Physics 112
Astronomy
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Name KEY

EXAM 2
April 7, 2004

I pledge my honor that during this examination I have neither given nor received assistance, and that I have seen no dishonest work.
Signed________________________________

I have intentionally not signed the pledge.____________________________

Useful equations $\lambda = \frac{.0029}{T}$ $L = \sigma T^4 4\pi R^2$ $b = \frac{L}{4\pi d^2}$ $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ $\Delta E = \frac{hc}{\lambda}$

$P^2 = \frac{4\pi^2}{G(M_1 + M_2)} R^3$ $F = \frac{GM_1 M_2}{r^2}$ $a = \frac{v^2}{R}$

Surface temperature of Sun—5800 K
Lifetime of Sun—10^{10} years
206265 AU = 1 pc
3.26 lt-year = 1 pc

1. On the screen you will see ten pictures of solar system objects all labeled with a number. Identify the objects. (1 pts apiece)

1. Europa
2. Mercury
3. Saturn
4. Jupiter
5. MARS
6. Io
7. Neptune
8. SUN
9. Asteroid
10. Callisto

2) A planet is discovered orbiting a star. The planet takes 3 years to orbit and is at a distance of 2 A.U. from the star. From this information can you obtain the mass of the planet? Why or why not? From this information can you obtain the mass of the star? Why or why not? Find either the mass of the planet or the star in terms of the mass of the sun. (10 pts)

Because $P^2 = \frac{4\pi^2}{G(M_1+M_2)} R^3$, if $M_1 \ll M_2$ then $M_1+M_2 \approx M_2$ and we can neglect M_1. So here we can neglect the mass of the planet and find the MASS of the STAR. Let's compare the star-planet system to the ~~=~~ sun-earth system

$$\frac{(3\,yr)^2}{(1\,yr)^2} = \frac{P_p^2}{P_E^2} = \frac{\frac{4\pi^2}{G M_{STAR}}}{\frac{4\pi^2}{G M_{SUN}}} \frac{R_{Star}^3}{(1\,AU)^3} = \frac{M_{SUN}}{M_{Star}} \frac{(2\,AU)^3}{(1\,AU)^3} \Rightarrow M_{St} = \frac{8}{9} M_{SU}$$

3) Why are the Jovian planets so different in chemical composition from the terrestrial planets? Explain in terms of the current theory of the formation of the solar system. (10 pts) It was due to temperature differences in the solar nebula. Close to the protosun, the stellar nebula was hot. The only materials that could form solid grains were metals. Because the initial growth of planets occured due to solid grains sticking together, the initial planets had a high proportion of their mass coming from metals.

Far from the protosun, it was cold. Metals, silicates, + hydrogen rich compounds were in solid form. There ~~was~~ was a lot of material in solid form available to stick together + form the Jovian planets. Eventually these planets grew so large that they could attract more material gravitationally

4) For what reason do you not see helium absorption lines in the sun's visible spectrum, even though helium is the sun's second most abundant element? (10 pts)

Helium is very tightly bound. The transition from the lowest orbit to a higher orbit needs a UV photon. Only in transitions ~~to hig~~ from a high orbit to a higher orbit will ~~abs~~ the electron absorb a visible photon. At ~~low~~ relatively low temperatures, there are ~~just~~ essentially no electrons in the higher energy orbits. The sun is just too COLD for us to see helium lines in the visible.

