Homework 2 (After Midterm)

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1 Homework Chapter 4 (Pt. 2)

1.1 Summary and Self Test

10. (a) aperture is **(3)** the diameter of the largest lens or mirror of the telescope
    (b) resolution affects the **(4)** ability to distinguish objects that appear close together in the sky
    (c) focal length is **(2)** the distance from lens to focal plane
    (d) chromatic aberration is **(6)** a rainbow-making effect
    (e) diffraction is **(7)** a smearing effect due to sharp edges
    (f) an interferometer is **(1)** several telescopes connected to act as one
    (g) adaptive optics is **(5)** computer-controlled active focusing which helps to correct for the distortion that occurs in Earth's atmosphere

1.2 Questions and Problems

22. **(b)** Astronomers put telescopes in space to avoid atmospheric effects. The atmosphere, for one, blocks most of electromagnetic waves other than radio and visible wavelengths. That means those waves simply don't reach the ground. Additionally, air bubbles in the atmosphere can distort images on the way down to the ground. Putting telescopes in space gets around those issues.

29. The primary disadvantage of using a simple lense in a refracting telescope is chromatic aberration. This can mess with the image, potentially creating fuzzing around the edges of a variety of colors. A compound lens is made up of two different materials which helps to correct for the chromatic aberration.

31. One advantage reflecting telescopes have over refractors is how many polished surfaces need to be made to create a "perfect" image. In a refracting telescope, there must be 3 lenses with two surfaces each, totaling 6 polished surfaces in order to make a telescope without chromatic aberration. With a reflecting telescope, the light never enters the glass and so at minimum there only needs to be one polished surface to create a perfect image. Another advantage is weight and weight distribution. A refractor has the three glass lenses versus the single piece of glass in a reflecting telescope. Additionally, the

weight in a reflecting telescope is at the bottom (allowing for a more stable design) versus the weight in a refractor being at the top.

34. Manufacturers of quality refracting telescopes and cameras correct for the problem of chromatic aberration by using compound lenses. These compound lenses are made of two different types of glass which helps to correct for chromatic aberration. For highest end refracting telescopes, a type of compound lens called a triplet lense is used which takes advantage of 3 single lenses to create a perfect image without any chromatic aberration.

1.3 Numerical Problems

43.

$$\begin{aligned} \text{light-gathering ability} &\propto \text{area} \\ \text{diameter}^2 &\propto \text{area} \\ \frac{16}{4} &= 4 \qquad \text{so} \\ 4 * \text{diameter} &\implies 4^2 = 16 * \text{area} \\ 16\text{area} &\implies 16 * \text{light-gathering ability} \end{aligned}$$

Therefore by increasing the diameter from 4 to 16, the light-gathering power increases by a factor of 4^2 or 16.

2 Homework Chapter 5

2.1 Summary and Self-Test

1. **(b,e,f)** Gravity does not determine the direction in which the system rotates since it is the same in all directions. The pull of it causes the cloud to collapse, the smaller particles coming together to form larger particles. Once bodies are large enough, gravity pulls them together to make even larger bodies. Gravity is required for atmospheres to form around planetesimals and to hold them on the object.

2. **(c)** When dust dust grains first begin to grow into larger objects, this occurs because of collisions between dust grains. These dust grains don't have enough gravity to pull each other in, but they *can* combine by colliding into each other.

3. **(c)** The direction of revolution in the plane of the Solar System was determined by the rotation of the original cloud. The net angular momentum of the cloud was counterclockwise and so since the Solar System formed from that cloud, it also has counterclockwise angular momentum and spins that way.

4. **(b)** The terrestrial planets are different from the giant planets because when they formed, the inner Solar System was hotter than the outer Solar System. In the hotter inner ring, volatile materials cannot form and so the planets there are made primarily of refractory materials which are more dense and smaller.

7. **(a)** Nuclear reactions require very high temperature and density. The atoms need to be pressed together with high temperatures like what happens inside the core of a star for nuclear reactions to happen.

10. **(d)** A planet in the "habitable zone" is at a distance where liquid water can exist on the surface. Life on Earth needs water to exist and so we define "habitable zone" to be a region where liquid water can exist on the surface of a planet.

