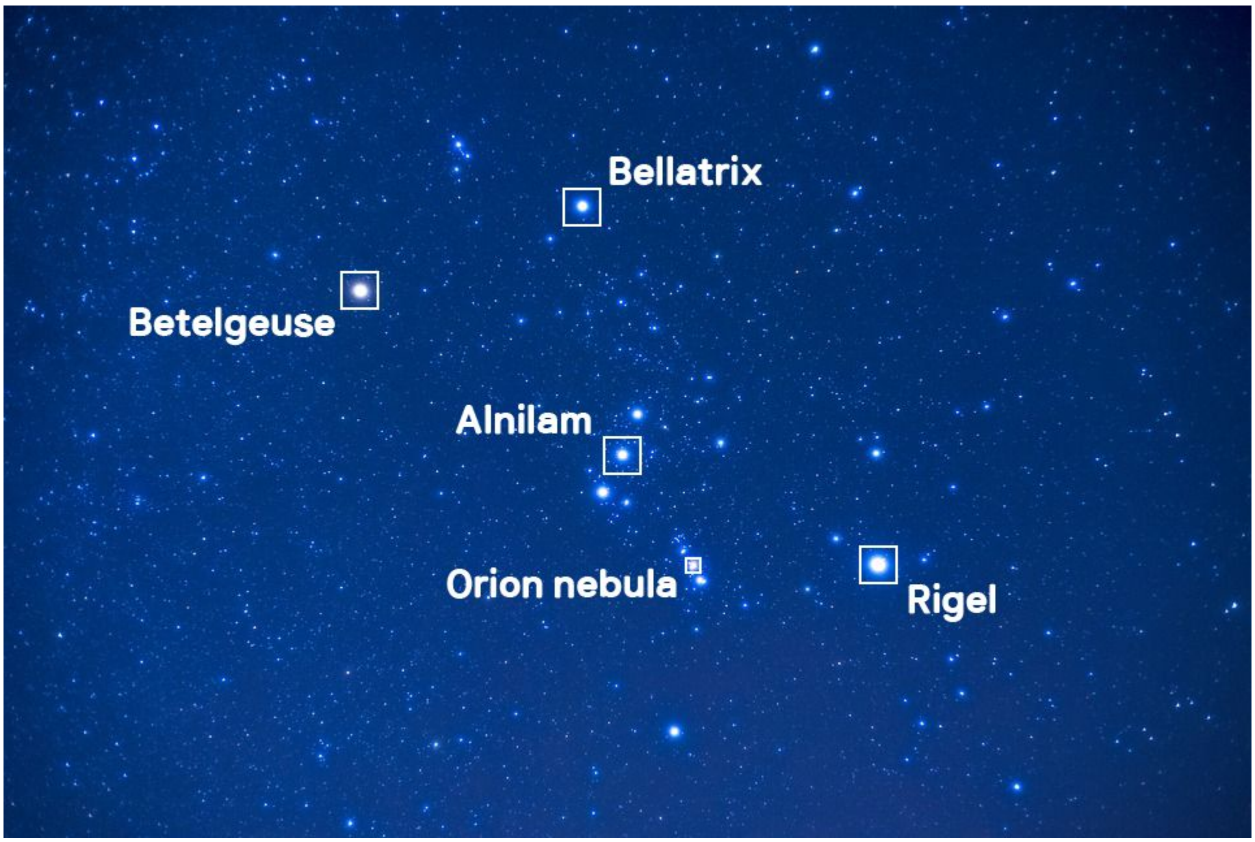
Natalie Mueller

PHYS-1010-501-Su20

Signature Assignment

Part 1 - Star Identification



Rigel

1. Rigel is actually formed by a star system that contains multiple stars. It is located in the bottom right of the image and appears brighter than the other labeled stars.
2. Rigel is approximately 780 to 860 light-years away from Earth.
3. The light from Rigel visible on Earth this year (2020) left the star between 1160 and 1240.

