mass as an electron (but opposite charge). Calculate the amount of energy released by the annihilation of an electron and a positron. (b) The products of the annihilation are two photons, each of equal energy. Calculate the wavelength of each photon and indicate what part of the spectrum this is.
- 4) Say we want to measure whether a star is coming towards us or away from us using the Doppler shift of the lines in its spectra, with an accuracy of 1 km s^{-1} or better. Assume for simplicity that the star is in the plane of the Earth's orbit around the Sun.
 - (a) Is it important to take into account the Earth's orbital motion around the Sun? How about Earth's rotational motion on its axis (ignore the tilt of the Earth's rotation axis for this problem)? In other words, if we didn't take these motions into account, could we make an error larger than 1 km s^{-1} ? Use figures to show these effects and calculate what are the largest velocity shifts these two effects can introduce, in km s^{-1} ? Use the Earth's sidereal year, orbit size, sidereal day, and radius.
 - (b) For the Earth's rotational motion, describe qualitatively how the velocity shift depends on latitude. That is, does it increase, decrease, or stay the same, and why?
- 5) In a typical solar oscillation, the Sun's surface moves up or down at a maximum speed of 0.1 m/s . An astronomer might look to measure this speed by detecting the Doppler shift of an iron absorption line with a wavelength of 557.6099 nm . What is the maximum shift in wavelength that the astronomer is looking to observe?
- 6) (a) Find the ratio of the energy flux from a patch of a sun-spot's penumbra to the energy flux of an equally large patch of undisturbed photosphere. Which patch is brighter? (b) Make the same comparison between penumbra and umbra.
- 7) Explain the difference between a star's apparent brightness and its luminosity.
- 8) Which are more common, stars more luminous than the Sun or stars less luminous than the Sun?

9) Explain why the color ratios of a star are related to the star's surface temperature.

10) What are the most prominent absorption lines you would expect to find in the spectrum of a star with a surface temperature of (a) 35,000 K, (b) 2800 K, and (c) 5800 K (like the Sun)? Briefly describe why these stars have such different spectra even though they have essentially the same chemical composition.