2.2 Multiple Choice and True/False

19. **(a)** Molecular clouds collapse because of gravity. Gravity pulls the particles of dust together and collapse towards the center of mass of the cloud.

20. **(a)** Because angular momentum is conserved, an ice-skater who throws her arms out will rotate more slowly. By throwing her arms out, she is increasing her moment of inertia and since angular momentum is conserved, rotational speed must reduce.

23. **(d)** Jupiter still has its primary atmosphere. Primary atmospheres are made of hydrogen and helium which don't last long unless the planet has enough gravity to hold the atmosphere. Jupiter is massive enough to keep its primary atmosphere.

24. **(e)** Extrasolar planets have been detected by the spectroscopic radial velocity method, the transit method, gravitational lensing, and direct imaging.

2.3 Conceptual Questions

30. The law of conservation of angular momentum controls a figure-skater's rate of spin based on that figure-skater's moment of inertia. Since angular momentum is conserved, a figure-skater can change their rate of spin by using their body to increase or decrease their moment of inertia. Moving their arms out allows the skater to spin slower, and moving their arms in allows the skater to spin faster.

33. The inner part of an accretion disk is hotter than the outer part since it is closer to the forming protostar which radiates heat to the material nearby. Another reason is because the particles closer to the center experience more gravity and are pulled longer distances, having more opportunity to collide with other particles and gain thermal energy.

35. The original atmospheres of the terrestrial planets fly away into space. Original atmospheres are made up of hydrogen and helium which are light and require strong gravity to keep together. Larger planets can hold their primary atmosphere, but the smaller and less massive terrestrial planets do not have strong enough gravity to keep their original atmospheres intact.

36. After the last of the planets formed, the leftover Solar System debris have settled mostly in their own places. Some small pieces, meteoroids, are floating about through the Solar System. Other debris has have been sent to places like the asteroid belt, the Kuiper belt, and the Oort cloud.

39. Originally, astronomers have understood that larger planets of volatile materials generally form further away from their parent star. After finding large planets in close orbits with their parent star, they have found that those planets may have formed further away and then spiraled in to end up much closer to their parent star.

3 Homework Chapter 9

3.1 Summary and Self-Test

5. **(d)** As a comet leaves the inner Solar System, its ion tail always points away from the Sun. The ion tail happens because of how the solar wind blows away material from the comet.As such, the ion tail always points away from the Sun, even when it it leaves the inner Solar System where the tail would be in front of the comet.

6. **(a,b,c,d)** Meteorites can tell us about the composition of the Solar System as well as the composition of asteroids. These meteorites are formed with the Solar System and because of that, they can tell us about the early composition of the Solar System. Additionally, some meteorites have come from parts of asteroids, meteors, or even other planets which means they could also tell us something about those objects.

7. **(a,b,d,e)** Titan resembles early Earth because it has an atmosphere of mostly nitrogen, terrain similar to Earth's, and is rich in organic compounds. On the surface, Titan has hills and ridges thought to be formed from its methane cycle which is similar to what water does on Earth. The organic compounds in the ground also are similar to what could have been on the early Earth. It also has a thick atmosphere like early Earth.

8. **(c,e)** Pluto differs significantly from the eight Solar System planets in that its orbit is chaotic and that it has not cleared its orbit. All of the eight classical planets have near circular orbits which are close to the ecliptic plane. Pluto, however, has an orbit off of the ecliptic plane and which is so eccentric it sometimes comes inside the orbit of Neptune. Pluto also lives inside of the Kuiper belt around many other objects.This is unlike the other planets who are essentially alone in their orbits.

9. **(b)** If an asteroid is not spherical, it tells you that its mass is low. An asteroid with high mass will have enough gravity to keep a more spherical shape while a low mass asteroid, when damaged, will not be able to keep a spherical shape.

3.2 Multiple Choice and True/False

19. **(a)** Short and long period comets differ because short-period comets orbit prograde while long-period comets have either prograde or retrograde orbits. Short period comets exist in the Kuiper belt which revolve around the Sun usually in the same direction while comets outside in the Oort cloud orbit in all directions.

23. **(a)** A meteoroid is found in space, a meteor is found in the atmosphere, nd a meteorite is found on the ground.