5. Multiple choice. Circle all correct statements—that is, one question may have more than one correct response.

   a. The number of days between the vernal equinox and the autumnal equinox (our spring and summer) is somewhat greater than the time between the autumnal equinox and the vernal equinox (our fall and winter. This is a result of (5 pts)
      i. The precession of the equinoxes.
      ii. Kepler's second law (equal areas).
      iii. Kepler's third law (how periods relate to orbital radii)
      iv. The use of leap years to correct our calendar.
      v. The tilt of our rotation axis compared to our axis of revolution.

   b. On Earth, the parallax angle measured for the star Procyon is 0.29 arcseconds. If you were able to measure Procyon's parallax angle from Venus, what would it be? (5 pts)
      i. More than 0.29 arcsecond
      ii. 0.29 arcsecond
      iii. less than 0.29 arcsecond, but not zero
      iv. zero arcseconds (no parallax)

   c. Venus has a runaway greenhouse effect. In the greenhouse effect (5 pts)
      i. The atmosphere absorbs strongly in the visible and ultraviolet and is transparent in the infrared.
      ii. The atmosphere absorbs strongly in the infrared and is transparent in the visible and ultraviolet.
      iii. The atmosphere absorbs strongly at all wavelengths.
      iv. The atmosphere is transparent at all wavelengths.
      v. The planet radiates in the infrared.

   d. Which of the following properties of the planets does NOT tell us something about the way in which our solar system must have evolved? (5 pts)
      i. The planets farther from the Sun take longer to complete their orbits.
      ii. The planets all orbit in about the same plane.
      iii. The planets' orbits are all nearly circular.
      iv. Most planets spin in the same direction (cc as seen from the north)
      v. Most moons revolve in the same direction as the planets do (cc as seen from the north)

6. One of the emission lines of hydrogen occurs at a wavelength of 656.3 nm. You measure the absorption spectrum from a star and determine that this same line appears at a wavelength of 644.0 nm. Is the star moving toward the Earth or away from it? Explain your answer. (5 pts)

The star has a shorter wavelength line than that seen in the lab so the star is blueshifting. It is moving toward us.

7. Explain why plastic bags do not deteriorate when exposed to incandescent lights inside your home but will degrade when exposed to sunlight for long periods. What photons likely are responsible for the degradation of the plastic? (10 pts)

It's those energetic UV rays that cause the degradation of the plastic. The light bulb radiates primarily in the infrared + visible — it's just too cold to produce much UV. The hotter sun produces a lot of visible + UV light. (This is Wien's law)

8. What is the peak wavelength of the blackbody radiation left over from the creation of the universe, whose temperature is 3 K? Is this radio wave, microwave, infrared, visible, ultraviolet, x-ray, or gamma ray radiation? (5 pts)

$$\lambda = \frac{.0029}{T} = \frac{.0029}{3^\circ K} = .00097\ m$$

$= 970\ \mu m$ which is in the microwave

9. Two stars, Jones and Smith, have recently been discovered. Jones is an A1 star and Smith is a M0 star. Both are main sequence stars. Jones' apparent brightness is 5×10^{-12} that of the Sun and Smith's apparent brightness is 10^{-18} that of the Sun.

a. Which is hotter? Explain your answer. (5 pts)

A stars are hotter than M stars so Jones is hotter.

b. What is the luminosity of Jones in terms of the luminosity of the sun? Explain how you arrived at your answer. (5 pts)

From the HR diagram $L_J = 10^{1.5} L_\odot = 32 L_\odot$

c. Jones has a surface temperature of 10000° K. What is Jones' radius in terms of the radius of the Sun? (5 pts)

$$32 = \frac{L_J}{L_\odot} = \frac{\sigma T_J^4 4\pi R_J^2}{\sigma T_\odot^4 4\pi R_\odot^2} = \left(\frac{10000}{5800}\right)^4 \left(\frac{R_J}{R_\odot}\right)^2 \Longrightarrow R_J = 1.9 R_\odot$$

d. What is the distance to Jones? Could Jones' distance be measured by parallax also? Explain your answer. (5 pts)

$$5\times10^{-12} = \frac{b_J}{b_\odot} = \frac{\frac{L_J}{4\pi d_J^2}}{\frac{L_\odot}{4\pi d_\odot^2}} = 32\left(\frac{d_\odot^2}{d_J^2}\right)$$

$d_J = 2.5\times 10^6$ AU

$= 12$ pc

This star is close so its parallax ~~could~~ shift could be ~~meas~~ measured