

U07a1 life of the stars review assignment

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Life of the Stars Review Assignment What is a molecular cloud? Briefly describe the process by which a protostar forms from gas in a molecular cloud. A molecular cloud is a cloud of interstellar gas that is cold ($T \sim 10$ to 30K) and dense (a density of at least 300 molecules per cm^3 is typical) and in which many of the atoms have bonded together to form molecules (such as H_2 and CO). Molecular clouds consist primarily of molecular hydrogen (H_2) gas, with temperatures in the range 10 – 100 K and carbon monoxide. Molecular clouds are the principal sites of ongoing star formation. Therefore, they tend to be associated with young stars and star-forming regions. It all starts with a cloud of gas. Due to gravity the cloud will start to shrink. This collapse is usually triggered by a shockwave from a nearby supernova or expanding planetary nebulae. As the cloud contracts the rotation will become faster and it will break up into individual clumps. If these masses are big enough the density and temperature in the core will become high enough so that nuclear fusion can start. Hydrogen will be converted into Helium. The "burning" of Hydrogen produce a counter pressure to gravity that will stop the gas cloud from further shrinking. The gas cloud becomes a stable star. This is the present state of our Sun. A molecular cloud is a cloud from which stars form. They're called molecular clouds because their hydrogen atoms form hydrogen molecules due to low temperatures. As a molecular cloud fragment collapses it becomes more dense. Radiation has a difficult time escaping and the central regions grow opaque. Thermal energy produced by gravitational contraction becomes trapped in the center which causes temperature and pressure to rise. At the start of collapse this thermal energy was radiated away, but now that the cloud is denser there is enough pressure to resist gravity. When this happens the cloud fragment

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becomes a protostar. It isn't a star yet because the center isn't hot enough for fusion. 2. What is degeneracy pressure, and how does it differ from thermal pressure? Explain why degeneracy pressure can support a stellar core against gravity even when the core becomes cold. The pressure maintained by a body of degenerate matter is called the degeneracy pressure. Thermal pressure is "the ordinary pressure of a gas arising from motions of particles that can be attributed to the object's temperature" Thermal pressure increases when temperature or thermal energy increases. Stars can maintain internal thermal pressure with help from nuclear fusion and gravitational contraction. Internal thermal pressure can only be maintained if the energy a star radiates into space is replaced. The Pauli Exclusion Principle in quantum mechanics forbids electrons (and all fermions with half integer spin including neutron) occupying the same state. Basically, each electron must have different energy when they are packed together, as they are in a white dwarf. The number of available low energy states is too small and many electrons are forced into high energy states. When this happens the electrons are said to be degenerate. These high energy electrons make a significant contribution to the pressure. Because this pressure arises from a quantum mechanical effect, it is insensitive to temperature, i. e., the pressure doesn't go down as the star cools. This pressure is known as electron degeneracy pressure and it is the force that supports white dwarf stars against their own gravity. 3. Why does helium fusion require much higher temperatures than hydrogen fusion? Briefly explain why helium fusion in the Sun will begin with a helium flash. Helium fusion requires much higher temperatures than hydrogen fusion because the nuclei carry a much greater positive charge. This means higher speeds are

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necessary in order to overcome the nuclei repelling each other. The basic reaction of helium fusion is that it converts 3 helium nuclei into one carbon nucleus. It requires a much higher temperature because Helium repels one another more strongly than Hydrogen so the higher temperature makes the nuclei move at higher speeds. After a low mass star exhausts its core Helium it will expand again and the Helium burning inside such a star never reaches equilibrium but instead proceeds in a series of thermal pulses. Gravitational collapse is halted by degeneracy pressure and the low mass star will eject its outer layers into space. It can't fuse Carbon into heavier elements because the core doesn't get above 600 million K for Carbon fusion to occur. the Sun starts on the main sequence (nuclear fusion of hydrogen into helium), after hydrogen burning ceases helium fusion occurs causing a helium flash (helium burning core into carbon, hydrogen burning shell), after helium burning ceases have thermal pulses and luminosity and radius increases, carbon fusion can't occur because core isn't hot enough so Sun ejects outer layers and the exposed core will emit ultraviolet radiation ionizing the gas (planetary nebula) and after the glow will fade the only remains will be a white dwarf. The onset of runaway helium burning in the core of a low-mass star (such as the Sun). The helium flash happens in the hydrogen-exhausted core of a star that has become a red giant. When gravitational pressure has raised the temperature of the dormant helium core to a temperature of about 100 million K, the helium nuclei start to undergo thermonuclear reactions. Once the helium burning has started, the temperature climbs rapidly, without a cooling, stabilizing expansion. The extreme sensitivity of the nuclear reaction rate to temperature causes the helium-burning process to accelerate. This in turn raises the temperature, which further accelerates

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the helium burning, until a point is reached at which the thermal pressure expands the core and thereby limits the flash. The helium flash can only occur when the helium core is less than the 1.4-Msun Chandrashekar limit and thus it is restricted to fairly low-mass stars.