25. **(b)** During a meteor shower, all meteors trace back to a single region in the sky because all the meteors area traveling in the same direction relative to Earth. Meteor showers happen when Earth passes into the orbit of a comet and run into all that dust and debris. Because they all come from comet, the meteors are all moving in the same direction when they enter the atmosphere and will look like they are originating from one region in the sky.

3.3 Conceptual Questions

26. Astronomers are especially interested in the asteroids whose orbits cross that of the Earth because those asteroids could potentially collide with the Earth. An asteroid collision could cause massive damage to the Earth and life on Earth and so they are studied since they could directly affect us.

27. Tidal heating drives volcanism on Jupiter's moon Io. As Io orbits Jupiter, Jupiter's gravity pulls and morphs Io as it orbits in its elliptical orbit which generates enough energy to melt part of it and create geological activity.

28. Cryovulcanism is essentially vulcanism, but with volatiles like water instead of molten rock. This means that the materials are liquid at very low temperatures. With cryovulcanism, solid forms of volatiles are melted and then spurted out in plumes.

29. Europa is thought to possibly be geologically active because its icy slabs have seemed to either shift or split apart. Titan is thought to be geologically active because of how the methane in its atmosphere still existed when it should have been destroyed by solar radiation. Geological activity could have renewed the methane in its atmosphere.

31. Titan contains abundant amounts of methane which requires an explanation because methane should have been destroyed by ultraviolet solar radiation. Photodissociation is the process that destroys methane in Titan's atmosphere.

32. Some moons, while not currently geologically active, have surface qualities that may provide evidence of past geological activity. Things like ripples on the surface can be evidence of the flow of magma on the surface and shallow craters with bulges can be evidence of deformations which have been partially filled in by geological activity.

34. The Kuiper Belt is closer to the Sun than the Oort Cloud is and is also significantly smaller. Objects in the Oort Cloud also orbit and rotate in all directions and at different angles. This is significantly different than objects in the Kuiper Belt which orbit and rotate in the same direction as the inner Solar System, and also more closely along the ecliptic plane. Finally, Oort Cloud objects have very elongated orbits with periods up to millions of years while Kuiper Belt objects have less elongated orbits with periods of under 200 years.

37. Meteorites, asteroids, and comets formed at the same time as the Solar System and, as such, can be used to study the Solar System. Earth is simply one object in the Solar System, there is a lot more out there. Studying other objects can help us understand more about the Solar System and how it formed.

38. We should be concerned about the possibility of a collision because, while they are rare, they can still happen and do happen. If we collide with an asteroid, it could drastically affect the Earth and the life on it. An asteroid or comet collision could potentially be prevented and so it is worth being concerned about.

40. A comet is significantly larger than a meteor and also can be seen for much longer. A comet becomes visible when it nears the Sun, and so can be visible for a while whereas a meteor will simply enter the Earth's atmosphere and likely disintegrate in short time. That also means the comet is usually much further away, being close to the sun rather than inside the Earth's atmosphere itself.

4 Homework Chapter 10

4.1 Summary and Self-Test

1. **(b)** Star B will appear brighter in the night sky because it apparent brightness is inversely proportional to distance squared.

2. **(a)** Star A is hotter because peak wavelength is inversely proportional to temperature. Since star A is blue, it has a shorter wavelength than star B and should be hotter.

3. **(b)** Star B is more massive. Luminosity over temperature to the fourth power is proportional to radius squared. The luminosity of the stars are equal, so since star A is hotter, it should be smaller than star B.

4. **(a,b)** If a star has very strong hydrogen absorption lines, the temperature is right for hydrogen to make lots of transitions, and hydrogen is abundant in the star because hydrogen is absorbing at these wavelengths. With strong absorption lines, the temperature must be just right to make many transitions to different energy states. Also, the fact that it matches up with hydrogen absorption lines means there is a lot of hydrogen in the star to absorb those specific wavelengths.

7. **(a)** If a star has very weak hydrogen lines and is blue, it most likely means the star is too hot for hydrogen lines to form. A blue star is very hot which would mean little hydrogen absorption since the hydrogen would be ionized and couldn't absorb photons. It is unlikely for the star to have no hydrogen since hydrogen is the simplest atom.