4. Rigel’s radius is approximately 70-80 times larger than the sun’s.
5. Rigel’s luminosity has a high variance and it can be anywhere from 60,000 to 360,000 times as luminous as the sun.

Betelgeuse

1. This star is located in the top left of the image and appears to be the second-brightest of the labeled stars.
2. Betelgeuse is approximately 650 to 700 light-years away from Earth.
3. The light from Betelgeuse visible on Earth this year (2020) left the star between 1320 and 1470.
4. Betelgeuse has a radius roughly 700 times that of the sun and is one of the largest known stars.
5. Betelgeuse is between 90,000 to 150,000 times as luminous as the sun.

Bellatrix

1. Bellatrix is in the top center of the image and is one of the brighter stars visible.
2. Bellatrix is about 240 light-years away from Earth.
3. The light from Bellatrix visible on Earth this year (2020) left the star in 1780.
4. Bellatrix is only about 6 times the radius of the sun.
5. Bellatrix is roughly 9,000 times as luminous as the sun.

Alnilam

1. Alnilam is the middle star in Orion’s Belt and appears to be the smallest of the four labeled stars.
2. Alnilam is about 1,350 light-years away from Earth.
3. The light from Alnilam visible on Earth this year (2020) left the star in the year 670.
4. Alnilam has a radius about 30-40 times bigger than the sun.
5. Alnilam is roughly 550,000 to 800,000 times as luminous as the sun.

Part 2 - Equation Analysis

Equation 1: $E = mc^2$

1. The figures in the equation represent the following:
    - ‘E’ is the variable for ‘Energy’
    - ‘m’ is the variable for ‘mass’
    - ‘c’ is a constant that represents ‘the speed of light’ (300,000,000 meters/second, also written as 3×10^8 m/s)
2. ‘c^2’ is equal to 90,000,000,000,000,000 meters squared per second squared, or 9×10^{16} m^2/s^2
3. Yes, mass and energy are positively correlated—if mass increases, energy also increases, and vice versa. We can verify this by plugging some numbers into the equation and solving for the remaining variable:
    - Plugging ‘m’ = ‘1kg’ into the equation E = 1kg x $(300,000,000 \text{ m/s})^2$, we end up with E = 90,000,000,000,000,000 kg x m^2/s^2, or E = 9×10^{16} J
    - Plugging ‘m’ = ‘2kg’ into the equation E = 2kg x $(300,000,000 \text{ m/s})^2$ instead shows us that E = 2 kg x (90,000,000,000,000,000 m^2/s^2), E = 180,000,000,000,000,000 kg x m^2/s^2, or E = 1.8×10^{17} J
4. If it is possible to change mass into energy, you could produce a titanic amount of energy from a tiny bit of mass. To put it into perspective, the energy it would take to lift that same 1kg a meter from the ground on earth takes only 9.8 J of energy. According to my math (apologies if it’s incorrect), the energy that could be converted from a 1kg mass would be enough energy to lift another 1kg mass 1m from the ground 9,200,000,000,000,000, or 9.2×10^{15} times! “A little bit of mass could produce a lot of energy” is the understatement of all space and time.

Equation 2: $d = gt^2/2$

5. Since the parts of the equation are only distance, acceleration, and time, (a) cannot be true. And by that reasoning, (b) must be true. We can see this in action if you drop a bowling ball and a feather together in a vacuum: https://www.youtube.com/watch?v=74MUjUj7bp8

Equation 3: $v = gt$

6. Using the same reasoning as in question 5, we can determine that (c) cannot be true because the velocity is only determined by acceleration by time. Once again, (d) must be true by that reasoning.

7. It’s difficult to test for a lot of variables in isolation, especially since air resistance is everywhere on earth. Someone who uses a feather and a bowling ball to test which one falls faster would see that a feather slowly floats to the ground and might mistakenly attribute that to its weight instead of the effect of air resistance.
8. Gravity’s pull on an object is greater if the object is more massive, but this increased force is canceled out by that mass’s inertia, which is what makes objects resist changes in motion. A more massive object will have both greater weight and greater inertia, which cancel each other out in regards to free fall.

