Astronomy 2110 Homework #5

Spring 2024 Due Thursday, Feb 22 in class.

For full credit you must write your solutions neatly and include all work. Do not forget the units.

1) What is spherical aberration? How can it be corrected?

2) What is diffraction? Why does it limit the angular resolution of a telescope? What other phenomenon is often a more important restriction on angular resolution for an optical telescope?

3) (a) Compare the light-gathering power of the Keck I 10 m telescope with that of the Hubble Space Telescope (HST) which has a 2.4 m objective mirror. (b) What advantages does Keck I have over HST? What advantages does HST have over Keck I?

4) Suppose your Newtonian reflector has an objective mirror 20 cm in diameter with a focal length of 2 m. For this telescope geometry the magnifying power equals the focal length of the mirror divided by the focal length of the eyepiece. What magnification do you get with eyepieces whose focal lengths are (a) 9mm, (b) 20 mm, and (c) 55 mm? (d) what is the telescope's diffraction-limited resolution when used with orange light at a wavelength of 600 nm? (e) Would it be possible to achieve this resolution at the top of the Sandia's?

5) The HST has been used to observe the galaxy M100, some 70 million light-years from Earth. (a) If the angular resolution of an HST image is 0.1 arcsec, what is the diameter in light-years of the smallest feature that could be discerned in the HST image? (b) At what distance (in km) would a US dime have an angular size of 0.1 arcsec?

6) To find out if ionized oxygen gas surrounds galaxies, astronomers aimed the ultraviolet telescope of the FUSE spacecraft at a distant galaxy. They then looked for an ultraviolet spectral line of ionized oxygen in the spectrum of the galaxy. Were they looking for an absorption or an emission line?

7) Mars has two small satellites, Phobos and Deimos. Phobos orbits Mars once every 0.31891 days at an average altitude of 5980 km above the planet's surface. The diameter of Mars is 6794 km. Knowing all this, calculate the mass and average density of Mars.

8) Suppose that a spacecraft landed on Jupiter's moon Europa which orbits Jupiter at a radius of 670,900 km. After collecting samples from the moon's surface the spacecraft prepares to return to Earth. (a) Calculate the escape velocity from the surface of Europa. (b) Calculate the escape velocity from Jupiter at the distance of Europa. (c) In order to return home, the spacecraft must achieve a velocity greater than your answer to (a) or (b). Explain why.

9) A hydrogen atom has a mass of 1.673×10^{-27} kg, and the temperature of the Sun's surface is 5800 K. What is the average speed of hydrogen atoms at the Sun's surface in km/s?

10) The Sun's mass is 1.99×10^{30} kg, and its radius is 6.96×10^{8} m. (a) Calculate the escape velocity from the Sun's surface. (b) Using your answer to question (9), explain why the Sun has lost very little hydrogen over its entire 4.56 billion-year history.