4.2 Multiple Choice and True/False

16. **(b)** If two stars have equal luminosities, but star A has a much larger radius, we can say that star A is cooler than star B. Luminosity per unit area is proportional to temperature to the fourth power. If star A has a larger radius, it would have less luminosity per unit area and thus be cooler than star B.

24. **(a)** If a star is found directly above the Sun on the H-R diagram, we can conclude that it is more luminous than the Sun. Luminosity is on the up and down axis with increasing luminosity going up.

25. **(d)** If a star has the same temperature as the Sun, we can not say anything about its mass without knowing if it was on the main sequence or not.

4.3 Conceptual Questions

28. If we were on the planet Mars, we would be able to use stellar parallax better. Since Mars has a larger orbit, there is a greater maximum distance possible and so we can measure the parallax of stars that are farther away than what we can do on Earth. On Jupiter, this is even further exaggerated with an even larger orbit than Mars or Earth. On Venus the effect would be the opposite and we would have more trouble measuring stellar parallax.

29. If viewers describe the brighter star as golden and the fainter one as sapphire blue, we can guess that the sapphire blue star is hotter since blue light has a longer wavelength than yellow. Additionally, since the brighter one is the golden one, the golden one must be significantly larger than the sapphire looking star. Luminosity over radius squared is proportional to temperature to the power of four and so the golden one must be large enough to keep the proportionality true.

33. In this spectrum, it is a white light source because all colors are represented in the spectrum. The spectrum tells us that there is a cool cloud of gas because there are gaps in the spectrum for wavelengths with the correct energy to be absorbed by the gas. If the cool cloud of gas were located behind the white light source, the spectrum would be full and even without breaks since the white light would not have to pass through the gas cloud.

35. The stellar spectral types are not in alphabetical order because they were originally based on hydrogen absorption lines and have since been rearranged. Originally, a spectral type A star had strongest spectral lines, and a spectral type B star had slightly weaker spectral lines. Eventually, some were removed and then they were reorganized based on surface temperature.

37. The only stars whose mass we can measure directly other the Sun are stars in binary systems because Kepler's third law only applies in systems in binary systems where we can measure the center of mass and average distance between the stars.

39. We can estimate the mass of stars not in binary systems if they are on the main sequence based on where they are located on the main sequence. We can also use stars which wobble because of planets to estimate the mass using Kepler's third law.

5 Homework Chapter 11

5.1 Summary and Self-Test

2. **(e=g=a,f,h=b,d=c)** First, two hydrogen nuclei collide to become ^{2}H. When this happens, a position, neutrino are emitted; then two gamma rays follow. In the next step, one deuterium nucleus and one hydrogen nucleus collide to get ^{3}He, emitting one gamma ray. In the third step, two ^{3}He collide and become ^{4}He, releasing two hydrogen nuclei.

3. **(c)** As energy moves out from the Sun's core toward its surface, it first travels by radiation, then by convection, and then by radiation. Moving out from the core, the first zone is the radiative zone where there are no atoms to carry energy. Once the energy reaches the convection zone, there are atoms to carry the energy and the energy is carried by convection to the surface. Once reaching the surface, the energy is radiated into space.

4. **(a)** The physical model of the Sun's interior has been confirmed by observations of neutrinos and seismic vibrations. Neutrinos are the only thing we know of that escape from the core of the Sun quickly and so they are used to create a physical model of the Sun's interior.

7. **(c)** Radiation transports energy by moving light. Photons carry the energy in electromagnetic waves without requiring a medium to move through. Convection transports energy by moving matter. Fluids are heated in a way which create a convection cycle, transferring energy between two things.

9. **(c)** The solar wind creates a teardrop-shaped bubble around the Solar System. This is because the Sun is also moving and so the solar wind which is come from the Sun is dragged behind, forming a teardrop shape.

5.2 Multiple Choice and True/False

16. **(b)** Hydrostatic equilibrium inside the Sun means that radiation pressure balances the weight of outer layers pushing down.

18. **(b)** The proton-proton chain doesn't happen spontaneously on Earth because the process requires very high temperatures and pressures. For nuclear fusion to happen, there needs to be enough temperature and pressure to get the positively charged hydrogen protons to get close enough to stick together by the strong nuclear force.