Part 3 - Learning about a law of physics

Boyle’s Law is a physics law, written as $k = PV$ or sometimes $P_1V_1 = P_2V_2$, which says that a gas’s pressure and volume multiplied together will always equal the same value (a constant) given a constant temperature (at different temperatures, k will be different.)

An easy way of saying this is that a gas’s volume and pressure are inverse values. If its volume increases, its pressure will decrease by the same amount, and if its pressure increases, its volume has to decrease by that amount, too.

Example 1

If you fill a plastic bag with air and squeeze on it, its pressure will increase as its volume decreases. If you squeeze hard enough, the pressure will become so great that the bag will burst.

Example 2

Scuba divers have to be very careful when dealing with air pressure on dives. The deeper into water you go, the higher the pressure is. This means that the air scuba divers breathe becomes lower in volume as they dive deeper, so they’re inhaling and exhaling more air particles. If a diver surfaces too quickly, the air inside their body can injure them when it expands because of the decreased pressure.

Example 3

While it is possible for spaceships to fly so high they escape earth's atmosphere because they are pushing away from fuel exhaust, helicopters operate by forcing air particles down with their blades, which in turn pushes back up against the helicopter, propelling it upward. There is less pressure the higher in the atmosphere you go, therefore air has greater volume. If a helicopter tries to fly too high, there are fewer air particles in its area for it to push on, therefore it won't be able to propel itself upward past a certain point.

Part 4 - Explanation of Fermi's Paradox and possible solutions

Fermi's paradox has two different sides: One says that there is an incredibly high probability of other intelligent life outside of earth existing in the universe, and the other side is that we have never seen evidence of any other intelligent life. It is a paradox because these two statements are in direct opposition of each other, yet both statements are formed by solid hypotheses.

There are several possible resolutions to this paradox, four of which are:

Solution 1

Life exists (or has existed) and we have never found any proof of it because we exist too far away in space and/or time. The universe is so incredibly massive that even the closest potentially habitable planet to earth is over four lightyears away (about 24 trillion miles), and with our current record of being able to travel in space at about 25,000 miles per hour, it would take us around 110,000 years to travel there. And that's just the very closest of potentially-life-friendly planets. There is just too much space in our universe for us to hope to get close enough to any potential existing intelligent life. Not to mention that all of humanity's existence is just a tiny blip in time, and there's a chance that signs of extraterrestrial life have been wiped out billions of years before we even existed.

Solution 2

Life exists (or has existed) and we have never found any proof of it because periodic extinction events wipe out intelligent life before it becomes advanced enough for interstellar communication or space travel. On earth alone we have had more than one major extinction event that has wiped out a majority of life on the planet, so it's likely that this has happened across the universe as well.

Solution 3

Life exists (or has existed) and we have never found any proof of it because, like ourselves, other species have not yet figured out interstellar travel. Humans are arguably the most advanced lifeform to ever have existed on earth, and even with all of our evolution and technological advances, we are far from being able to crack interstellar travel. There's a good chance that other intelligent life that may exist in the universe is similarly stranded on their home planets too.

Solution 4

Life exists (or has existed) and we have never found any proof of it because other extraterrestrial intelligent life deliberately does not contact earth specifically. While it might sound like an awful reason, humanity's history, and even earth's history as a whole is rife with violence. Animals consume each other, and people murder each other. While this is how life has evolved on our planet, there's a chance that life on other planets has not evolved in the midst of such violence. Other intelligent life could be purposely avoiding us because they're disgusted with our behavior.

So as you can see, just because it is seemingly paradoxical to state both that there's a good chance life exists elsewhere in the universe and that we have never found proof of life existing outside of earth doesn't mean that both statements cannot be true.