4. The iron in my blood came from a star that blew up more than 4 billion years ago. The iron in my blood came from a star that blew up over 4 billion years ago. This statement is sensible. The iron in the solar system was created before our Sun was formed about 4.6 billion years ago. Because iron is created in high-mass stars and delivered into interstellar space by supernova explosions, the supernova (or supernovae) responsible for creating the solar system's iron must have occurred before the Sun formed. With plentiful amounts of iron available, life evolved and incorporated it into itself. For example, in animals, it was incorporated into hemoglobin, a component of blood. One type of animal, called 'mammals' created a nutritional substance to feed its young. This substance (that we call 'milk') included iron since the young would need a lot of iron to produce the amount of blood it needed to make during its rapid 'birth growth' period. One of these 'mammals' was a species commonly called a 'cow'. And, of course, we get ice cream from cow's milk and thus, we get iron in ice cream.

5. What would you be most likely to find if you returned to the solar system in 10 billion years? (a) a neutron star (b) a white dwarf (c) a black hole

The Sun would've turned into a red giant just 4 billion years ago. It would've cooled down after 10 billion years thus turning into a white dwarf. It can't be a neutron star because the Sun is too small to turn into a neutron star. It can't be a black hole because the Sun is very small even to be a slight black hole.

6. Describe the mass, size, and density of a typical white dwarf. How does the size of a white dwarf depend

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on its mass? White dwarf, in astronomy, a type of star that is abnormally faint for its white-hot temperature. Typically, a white dwarf star has the mass of the sun and the radius of the earth but does not emit enough light or other radiation to be easily detected. A white dwarf is the hot core of a star, left over after the star uses up its nuclear fuel and dies. It is made mostly of carbon and is coated by a thin layer of hydrogen and helium gases. The physical conditions inside the star are quite unusual; the central density is about 1 million times that of water. A white dwarf would be a 2 solar mass sphere of about 100 km in diameter. They are very dense. A white dwarf's mass is comparable to that of the Sun and its volume is comparable to that of the Earth. A typical white dwarf will have about 1 solar mass compressed into the size of the Earth. Mass: 1.989×10^{30} kg. Density: 1×10^9 kg/m³

White dwarfs are stars that have come to the end of their lives and have blown off the outer shells of gas and dust in a supernova explosion leaving behind the core of the aged star. This core is composed mostly of the heavier elements Carbon and Oxygen and is not like ordinary stars at all.

White dwarfs are some of the densest objects known in astronomy with masses of around that of the Sun in a volume of around that of the Earth.

The radius of the white dwarf star depends inversely on its mass. This means that as the white dwarf star acquires more mass, it shrinks in size. Hence the size of a white dwarf depends on its mass.

5. What is a nova? Describe the process that creates a nova and what a nova looks like. A nova is a sudden brightening of a star. Novae are thought to occur on the surface of a white dwarf star in a binary system with another star. If these two stars are close enough to each other, material from one star can be pulled off its surface and onto the white dwarf. Occasionally, the temperature of this new material

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on the surface of the white dwarf may become hot enough to start nuclear fusion and suddenly the surface of the white dwarf will start to fuse the hydrogen into helium over its surface. This causes the white dwarf to suddenly become very bright. Ancient astronomers, who did not have telescopes and other instruments modern astronomers now have, did not realize that there was a star already there, and so they would just see a new star where they had not seen one before. As the companion star expands, it loses some of its matter, mostly hydrogen to the strong gravitational pull of the white dwarf. After a time, enough matter collects in a thin, dense, hot layer on the surface of the white dwarf to initiate nuclear fusion reactions. The hydrogen on the white dwarf's surface burns away, and while it does so, the white dwarf glows brightly. This is a nova. After reaching its peak brightness, it slowly fades over a period of days or weeks.