22. **(d)** If the Sun were to suddenly burn an abnormally large number of hydrogen in its core, the first thing that would observe is the emission of more neutrinos. It would take a long time for the light inside the core to reach the outer layers and so we would not see it become brighter or bluer at first. Similarly, it would also take time for the increased pressure in the core to affect the Sun visibly because of inertia. Neutrinos, however, move very fast and do not interact with matter which means that it can go straight out into space.

23. **(d)** The corona isn't much much brighter than the photosphere despite significantly higher temperatures because the corona has much lower density. The few atoms in the corona can be very hot, but still faint because the total emitted energy of the whole area is low.

5.3 Conceptual Questions

26. Hydrostatic equilibrium is the balance of pressures. With all of the nuclear reactions happening in the core, there is pressure outwards towards the surface. With the large mass of the Sun, however, there is the force of gravity counteracting the radiation pressure. This creates an equilibrium. There is a similar balance with energies and the Sun. The energy that is generated in the Sun's core is equal to the energy that is emitted from the Sun. This keeps the energy of the Sun the same so that it maintains its shape. If this balance isn't quite there, the star will need to expand to allow more energy to escape.

30. Nuclear fusion is the fusion of light atoms to form a heavier one. One example of this is the proton-proton chain which creates a Helium nucleus from 4 hydrogen nuclei. A helium nucleus is slightly less massive than 4 hydrogen nuclei, however, so the remaining mass is converted to energy. This relates to the Sun's source of energy because the proton-proton chain is what happens inside of the Sun's core.

33. To start, the proton-proton chain requires 4 hydrogen nuclei. Two combine, creating a deuterium nucleus, as well as a positron, neutrino, and two gamma rays. The remaining two hydrogen nuclei combine in the same way. Each of the deuterium nuclei then combine with another hydrogen nucleus to make a helion each along with a gamma ray each. Finally, these helions combine, creating a helium nucleus, emitting two leftover hydrogen nuclei.

35. In the proton-proton chain, even though six hydrogen nuclei are involved, we only include four because two are emitted at the end. In essence, there are two recycled hydrogen nuclei which means that only four are "consumed" or used in the process.

39. To make models of the Earth's interior, we make predictions and measurements of how seismic waves travel through the Earth. Scientists then make measurements of the Sun's vibrations to find out about the Sun's interior with helioseismology.

6 Homework Chapter 12

6.1 Multiple Choice and True/False

16. **(b)** During the vertical portion of the process to become a low mass star, the luminosity falls, but temperature remains nearly constant. This is because luminosity is on the vertical axis while temperature is on the horizontal axis.

18. **(a)** When the Sun becomes a red giant, its density will decrease and its luminosity will increase. With Stefan's law, we know that luminosity is proportional to area. With the Sun expanding to a red giant, the luminosity will increase, but since the mass stays roughly the same, the density will decrease.

19. **(b)** As a low mass star dies, it moves across the top of the H-R diagram because we see deeper into the star. The dying star's outer envelop begins to expand and gets less and less dense which eventually begins to reveal the hot core.

22. **(a)** If a low mass star is in a close binary system, it still can become a nova or supernova if it can pull material from the sister star.

6.2 Conceptual Questions

28. Stars with more mass will have more gravity and thus create nuclear reactions at a much faster rate. This means that, while they have more material to use as fuel, they run through their hydrogen faster than less massive stars.

31. Stars in binary systems can have a different destiny than what might be initially determined by its mass. In a binary system, mass can be transferred between the stars. For that reason, a star destined originally to become a white dwarf can become a nova or supernova.

33. When a star runs out of nuclear fuel in its core, the core begins to compress, increasing the gravity and the energy generation in the hydrogen shell around it. The star, therefore releases more energy, but also expands which causes it too be cooler at the surface.

36. If you were an astronomer making a survey of the observable stars in our galaxy, the chances of seeing a star undergoing the helium flash would be very slim. The helium flash takes place in only several hours in contrast to the billions of years of the lifetime of a star. There are many stars in the sky, but we don't see every single one yet and so the chances are even more slim.

38. As an AGB star evolves into a white dwarf, it runs out of nuclear fuel, but is left with the hot core. Cores of stars are much hotter than surface temperatures, and so as a star becomes a white dwarf and the outer envelope begins to expand, more and more of the hot core is revealed until only a white dwarf is left.