6. How do we know that pulsars are neutron stars? Are all neutron stars also pulsars? Explain. Neutron stars are the most massive stars. A neutron star is about 20 km in diameter and has the mass of about 1.4 times that of our Sun. This means that a neutron star is so dense that on Earth, because of its small size and high density, a neutron star possesses a surface gravitational field about 2×10^{11} times that of Earth. Neutron stars can also have magnetic fields a million times stronger than the strongest magnetic fields produced on Earth. After these stars have finished burning their nuclear fuel, they undergo a supernova explosion. This explosion blows off the outer layers of a star into a beautiful supernova remnant. The central region of the star collapses under gravity. It collapses so much that protons and electrons combine to form neutrons. Hence the name "neutron star". Pulsars are rotating neutron stars. And pulsars appear to pulse because they rotate. Pulsars are spinning

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neutron stars that have jets of particles moving almost at the speed of light streaming out above their magnetic poles. Neutron stars for which we see pulses are called " pulsars", or sometimes " spin-powered pulsars," indicating that the source of energy is the rotation of the neutron star. And hence all pulsars are neutron stars, not all neutron stars are pulsars. 1.

Magnetospheric Emission: Like gamma-ray pulsars, X-ray pulsars can be produced when high-energy electrons interact in the magnetic field regions above the neutron star's magnetic poles. Pulsars seen this way, whether in the radio, optical, X-ray, or gamma-ray, are often referred to as " spin-powered pulsars," because the ultimate source of energy comes from the neutron star's rotation. The eventual loss of rotational energy results in a slowing of the pulsar spin period. 2. Cooling Neutron Stars: When a neutron star is first formed in a supernova, its surface is extremely hot (more than 1 million degrees). Over time, the surface cools. While the surface is still hot enough, it can be seen with X-ray telescopes. If some parts of the neutron star are hotter than others, such as the magnetic poles, then pulses of thermal X-rays from the neutron star surface can be seen as the hot spots pass through our line of sight. Some pulsars, show both thermal and magnetospheric pulses. 3. Accretion: If a neutron star is in a binary system with a normal star, the powerful gravitational field of the neutron star can pull material from the surface of the normal star. As this material spirals around the neutron star, it is funneled by the magnetic field toward the neutron star magnetic poles. In the process, the material is heated until it becomes hot enough to radiate X-rays. As the neutron star spins, these hot regions pass through the line of sight from Earth and X-ray telescopes see these as X-ray pulsars. Because the gravitational pull on the material is the

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basic source of energy for this emission, these are often called "accretion-powered pulsars." 7. If the Sun suddenly became a 1MSun black hole, the orbits of the planets would not change at all. This statement makes sense. The Schwarzschild radius of the black hole with a 1Msun mass is 3km. The effects of the black hole would be seen only at a distance of 10 times the Schwarzschild radius i. e. 30km. The closest planet from the sun, Mercury is at a distance much greater than 30km from the sun. Thus, the orbits of the planets orbiting the sun would not change if the sun suddenly became a 1Msun black hole. 8. Which of these things has the smallest radius? (a) a 1. 2MSun white dwarf (b) the event horizon of a 3. 0MSun black hole (c) the event horizon of a 10MSun black hole Answer (b): A typical white dwarf is at least small-planet sized. A black hole's event horizon is larger the greater the mass, so a 3-solar mass hole would have a smaller horizon than a 10-solar mass hole. If the Sun were to become a black hole, then its size would be about 3 km. Reference: 1. McGraw-Hill Science & Technology Encyclopedia, Molecular cloud, retrieved on 27th May 2011 from [http://www. answers. com/topic/molecular-cloud](http://www.answers.com/topic/molecular-cloud) 2. Wiley Book of Astronomy, molecular cloud, retrieved on 27th May 2011 from [http://www. answers. com/topic/molecular-cloud](http://www.answers.com/topic/molecular-cloud) 3. Prostar Formation, retrieved on 27th May 2011 from [http://www. shari. com/2002/02/phys_1412_chapt_1. html](http://www.shari.com/2002/02/phys_1412_chapt_1.html) 4. Degeneracy Pressure, retrieved on 27th May 2011 from, [http://universe-review. ca/R08-04-degeneracy. htm](http://universe-review.ca/R08-04-degeneracy.htm) 5. Prof. Dale E. Gary, Life as a Low-Mass Star, retrieved on 27th May 2011 from [http://web. njit. edu/~gary/202/Lecture18. html](http://web.njit.edu/~gary/202/Lecture18.html) 6. White Dwarfs, retrieved on 27th May 2011 from [http://imagine. gsfc. nasa. gov/docs/science/know_l2/dwarfs. html](http://imagine.gsfc.nasa.gov/docs/science/know_l2/dwarfs.html) 7. White Dwarfs, retrieved on 27th May 2011 from [http://astronomy. nmsu.](http://astronomy.nmsu)

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